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“GLOBAL CHALLENGES THROUGH THE PRISM OF RURAL
DEVELOPMENT IN THE SECTOR OF AGRICULTURE AND
TOURISM”



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Agriculture

CHEMICAL COMPOSITION OF SMEDEREVKA AND VRANEC WINES

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ABSTRACT

In this study, white Smederevka wine and red Vranec wine (vintage 2021) were produced from grapes grown at Ovce Pole wine district, Republic of N. Macedonia. Production of wines have been performed in a large-scale winery. In order to determine the quality of wines, following principal chemical parameters have been determined: alcohol, specific gravity, dry extract, total and volatile acidity, SO₂ (free and total), reducing sugars and pH. In addition, citric acid and toxic elements such as Cd, Cu, Fe and Pb have been analyzed in the wines. Wines presented satisfactory quality, containing alcohol content of 11 % and 11.61 % in Smederevka and Vranec, respectively. Total acidity was relatively high to ensure chemical and microbiological stability of wines, while volatile acidity was low in both wines influencing good balance and sensory quality. The wine stability was confirmed by pH (3.19 in Smederevka and 3.45 in Vranec). Citric acid is another mandatory parameter that should be determined according to regulations in order to ensure wine quality. Smederevka and Vranec wines contained low concentration of citric acid (32 mg/L in Smederevka wine and 122 mg/L in Vranec wine), meaning that citric acid was not added to the wines. Both wines were dry wines, with reducing sugar content lower than 4 g/L and they were well protected from oxidation with appropriate concentration of added SO₂. In addition, Smederevka and Vranec wines presented very low levels of the toxic and harmful elements Cd, Cu, Fe and Pb, lower than maximal allowed concentrations according to the safety regulations, which confirmed that the wines were safe for consumption with satisfactory chemical quality and stability.

Keywords: chemical parameters, citric acid, toxic elements, Smederevka, Vranec.

INTRODUCTION

Wine is a widely consumed beverage in the world, obtained by alcoholic fermentation of sugars from the grape in the presence of yeast (*Saccharomyces cerevisiae*), and followed by an appropriate period of aging. The chemical composition of wine is very complex since it contains a mixture of a large number of compounds including carbohydrates, organic acids, polyphenols, esters, alcohols, aldehydes, proteins, macro and micro elements, biogenic amines, amino acids, vitamins, etc. (Ivanova-Petropulos, et al. 2013, 2014, 2015). However, the two main components in wine are water, which consist of about 80%, and ethanol, present at about 12%. Ethanol is the most important alcohol in wine which is produced by the yeast fermentation and it is a significant factor for wine quality. The alcohol content mainly depends on the ripeness of the grapes and it can be accumulated at up to about 14-15% under standard fermentation conditions. Wines have a high alcohol content in years when the weather conditions are significantly good, followed by sunny days. Reducing sugars, glucose and fructose, are the main carbohydrates in grapes, which are converted into ethanol during the yeast fermentation (Ivanova Petropulos & Mitrev, 2014b).

Organic acids are important components affecting the composition, stability and organoleptic characteristics of wines, especially white wines (Ivanova-Petropulos et al., 2020). Young white wines with high acidity have more potential for aging. Red wines are stable at lower acidity due to the presence of phenols that increase acidity and enable stability of the wines during maturation. Citric acid is an organic acid present in grapes and also widely distributed compound in nature (e.g. in lemons). It is an important component in biochemical and metabolic processes (Krebs cycle). Citric acid slows the growth of yeasts, but it does not block their activity. Its concentration in must and wine, before malolactic fermentation, ranges from 0.2 to 1 g/L.

Volatile acidity is another very important parameter which determines the wine quality. Acetic acid is the main volatile acid, which is a product of the yeast and bacteria metabolism and its concentration should be monitored during the winemaking and wine aging. Increased volatile acidity in wine negatively affects its organoleptic characteristics, as well as its overall quality. Usually, volatile acidity is determined by wine distillation and is expressed as acetic acid equivalents (in g/L) (Piperevski et al., 2023).

Trace elements are considered as contaminants and information about the content of metals in wine is of great importance for producers and consumers for their health protection against toxic elements, as well as for the government authorities in order to guarantee the quality of the own traditional product. Trace elements concentration in wine is a significant parameter with a positive or negative effect on the quality of the final product (Pohl, 2007, Ivanova-Petropulos et al., 2013). From nutritional and toxicological points of view, elements are classified into essential and non-essential. Elements such as Ca, Cr, Co, K, Mg, Mn, Na Se and Zn are considered as essential elements for the human organism, while As, Cd and Pb are harmful and toxic elements because they are not chemically or biologically degradable (Ivanova-Petropulos et al., 2013).

In order to protect wine from oxidation, the mostly used agent is SO₂. Sulfphur dioxide is efficient antioxidant which reduces the enzymatic and non-enzymatic oxidation, inhibits reactions of browning especially visible for white wines, as well as acts as antimicrobial agent slowing down the development of microorganisms, thus influencing the wine stability (Ivanova Petropulos & Mitrev, 2014b). SO₂ can be added into wine in several forms: as liquid gas, SO₂ solution and in a form of power or

effervescent tablets of salt potassium metabisulphate ($K_2S_2O_5$). In addition, $K_2S_2O_5$ is a white crystalline salt, which contains 57.6 % sulfur dioxide (SO_2) and it should be dissolved in a warm water before being used. When is added into the must, it reacts with the natural acids to release sulfur dioxide, which protects wines from unwanted microorganisms and oxidation.

Republic of N. Macedonia has a very long tradition of wine production. Wine is one of the key products related to agriculture and very important for the economy in the country, as well as for development of the rural tourism in the country. In total, 81 grape varieties are permitted for planting, in which Smederevka is most dominated white grape variety in R. Macedonia, planted in all vineyard areas, followed by Riesling and Chardonnay. The most widely cultivated and the most important variety for production of quality red wines is Vranec, followed by Merlo and Cabernet Sauvignon. This study is focused on production of wines from Smederevka and Vranec grapes grown in Ovce pole wine-growing district and determination of the principal chemical parameters, such as alcohol, specific gravity, dry extract, total and volatile acidity, SO_2 (free and total), reducing sugars, pH, citric acid as well as toxic elements Cd, Cu, Fe and Pb.

MATERIAL AND METHODS OF WORK

Vinification protocol

White winemaking. Grapes from Smederevka (*Vitis vinifera* L.) variety grown in Ovce Pole wine district, have been harvested at optimal technological maturity (19.2° Brix) at vintage 2021 vintage and used for wine production. Ovce Pole wine district is located around the cities of Sveti Nikole, Štip and Probištip, north from the river Zletovo and covers area of 2456 hectares vineyards, at attitude of 300 to 560 m.

Grapes (about 1 million kg) were transported to Vineks winery (with capacity of 1.8 million liters, located in Sveti Nikole, Ovce Pole wine district), for wine production. Grapes were processed using electrical inox crusher/destemmer, and the grape juice was immediately separated from the pomace and placed in a tank. Then, SO_2 was added into the grape juice (ca. 75 mg/L total concentration), followed with inoculation with *Saccharomyces cerevisiae* yeast strain (Fermactive Blanc Aromatique, Sodinal, Bulgaria, in a dose of 20 g/100 L) and addition of balanced nutrients composed of organic nitrogen, mineral nitrogen and vitamins (Fermactive Activateur Complexe, Sodina, Bulgaria, in a dose of 10g/100 L) for yeast nutrition. In addition, enzyme (Speed up Blanc, Sodinal, Bulgaria, in a dose of 10 g/100L) and tannin (Tanivin Blanc, Sodinal, Bulgaria, in a dose of of 10g/100L) were added into the juice in order to ensure fast and efficient clarification and stabilization of redox potential of wine. After finishing the alcoholic fermentation, wine was stabilized with bentonite (2 g/L) and followed with addition of a product consisting of metatartaric acid and gum arabic (10 g/100 L) (MetaGum, Erbslöh, Geisenheim, Germany) to ensure long-term crystal wine stabilization. After 5-6 months of storage, wine was bottled. Before bottling, wine was three times filtered, at first passing through a filter with pore sizes of 1.3 microns, followed with passing of the wine through a filter with pore sizes of 0.9 microns and 0.6 microns and additionally protected with appropriate amount of SO_2 . A total of 700 000 liters of Smederevka wine was produced.

Red winemaking. Grapes from Vranec (*Vitis vinifera* L.) variety grown in Ovce Pole wine district, have been harvested at optimal technological maturity (22.5° Brix), at vintage 2021 vintage. Grapes (1.5 million kilograms) were transported to Vineks winery

for wine production. Grapes were processed using electrical inox crusher/destemmer, then added with SO₂ (ca. 50 mg/L total concentration) before inoculation with *Saccharomyces cerevisiae* yeast strain (Fermactive aroma varietale, Sodinal, Bulgaria, in a dose of 20 g/100 L), followed with addition of nutrients (Fermactive Activateur Complexe, Sodina, Bulgaria, in a dose of 10g/100 L) for yeast nutrition. The grape mash was macerated for 5-6 days at 25-30 °C, with pumping over and delastage performed twice per day, followed by separation of the wine from the sediment and treatment with bentonite (1g/L) and with a product consisting of metatartaric acid and gum arabic (10 g/100 L) (MetaGum, Erbslöh, Geisenheim, Germany) to ensure long-term crystal stabilization in wine. After 5-6 months of storage, wine was bottled. Before bottling, wine was two times filtered, at first passing through a filter with pore sizes of 1.3 microns, followed with passing of the wine through a filter with pore sizes of 0.9 microns and additionally protected from oxidation by adding appropriate amount of SO₂. A total of 1 million liters of Vranec wine was produced.

Chemical composition

The principal chemical parameters have been determined using the official methods of analysis of wines (OIV, 2022): alcohol (OIVMA-AS312-01 A), specific density (OIV-MA-AS2-01 A), dry extract (OIVMA-AS2-03B), total acidity (OIV-MAAS313-01), volatile acidity (OIV-MA-AS313-02) and pH (OIV-MAAS313-15). Determination of reducing sugars, free SO₂ and total SO₂ was performed according to the methods published by Ivanova-Petropulos & Mitrev (2014b).

HPLC-DAD analysis of citric acid was performed according to the method published by Ivanova-Petropulos et al. (2020), and analysis of heavy metals Cd, Cu, Fe and Pb was performed according to official OIV method (OIV, 2022): (OIV-MA-AS323-07). All analyses have been performed after three to four months of storage.

Statistical analysis

Statistical analysis included determination of means and standard deviation, calculated using Microsoft Excel (2013).

RESULTS AND DISCUSSION

The basic chemical parameters that are important for wine quality are alcohol, specific density, dry extract, total acidity, volatile acidity, free SO₂, total SO₂, pH, reducing sugars and citric acid. These parameters have been determined in white Smederevka and red Vranec wines, vintage 2021 (Table 1).

Table 1. Basic chemical composition of Smederevka and Vranec wines

Parameters	Smederevka	Vranec
Alcohol, %, v\ v	11.0±0.012	11.61±0.011
Specific density at 20°C	0.9913±0.0001	0.9936±0.0001
Total dry extract (g\ L)	19.1±0.12	27.8±0.16
Total acids (g\ L)	7.2±0.014	5.0±0.11
Volatile acids (g\ L)	0.3±0.001	0.42±0.002
Free SO ₂ (mg\ L)	75.5±1.42	23.04±1.35
Total SO ₂ (mg\ L)	140±2.71	70.4±2.68
pH	3.19±0.01	3.45±0.01
Reducing sugars (g\ L)	1.3±0.38	1.9±0.45
Citric acid (mg\ L)	32±1.53	122±3.56

Results are average values of three repetitions ± standard deviation

The alcohol content determined in Smederevka and Vranec wines was 11 % and 11.61 %, respectively. Smederevka wine contained a slightly lower content of alcohol compared to the Vranec wine, because Smederevka grapes had a slightly lower content of reducing sugars than Vranec grapes (19.2° Brix in Smederevka grapes and 22.5° in Vranec grapes). It is already known that the alcohol content mainly depends on the sugar content in the grapes/must, since the alcohol is produced during the alcoholic fermentation by the yeasts, which transforms the carbohydrates (glucose and fructose) into ethanol and carbon dioxide.

The values for the specific gravity were 0.9913 for Smederevka wine and 0.9936 for Vranec wine, as expected and in accordance to the determined alcohol content and dry extract. Regarding the dry extract which consists of nonvolatile soluble components, including sugars, non-volatile acids, glycerol and phenols, wines presented relatively high values appropriate for white and red wine. Thus, the dry extract for Smederevka was 19.1 g/L and for Vranec was 27.8 g/L.

Total acidity is defined as a sum of “non-volatile and volatile acidity”, including the all types of acids, such as formic acid, organic acids (tartaric, malic and citric), as well as amino acids. Tartaric acid is the predominant organic acid in the must and wine, and therefore, the total acidity is expressed in tartaric acid equivalents. In this study, the measured content of total acidity for Smederevka and Vranec was 7.2 g/L and 5.0, respectively. Both wines presented relatively high values of total acids which are sufficient to ensure the chemical and microbiological stability of wines.

pH is another factor important for the wine stability and acidity. In this study, Smederevka and Vranec wines presented pH 3.19 and 3.45, respectively, which was in a correlation to the total acidity. Usually, the pH values of wine range between 3.1 to 3.6. As the pH is lower, the more stable is the wine since it is the more difficult for microorganisms to survive at lower pH.

Citric acid also influences the acidity of wines and it is one of the main organic acids which is found in grapes. The content of citric acid in both wines was lower than 1 g/L (32 mg/L in Smederevka wine and 122 mg/L in Vranec wine) which is in accordance with regulations (Official Gazette of Republic of N. Macedonia 2012).

Usually, this acid is added to wine in order to correct the wine acidity, and therefore, its content should be controlled. In our study, citric acid was not added to the wines and its concentration was in normal ranges.

Volatile acidity of wine represents a significant physico-chemical parameter, which should be monitored during the winemaking process. According to the wine law, the maximal allowed content of acetic acid in wine is 1.08 g/L for white and rose wine, and 1.2 g/L for red wine (Official Gazette of Republic of N. Macedonia 2012). In this study, Smederevka and Vranec wines presented low values of volatile acidity (0.3 and 0.42 g/L, respectively), which means that wines had satisfactory quality.

SO₂ is a valuable component which is used in winemaking due to its ability to act as an effective antioxidant and antimicrobial agent. Moreover, SO₂ has the ability to eliminate unpleasant odours in wine and selectively act against wild yeasts which originate from grape skins, blocking their activity. Considering the content of SO₂ in the analyzed wines in this study, they were regularly protected from oxidation and microbial contamination by the free SO₂ (75.5 mg/L in Smederevka and 23.04 mg/L in Vranec). The total SO₂ ranged from 70.4 (Vranec) to 140 mg/L (Smederevka) (Table 1). These results were in a correlation to the legal regulations according to which the maximum allowed amount of SO₂ in red wines is 150 mg/L and 200 mg/L in white and rose wines (Official Gazette of Republic of N. Macedonia 2012).

Reducing sugars are glucose and fructose, the main carbohydrates in grapes. Their content in grapes depends on the variety, ripeness, health and growing conditions. During alcoholic fermentation, the content of reducing sugars decreases as a result of their conversion to ethyl alcohol (Neceva & Ivanova Petropulos, 2016). In this study, the analyzed wines had a low content of reducing sugars (1.3 g/L Smederevka and 1.9 g/L Vranec), which means that wines were dry and in all of them the alcoholic fermentation ended successfully. The results for basic chemical parameters are in good agreement with previously published data for Smederevka and Vranec wines, as well as for other wine varieties (Neceva & Ivanova Petropulos, 2016, Pajović-Šćepanović et al., 2016, Piperevski et al., 2023).

The concentrations of some heavy metals (Cd, Cu, Fe and Pb) have been determined in Smederevka and Vranec wines, and presented in Table 2.

Table 2. Content of heavy metals (mg/L) in Smederevka and Vranec wines

Heavy metals (mg/L)	Smederevka	Vranec
Cd	0.0064±0.001	0.032±0.002
Cu	0.15±0.01	0.21±0.02
Fe	0.98±0.11	1.25±0.4
Pb	0.016±0.02	0.028±0.004
Σ	1.15	1.52

Results are average values of three repetitions ± standard deviation

The application of fining agents, such as bentonite, copper sulfate (Al, Ca, Cd, Cr, Cu, Fe, Zn) and other environmental pollution (Cd, Co, Cr, Hg, Ni, Pb, V) may contribute to wine contamination. Most of the heavy metals in the grapes precipitate during the alcoholic fermentation causing significant reduction of their content in the wine. The limit for the heavy metals and harmful elements is set by the International Organization of Vine and Wine (OIV). Maximal acceptable limits for these toxic elements are as follows: Cd 0.01 mg/L, Cu 1 mg/L, Fe 10 mg/L and Pb 0.2 mg/L (OIV). From the obtained results (Table 2) it can be seen that wine samples presented very low levels of Cd, Cu, Fe and Pb, lower than maximal allowed concentrations in wine according to the Macedonian food safety regulation (Official Gazette of Republic of N. Macedonia 2012). as well as according to the maximal allowed threshold recommended by the International Organization of Vine and Wine.

The presence of Cd, which is a highly toxic element, depends on both natural and exogenous factors. The main sources of cadmium pollution are the nonferrous metal production and mining, waste incineration, phosphate fertilizer manufacture, wood, coal, oil and gasoline combustion, as well as iron and steel production (Cvetković et al., 2006). In addition, natural factors of Cd in wine are soil type and composition, grape variety, climate, amounts of products used in a particular vineyard, the vintage period, the amount of rain, etc. Exogenous factors, such as fermentation process, maceration time, addition of sulfur dioxide and yeasts, could affect the Cd concentration in wine. Generally, the cadmium content in the analyzed wines has been found to be very low (0.0064 mg/L in Smederevka wine and 0.032 in Vranec wine).

Copper is also one of the most frequently occurring heavy metals in wine. The main sources of Cu in wine are use of copper-containing fungicides to control powdery mildew, treatments of vine plants with copper sulphate, brass fittings, or use of copper sulphate for treatment of reductive off-flavors in wine. High residual copper can contribute to an enhanced rate of oxidative spoilage, which results in wine browning, particularly white ones. The copper concentration in analyzed wines was low (0.15 mg/L in Smederevka and 0.21 mg/L in Vranec), even lower than generally recommended concentration (0.3 – 0.5 mg/L) (Pyrzynska, 2007), meaning that Smederevka and Vranec wines in relation to the copper content did not pose a risk to the wine stability and human health as well.

Iron exist in two forms in wine, maintaining oxidation-reduction balance, according to the equation: $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-$. The $\text{Fe}^{3+}/\text{Fe}^{2+}$ ratio in wine depends on the storage conditions, especially on the concentration of free SO_2 . Therefore, in wine subjected to aeration, turbidity and instability from iron (ferric casse) appears because the level of Fe^{3+} , the ion responsible for that phenomenon, increases. At low concentrations, Fe is an enzyme activator, stabilizer and functional component of proteins. At higher concentrations, it participates in oxidation-reduction systems in wines, affects the sensory properties of wine and participates in formation of complexes with tannins and phosphates. Therefore, its concentration should be controlled. The content of Fe in Smedervka and Vranec wines was low (0.98 and 1.25 mg/L, respectively), which means that the wines were stable.

The determined content of lead (Pb) in wines was 0.016 mg/L in Smederevka and 0.028 mg/L in Vranec wines, which indicates that the wines were safe for consumption. Lead contamination of wine arises from numerous sources, natural and anthropogenic. Atmospheric lead from industrial pollution and leaded gasoline can contaminate wine through deposition on vine plants. Moreover, use of lead-based pesticides can be a significant source of lead in grapes (Handson 1984). Lead contamination of wine can arise from winemaking practices as well as use of brass components in winemaking, such as pumps, valves, faucets and piping (Tariba et al. 2011).

In general, white wine contained lower amount of heavy metals (1.15 mg/L), compared to the red wine (1.52 mg/L) as it was expected since red wines are produced with maceration which prolongs the extraction of elements from the grapes into the wine. The results are in good agreement with previously published data in the literature (Cvetković et al., 2006, Tariba et al., 2011, Ivanova-Petropulos et al., 2013, 2015, Mitic et al., 2014).

CONCLUSIONS

The chemical composition of Smederevka and Vranec wines produced in a large-scale winery have been determined. Wine presented relatively high values of total acidity and low values of volatile acidity, while the alcohol content was 11 and 11.6 % for Smederevka and Vranec, respectively, confirming that the wines were chemically and microbiologically stable, with satisfactory quality. Moreover, wines were well protected from oxidation containing enough content of SO₂ and contained small amount of reducing sugars (1.3 and 1.9 g/L). The natural concentration of citric acid in wines was determined (32 mg/L in Smederevka wine and 122 mg/L in Vranec wine). In addition, the content of toxic elements Cd, Cu, Fe and Pb was lower than the maximal allowed concentrations according to the safety regulations, confirming their quality and safety for consumption.

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GROWING SEASON LENGTH AND THE METHOD OF HEAT UNITS IN SPRING VEGETABLE PEA PRODUCTION

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ABSTRACT

Vegetable pea production hinges significantly on the duration of its growing season, primarily due to the fact that the period of optimal technological maturity of pea grains is short. Knowledge of the duration of the growing season for vegetable peas is of great importance from the aspect of production planning, especially on large-scale farms, in order to synchronize sowing and maturation timing with the capacities of mechanization for harvesting and processing. Interpretation of results based on weather conditions is of great importance as well, because environmental conditions closely determine pea yield and quality. In this paper, the length of the pea growing season was determined using the method of heat units for 12 different spring vegetable pea genotypes. The research included genotypes with varying growing season lengths, categorized as early, mid-early, mid-late, and late, spanning from 60 to 76 days. The examined pea genotypes accrued heat units ranging from 612.1 to 986.3, signifying varying degrees of heat accumulation. The methodology adopted for employing heat units in the planning of spring vegetable pea cultivation and maturation operates on the premise that heat accumulation during the growing season correlates linearly with growth and development intensity, as well as the duration of the growing season itself. Consequently, the summation of heat units emerges as a distinctive characteristic of each cultivar, facilitating informed decision-making in agricultural practices.

Keywords: vegetable pea, *Pisum sativum* L., mean temperature, number of days, pea sowing.

INTRODUCTION

The length of growing season from sprouting to technological maturity is a cultivar characteristic most affected by climate. During growing season, the pea crop is known to be highly sensitive to climatic conditions. More precisely, high temperatures during the grain formation period have a significant impact on pea (*Pisum sativum* L.) yield (Bénézit et al., 2017). Each crop has specific requirements for optimal environmental conditions to ensure proper growth and yield. Temperature stands out as a critical weather parameter that plays a crucial role in controlling plant growth and development. It has adverse effects on various physiological processes, including photosynthesis, respiration, membrane stability, fertilization, maturity, seed quality, and nutrient absorption. The method of heat units is quite useful in predicting growth and yield of various crops, including vegetable peas (Devi et al., 2019).

The system of heat units is used for the purpose of linking growth, development and maturity of plants with air temperatures. The direct and linear relationship between plant growth and temperature is generally assumed (Parthasarathi et. al., 2013).

Olivier and Annandale (1998) concluded that, due to the effect of temperatures, crops will not need the same amount of calendar time to reach a particular developmental stage. Bourgeois et al. (2000) stated that the system of heat units includes the sum of mean daily temperatures above a given base temperature. It is often stated that the base temperature of 0 to 5°C is most favourable for pea production, although each cultivar requires its own specific temperature. The system of heat units is used in the processing of peas so as to determine the date of sowing and relative maturity during the growing season based on data on mean daily temperatures. Heat unit systems often predict the time from sowing to crop maturity.

The aim of our study was to determine the length of the growing season and the sum of heat units in order to identify the optimal sowing time for the selected vegetable pea breeding lines. Additionally, we aimed to illustrate the method of determining the sum of heat units as a significant approach in planning optimal sowing dates for vegetable pea production.

MATERIAL AND METHODS OF WORK

Field trial

The field trial was set up during 2022, at the Rimski Šančevi site on chernozem-type land, in an irrigation system, at the Department of Vegetable and Alternative Crops of the Institute of Field and Vegetable Crops Novi Sad (45° 19' 55.7" northern latitude 19° 50' 14.9" east longitude and 86 m above sea level). The trial was set up as a randomized block design with five replications. The main plot consisted of two rows of peas with interrow spacing of 20 cm, intrarow spacing of 5 cm, and row length of 3 m. The distance between the two plots was 80 cm for easier manipulation and inter-row processing during the growing season.

Pea varieties can be classified according to their use into varieties grown for their grain and varieties where the young pod is used (Jovićević, 2011). Peas are grown primarily for their grain and less often for their pods (Đorđević et al., 2021). All genotypes used in this study belong to the group of peas cultivated for their grain. The research included 10 lines, named S-1 to S-10, and 2 domestic cultivars: Tamiš (S-T) and Dunav (S-D) of spring vegetable peas. The examined material is a part of the collection of *Pisum sativum* L. maintained at the Institute of Field and Vegetable Crops Novi Sad.

Harvesting of all tested genotypes was done manually at technological maturity. The primary sample for analysis consisted of 10 plants per repetition, i.e. 50 plants in total per one genotype.

The sum of heat units is calculated as the sum of mean daily temperatures minus minimum pea growing temperature of 4.5 °C from sowing to technological maturity (Đinović et al., 1984).

Agrometeorological conditions during the trial

Interpretation of results based on weather conditions is of great importance because environmental conditions largely determine the yield and quality of vegetable crops.

The values of the analyzed parameters were compared with the corresponding values of the multi-year average for the reference period from 1964 to 2014. The multi-year average data were taken from the electronic publication Meteorological yearbook-climate data of the Hydrometeorological Institute of the Republic of Serbia (<http://www.hidmet.gov.rs>). As an important parameter in vegetable pea production, the number of days in the growing season with maximum temperatures above 25 °C is shown. Maximum daily temperatures above 25°C have a depressive effect on the vegetative phase, flowering, pod setting, and pod development (Đinović, 1984; Fallon et al., 2006; Bénézit et al., 2017). The negative effect becomes stronger as temperatures rise and persist longer. Growth stops at 35°C. The plant is most sensitive to high temperatures immediately after flowering. Flowers drop, pods remain small and stunted, and only a small number of tiny seeds develop in them. Furthermore, high temperatures accelerate and shorten the period to technological maturity (Đinović, 1984). In the vegetative phase of development, high temperatures hinder optimal plant growth, resulting in significantly shorter plants that rapidly transition to the generative phase (Jovičević, 2011).

Precipitation sum during February was lower than the multi-annual average by 5.2 mm. Amounting to 1 mm, precipitation sum in March was negligible compared to the multi-annual average of 38.8 mm. The long period from sowing (February 24) to emergence (March 25) can thus be explained by the precipitation deficit in the period after sowing, as well as slightly lower temperatures during March as compared to the multi-annual average. During April, the precipitation sum was higher than in March, but still below average values, while the temperature was within the multi-annual average (Tab. 2). At the time of flowering and pod formation in May, precipitation were 44.6 mm below the multi-annual average. The same trend continued during June, even though the highest sum of precipitation during the growing season was measured in mid-June. The average temperatures in May were slightly higher than the multi- annual average.

Table 1. Mean maximum, minimum and average air temperatures (°C) at the investigated locality during the growing season.

Month	Maximum (°C)			Minimum (°C)			Mean (°C)			Multiannual average (°C)		
	I	II	III	I	II	III	I	II	III	I	II	III
February	18.0	18.4	18.1	-3.3	-3.8	-1.7	5.8	7.7	6.2	1.3	1.6	2.6
March	9.2	16.6	23.3	-4.5	-9.4	-6.3	2.5	4.3	10.3	4.3	6.2	8.8
April	22.3	24.8	23.2	-2.5	-1.4	1.6	10.4	9.3	13.1	10.8	10.8	13.5
May	26.0	31.4	32.3	8.5	6.0	11.7	17.2	19.6	19.7	15.8	17.2	17.9
June	33.0	33.7	36.2	12.8	12.4	15.3	23.2	22.0	24.9	19.2	20.0	20.9

Table 2. Precipitation sum (mm) per 10-day period at the investigated location during the growing season.

Month	Period			Sum	Multiannual sum
	I	II	III		
February	8	5	16	29	34.2
March	1	0	0	1	38.8
April	18	2	17	37	47.5
May	0	3	17	20	64.6
June	8	23	12	43	87.7

Table 3. Number of days with maximum temperatures above 25 °C.

Month	10 day period		
	I	II	III
February	0	0	0
March	0	0	0
April	0	0	0
May	1	9	6
June	10	10	8

The optimal average daily temperature for the growth and development of peas is $16\pm 7^{\circ}\text{C}$ ($9\text{-}23^{\circ}\text{C}$), (Đinović, 1994). In the vegetative phase $12\text{-}16^{\circ}\text{C}$, during flowering $16\text{-}20^{\circ}\text{C}$, and at pod development $16\text{-}22^{\circ}\text{C}$ (Đinović, 1984; Cervenski et al., 2021). Most days with maximum temperatures above 25°C , which have a mitigating effect during flowering and immediately after flowering, were recorded in the second decade of May and throughout June (Tab. 1, 2, 3).

Early harvesting decreases pea yield but improves crop quality due to greater softness and sweetness of pea seed. Later harvesting increases pea yields at the expense of quality. Therefore, it is important to determine harvest dates that ensure both acceptable quality and yield. Pea yields are sensitive to environmental conditions, especially extreme temperatures and water deficit. Heat stress ($> 27^{\circ}\text{C}$) in the period between flowering and harvest has the great negative impact on pea yield (Lambert and Linck 1958; Fallon et.al. 2006). Each degree/day above 25.6°C during flowering and pod filling reduces yield. Water stress during flowering has a greater negative impact on yield than if stress occurs during pod filling (Fallon et al., 2006).

RESULTS AND DISCUSSION

The length of growing season is a highly significant characteristic for peas, given that the period of optimal technological maturity for pea grains is short. In order to ensure harvesting peas at optimal technological maturity, when the grain is of the highest quality, it is necessary to plan the sowing carefully. When planning sowing, it should be adjusted so that the crops reach technological maturity in line with the harvesting machinery capacity and processing capacity (Đinović et al., 1984).

Given the percentage of sugar is in direct correlation with the quality of pea seed, more attention is paid to maturity (Jovičević et al., 2009). As the seed matures, the content of sugar and peptides decreases while the content of protein and starch increases, resulting in harder seed with higher tenderometric values, as such unsuitable for any form of processing. Physiologically mature grain has little water, higher energy value and is a significant protein food (Červenski et al., 2021; Zec, 2022).

According to Maynard and Hochmuth (2007), technologically mature pea grain contain 21% dry matter, 5.4% protein, and an average of 81 calories per 100 grams of grain. On the other hand, the dry matter content in botanically mature seeds ranges from 86 to 90%, with protein content between 21 and 28% (Jovičević, 2011).

The production of peas for processing can be planned with greater precision using the method of heat units. The methodology of heat units used in the planning of pea sowing and maturity is based on the assumption that the heat accumulated during the growing season is linearly proportional to the intensity of growth and development, and to the length of growing season. For pea crops, the sum of heat units is calculated as the sum of mean daily temperatures minus 4.5 °C for all days from sowing to technological maturity. The temperature of 4.5 °C is considered minimum growth temperature. Therefore, the days with an average daily temperature of 4.5 °C or lower enter the sum with 0 heat units because under such conditions the plant mostly does not grow. The sum of heat units depends on the cultivar. However, it is not a 'one size fits all', as the sum of heat units is also affected by other factors, namely the type and fertility of soil, slope of the terrain, sowing depth, humidity, etc. For these reasons, the sum of heat units should be determined for each area and each cultivar. In our climate, the sum of heat units is from 600 to 1000 heat units, depending on the cultivar (Đinović et al., 1984; Lešić et al. 2002).

The production of large-scale pea seed is achieved by successive sowing of one variety, or simultaneous sowing of cultivars with different duration of growing season (Ambrose, 2008). Research conducted by Takač et al. (2012) concluded that safer production is achieved by sowing more cultivars with different duration of growing season, as compared to sowing fewer cultivars with the same length of growing season. Vegetable pea breeding lines with different duration of growing season (early, mid-early, mid-late and late) were included in the research. The length of the growing season ranged from 60 days to 76 days, and the sum of heat units ranged from 612.1 to 986.3 (Tab. 5). According to Savić (2019) early maturity of genotypes is an important criterion in breeding, while genotypes with a shorter growing season can be used when selecting parental pairs for breeding for a shorter growing season. Sums of heat units, growing season length and harvest dates for each genotype are shown in the tables 4 and 5.

Table 4. Heat units (from sowing time to harvest) at Rimski Šančevi in 2022

M	February			March			April			May			June		
D	SDT	KDTJ	ATJ	SDT	KDTJ	ATJ	SDT	KDTJ	ATJ	SDT	KDTJ	ATJ	SDT	KDTJ	ATJ
1	x	x	x	2.8	0	3.8	12.5	8	88.3	16.7	12.2	287.2	22	17.5	746.5
2	x	x	x	1.6	0	3.8	3.4	0	88.3	15.3	10.8	298	23.6	19.1	765.6
3	x	x	x	2.7	0	3.8	3.2	0	88.3	15.9	11.4	309.4	24.9	20.4	786
4	x	x	x	2.1	0	3.8	4.9	0.4	88.7	17.5	13	322.4	24.1	19.6	805.6
5	x	x	x	0.1	0	3.8	10.5	6	94.7	18.4	13.9	336.3	26.5	22	827.6
6	x	x	x	1.1	0	3.8	14.2	9.7	104.4	18.1	13.6	349.9	22.7	18.2	845.8
7	x	x	x	1.7	0	3.8	10.8	6.3	110.7	16.6	12.1	362	23.3	18.8	864.6
8	x	x	x	1.2	0	3.8	16.6	12.1	122.8	17.8	13.3	375.3	21.1	16.6	881.2
9	x	x	x	2.6	0	3.8	10.5	6	128.8	18.5	14	389.3	22.5	18	899.2
10	x	x	x	1.6	0	3.8	6.7	2.2	131.0	16.1	11.6	400.9	22.2	17.7	916.9
11	x	x	x	-2.3	0	3.8	6.9	2.4	133.4	20.0	15.5	416.4	22.5	18	934.9
12	x	x	x	-0.4	0	3.8	10.1	5.6	139.0	22.8	18.3	434.7	22.9	18.4	953.3
13	x	x	x	2.1	0	3.8	11.9	7.4	146.4	24.1	19.6	454.3	22.8	18.3	971.6
14	x	x	x	5.0	0.5	4.3	12.6	8.1	154.5	20.7	16.2	470.5	19.2	14.7	986.3
15	x	x	x	8.9	4.4	8.7	14.9	10.4	164.9	21.2	16.7	487.2	20.9	16.4	1002.7
16	x	x	x	8.7	4.2	12.9	11.2	6.7	171.6	22.5	18	505.2	23.8	19.3	1022
17	x	x	x	5.3	0.8	13.7	8	3.5	175.1	20.5	16	521.2	21.8	17.3	1039.3
18	x	x	x	4.2	0	13.7	5	0.5	175.6	15.7	11.2	532.4	21.7	17.2	1056.5
19	x	x	x	4.3	0	13.7	8.3	3.8	179.4	17.2	12.7	545.1	24.4	19.9	1076.4
20	x	x	x	3.2	0	13.7	7.6	3.1	182.5	21.9	17.4	562.5	27.2	22.7	1099.1
21	x	x	x	4.1	0	13.7	12.6	8.1	190.6	24.3	19.8	582.3	25.6	21.1	1120.2
22	x	x	x	7.8	3.3	17.0	14.8	10.3	200.9	19.7	15.2	597.5	23.8	19.3	1139.5
23	x	x	x	9.2	4.7	21.7	13.3	8.8	209.7	19.1	14.6	612.1	21.2	16.7	1156.2
24	4.6	0.1	0.1	10.9	6.4	28.1	15.3	10.8	220.5	22.5	18	630.1	24.6	20.1	1176.3
25	5.8	1.3	1.4	9.9	5.4	33.5	14.9	10.4	230.9	24.7	20.2	650.3	23.3	18.8	1195.1
26	5.7	1.2	2.6	10.4	5.9	39.4	14.9	10.4	241.3	20.7	16.2	666.5	25.4	20.9	1216
27	5.7	1.2	3.8	10.2	5.7	45.1	13.5	9	250.3	23.6	19.1	685.6	27.4	22.9	1238.9
28	1.6	0	3.8	11.4	6.9	52.0	11.1	6.6	256.9	14.3	9.8	695.4	28.6	24.1	1263
29	x	x	x	13.3	8.8	60.8	13	8.5	265.4	15	10.5	705.9	27.5	23	1286
30	x	x	x	14.4	9.9	70.7	14.1	9.6	275	14.4	9.9	715.8	29.3	24.8	1310.8
31	x	x	x	14.1	9.6	80.3	x	x	x	17.7	13.2	729	x	x	x
sum		3.8			76.5			194.7			454			581.8	

Legend: M-month; D-day; SDT-mean daily temperature; KDTJ-daily heat unit; ATJ-accumulated heat unit

Table 5. Duration of growing season, harvest date and ATJ for examined vegetable pea genotypes

Genotype	Growing season	Harvest date	ATJ
S-1	65	June 1 st	746.5
S-2	61	May 24 th	630.1
S-3	60	May 23 th	612.1
S-4	66	June 2 nd	765.6
S-5	65	June 1 st	746.5
S-6	70	June 8 th	881.2
S-7	70	June 8 th	881.2
S-8	72	June 10 th	916.9
S-9	76	June 13 th	971.6
S-10	76	June 14 th	986.3
S-T	63	May 27 th	685.6
S-D	64	May 28 th	695.4

Growing season length of peas represents the period from sprouting to technological maturity. The specified property is expressed in the number of days. Growing season length of the pea genotypes tested in our research was from 60 days to 76 days. Genotype S-3 had the shortest growing season (60 days). Followed by S-2 with 61 days, S-T with 63 days, S-D with 64 days, S-1 and S-5 with 65 days, S-4 with 66 days, S-6 and S-7 with 70 days, S-8 with 72 days and finally with the longest growing season were genotypes S-9 and S-10 with 76 days of growing season (Tab 5).

According to growing season length, all cultivars can be classified into four groups:

1. Early up to 60 days of growing season
2. Mid-early 61-65 days of growing season
3. Mid-late with 66-70 days of growing season
4. Late 70 days of growing season and longer (Đinović et al., 1984; Jovičević, 2011).

Genotype S-3 was the earliest in this research, where 60 days passed from germination to technological maturity, accumulated a sum of 612.1 heat units from sowing to technological maturity. The next genotype with 61 days was S-2, which accumulated 630.1 heat units from sowing to technological maturity. 685.6 heat units were required from sowing to technological maturity for the S-T genotype, with a growing season length of 63 days, and 695.4 heat units for the S-D genotype with 64 days of growing season. Genotypes S-1 and S-5 with 65 days of growing season accumulated 746.5, and genotype S-4 with 66 days of growing season accumulated 765.6 heat units. With 70 days of growing season, genotypes S-6 and S-7 accumulated 881.2 heat units. Genotypes S-8 with 72 days of growing season accumulated 916.9 heat units. As the latest in the experiment with 76 days of growing season, genotypes S-9 and S-10 accumulated 971.6 and 986.3 heat units (Tab. 4 and 5). Olivier and Annandale (1998), showed that the sum of heat units from sowing to flowering varied from 770°C to 890°C depending on the cultivar, and from 1370°C to 1450°C from sowing to maturity (where harvest date was defined with a tenderometric value of 130). They also stated that the optimum temperature is somewhere between 25 °C and 30 °C. A detailed research on the impact of temperature on the growth and development of vegetable peas suggests that, considering the accumulated temperature during growing season, it is possible to strategically plan the sowing time and harvest dates in alignment with mechanization capacities.

Pea cultivars in the research of Bourgeois et.al. (2000) had the sum of thermal units from 711 to 996. In the results of Ivić (2016), growing season of the studied cultivars was from 80 to 88 days. During the growing season, the examined varieties accumulated from 799 to 935°C heat units.

CONCLUSIONS

The research included vegetable pea genotypes of different duration of growing season (early, mid-early, mid-late and late) which ranged from 60 days to 76 days. Line S-3 had the shortest growing season (60 days), followed by S-2 with 61 days, ST with 63 days, SD with 64 days, S-1 and S-5 with 65 days, S-4 with 66 days, S-6 and S-7 with 70 days, S-8 with 72 days and finally lines S-9 and S-10 with the longest growing season of 76 days. The methodology of heat units in planning pea sowing and maturity is based on the assumption that the heat accumulated during the growing season is linearly proportional to the intensity of growth and development as well as the length of vegetation.

The sum of heat units is characteristic of the cultivar, and the tested pea genotypes accumulated sums from 612.1 to 986.3 heat units.

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YIELD COMPONENTS AND GENETIC POTENTIAL OF WINTER BARLEY ON ALLUVIUM SOIL OF SOUTH SERBIA

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ABSTRACT

The experiment was established in the experimental field at the experimental field in Leskovac (Serbia) during the three growing seasons. The objective of this study was to investigate the influence of genotype and environment on the yield of winter barley cultivars (Nonius, Bc Srećko and Bc Bosut). The following characteristics were analysed: grain yield, 1000 grain weight and test weight. The grain yield of winter barley significantly varied across years, from 3.463 t/ha in 2021/22 to 4.971 t/ha in 2020/21. The highest yield, 1000 grain weight and test weight in all barley varieties were in the first vegetation period with moderate temperatures at the time of grain filling and a large amount of precipitation. The average yield during the three-year trial, for all examined barley varieties in the study was 4.454 t/ha. The highest three-year average of grain yield (4.701 t/ha) were obtained by Nonius cultivar. The average 1000 grain weight in the study was 46.31 g. The test weight for all examined barley varieties in the study was 60.52 kg/hl.

Analysis of variance revealed a highly significant effect of the growing season on all studied traits of barley. A highly significant effect of genotype on 1000 grain weight was determined. Correlation coefficients showed large variations, which results from the interaction between the properties within each genotype and genotype interactions with environmental factors.

Keywords: cultivar, grain yield, winter barley.

INTRODUCTION

Barley cultivars that were in production until the end of the eighties were characterized by the lower yields, good technological quality and higher stem sensitive on lodging. Barley is globally cultivated on an area of about 51.61 million hectares, an average yield of 3.043 t/ha. The largest areas under barley are in Russia (8.267.448 ha), Australia (5.040.903 ha) and Turkish (3.092.442 ha). The highest average yields of barley grain in 2020 were achieved in Ireland at 6.975 t/ha, followed by Germany at 6.459 t/ha, Austria at 6.416 t/ha and Denmark at 6.363 t/ha (FAO, 2020). In Serbia, barley is grown on 106.318 ha with an average yield of 4.610 t/ha and ranks third with 490.115 tons (FAO, 2020).

The success of barley production mainly depends on the influence of the external environment, that is, on climatic factors that can cause significant losses in yield (Bratković et al., 2024). A different ideotype does not imply agronomic and technological inferiority, but a genetic basis that manifests the most favorable interaction with environmental environmental factors and specific production technology (Pržulj et al., 2013; Senapati and Goyari, 2020). The interaction between the genotype and environment greatly limits the effectiveness of selection, if it is performed only based on the average yield. Varieties that have a smaller contribution to interaction are less sensitive to changing environmental conditions, such varieties are stable (Bratković et al., 2014; Jelić et al., 2014; Đekić et al., 2019; Rajičić et al. 2020). New varieties are characterized by good technological quality, better resistance to lodging and diseases, shorter stems and more efficient assimilated usage (Pržulj et al., 2015).

The grain quality of barley is affected by genetic and environmental factors as well as their interaction. Because of this, the same cultivar in different years can behave like brewing or feeding barley, according to the content of grain nutrients, which determines end-use (Đekić et al., 2017). It is known that individual or mutual influence of abiotic stress factors (high and low temperatures, drought, acidic and saline soil) in different barley growth stages limited the expression of the maximum grain yield potential (Đekić et al., 2019). The length and intensity of the stress period vary from the environment to the environment, as well as between years in the same environment (Bratković et al., 2018). The need for a variety of short or long growing season depends on the environmental conditions of a particular area. In winter barley often variations in yield can be detected, also between the years and between locations (Đekić et al., 2015; Rajičić et al. 2019; Biberdžić et al., 2023; Bratković et al., 2023). Various stress abiotic factors (high and low temperatures, drought, acid and salt soil) in various stages of barley development limit the expression of maximum genetic potential. The duration and severity of stress varies from location to location and on the same location from year to year. Rarely only one stress occurs, plants often grow in the conditions of a combination of more stresses, which makes the assessment of adaptability more complicated (Mohamadi et al., 2013). The 1000 grain weight and test weight are direct components of grain yield and change under the influence of environmental factors, but primarily varietal characteristics. They indicate the grain size and are important criterions in breeding barley.

The aim of this study was the determine the cultivars and ecological environmental factors that influence differences in stability and adaptability of cultivars regarding the grain yield, 1000 grains weight and test weight of tested winter barley cultivars, as well as specificity cultivars exploring regarding growing seasons conditions.

MATERIAL AND METHODS OF WORK

Materials and field trials

During the three growing seasons, three cultivars of winter barley, cultivated at the experimental field on an agricultural farm in Pečenjevac in Leskovac (43°01' N, 21°56' E, 225 m above sea level) were investigated. Experiments have been conducted in randomized block systems, with a plot size of 300 m² (60 m x 5 m) in five replicates. The usual techniques for barley production were applied, and it was done in the optimum sowing time in late October. It was sown in the third decade of October, with 300 kg/ha of fertilizer NPK 16:16:16, which was added in the fall, while during the spring fertilization soil was carried out in 2-3 leaf stage was supplemented with 170 kg/ha KAN (calcium-ammonium-nitrate, 27%N).

The winter barley varieties Bc Bosut and Bc Srećko originating from the Bc Institute for Plant Breeding and Production in Croatia and Nonius originating from the Institute of Field and Vegetable Crops in Novi Sad were selected as the material for the experiment.

The following properties were analyzed: grain yield (t/ha), 1000 grain weight (g) and test weight (kg/hl). Grain yield was measured for each plot and converted to grain yield in t/ha based on 14% grain moisture, after which a sample was taken for analysis of 1000 grain weight and test weight of the barley.

Meteorological conditions

Leskovac area is characterized by a moderate continental climate, with warm summers and mild winters, which general feature is the uneven distribution of rainfall by months. The annual average temperature is 11.1°C, and the city, and the Leskovac Valley itself, are among the warmer regions of Serbia. High summer and early autumn temperatures and mild winters have a decisive influence on such a high average annual temperature. The latitude of the meteorological station in Leskovac is 42° 59', longitude 21° 57', and the altitude is 230 m.

Data in Table 1 for the investigated period (2020-2023) clearly indicate that the years in which the researches were conducted differed from the typical multi-year average for Leskovac region, regarding the meteorological conditions. The average air temperature in 2020/21 was smaller by 0.45°C, in 2021/22 was smaller by 0.67°C and 2022/23 was higher by 0.23°C than the average of many years.

Table 1. Middle monthly air temperature and precipitation amount (Leskovac)

Interval	Months									Average
	X	XI	XII	I	II	III	IV	V	VI	
	Mean monthly air temperature (°C)									
2020/21	13.2	6.3	6.0	3.4	5.6	5.4	10.3	17.4	19.6	9.69
2021/22	10.8	8.5	6.3	1.0	3.1	4.4	10.9	18.0	22.2	9.47
2022/23	12.9	9.0	5.9	5.2	3.7	8.9	10.6	16.5	20.6	10.37
Average	14.0	8.6	3.6	1.2	4.5	8.2	13.2	17.1	20.9	10.14
	Monthly sums of precipitation (mm)									
2020/21	61	5	45	231	51	93	45	47	121	699
2021/22	61	5	45	26	16	8	68	47.1	78	354.1
2022/23	5	27	75	51	23	77	68	63	105	494
Average	59.4	55.1	57.1	52.2	48.1	57.7	62.9	70.2	59.7	522.4

The sum of rainfall precipitation in 2020/21 was higher by 176.6 mm, where the sum of rainfall in 2021/22 was lower by 168.3 mm and in 2022/23 was lower by 28.4 mm than the average of many years and with a very uneven distribution of precipitation per months. During the Mart in 2020/21 it was 93 mm of rainfall, what was 35.3 mm and in 2022/23 it was 77 mm of rainfall, what was 19.3 mm more compared with the perennial average. During the June in 2020/21 it was 121 mm of rainfall, what was 61.3 mm and in 2022/23 it was 105 mm of rainfall, what was 45.3 mm more compared with the perennial average. Regard the high importance of sufficient rainfall amounts during the spring months the distribution and amount of rainfall over the growing season 2020/21 were considerably more favorable, what resulted with the increment of yields during that year. Based on the fact that sufficient amounts of rainfall in these months are very important for the successful production of cereal crops it can be concluded that the years 2020/21 and 2022/23 in which the researches were conducted were favorable for the barley growing.

Temperature, precipitation and a sufficient amount of water in the soil are the three most important reasons for the instability of yield in our area. In ecological conditions of Serbia, high temperatures and water deficit in June lead to reduced yields and deterioration of technological properties of grains and malt, which is why the extension of the total vegetation cannot influence the prolongation of the grain filling period to increase the yield (Pržulj et al., 1997).

Varieties of shorter vegetation, especially winter beer barley, finish the synthesis of most of the dry matter before the onset of the dry period, but have a lower genetic potential for yield due to the positive correlation between these properties (Pržulj and Momčilović, 2008; Al-Tabbal, 2012; Carpici and Celim, 2012; Bratković et al., 2018; Madić et al., 2019; Rajičić et al. 2020).

Soil conditions

Agrochemical properties of the treated alluvium are favorable. Soil analyzes have been performed by standard chemical methods, as follows: pH in H₂O and KCl, electrometrically with a glass electrode in a 1:2.5 suspension; content humus by Kotzmann's method; total nitrogen has been determined by the Kjeldahl's method, available phosphorus and potassium by Egner-Riehm's Al method. The humus content in the surface layer of soil was low (2.65) and the soil was medium provided with total nitrogen (0.14% N). Based on the results of the agrochemical analysis of the soil, it can be concluded that the soil on which the three-year test was carried out belongs to the group of moderately acidic soils (pH H₂O=7.74, KCl=5.78). The soil was optimally provided with readily available phosphorus (below 17.56 mg/100 g of soil P₂O₅). According to the content of readily available potassium, the treated soil is well supplied and belongs to the highly supplied soil class (34.0 mg/100 g of soil K₂O).

Statistical Analysis

On the basis of achieved research results the usual variational statistical indicators were calculated: average values. Experimental data were analyzed by descriptive and analytical statistics using the statistics module Analyst Program GenStat (2013) for PC/Windows 7. All evaluations of significance were made on the basis of the ANOVA test at 5% and 1% significance levels.

RESULTS AND DISCUSSION

Grain yield and yield components

Average values of yield (t/ha), 1000 grain weight (g) and test weight (kg/hl) at investigated winter barley cultivars grown at the experimental field in Leskovac during three growing seasons, are presented in Table 2.

The grain yield of winter barley significantly varied across years, from 3.463 t/ha in 2021/22 to 4.971 t/ha in 2020/21 (Table 2). During the first year of investigations, cultivar Nonius achieved the highest grains yield (5.219 t/ha), followed by Bc Srećko (4.969 t/ha), while the lowest yield was at Bc Bosut cultivar (4.724 t/ha). During the second year of investigations (2021/22), the yield of Nonius cultivar was the highest with 3.745 t/ha. During the 2022/23 year of investigations, cultivar Nonius achieved the highest grains yield (5.140 t/ha), while the lowest yield was at Bc Bosut cultivar (4.686 t/ha). Average grains yield observed in the three-year period was the highest at Nonius and Bc Srećko varieties (4.701 t/ha and 4.500), while the lowest yield was obtained by Bc Bosut cultivar (4.162 t/ha). Spring months in 2021/22 were the dry ones in deficit of precipitation, what affected unfavorable on the crop barley. Regard the high importance of sufficient rainfall amounts during the spring months the distribution and amount of rainfall over the growing season 2020/21 were considerably more favorable, what resulted with the increment of yields during that year. Yields of winter barley in research conducted by Rajičić et al. (2020) significantly varied during the two-year experiment and ranged from an average of 5.342 t/ha in 2013/14 to 5.922 t/ha in 2014/15. Considerable variation in yield depending on years of research have established Bratković et al. (2014), Jelić et al. (2014) and Popović et al. (2011). Pržulj (2001), states that in our production conditions higher yields are realized by varieties of shorter vegetation because they succeed in forming the largest part of the yield before the occurrence of high temperatures.

Table 2. Average values of investigated barley cultivars characteristics

Traits	Cultivar	2020/21		2021/22		2022/23		Average	
		x	S	x	S	x	S	x	S
Grain yield (t/ha)	Nonius	5.219	0.307	3.745	0.234	5.140	0.188	4.701	0.738
	Bc Srećko	4.969	0.169	3.569	0.175	4.961	0.360	4.500	0.720
	Bc Bosut	4.724	0.287	3.076	0.159	4.686	0.142	4.162	0.818
	Average	4.971	0.320	3.463	0.343	4.929	0.301	4.454	0.775
1000 grain weight (g)	Nonius	48.89	1.621	46.73	0.893	51.01	0.860	48.87	2.112
	Bc Srećko	43.23	1.185	40.47	0.888	49.56	0.625	44.42	4.028
	Bc Bosut	44.60	0.575	43.50	0.738	48.81	0.731	45.64	2.454
	Average	45.57	2.732	43.56	2.755	49.79	1.168	46.31	3.480
Test weight (kg/hl)	Nonius	59.68	1.853	60.20	0.531	65.84	0.788	61.91	3.094
	Bc Srećko	56.65	1.810	62.64	0.919	59.89	0.528	59.73	2.771
	Bc Bosut	58.32	0.549	63.14	0.592	58.32	0.563	59.93	2.410
	Average	58.22	1.910	61.99	1.480	61.35	3.403	60.52	2.886

The 1000 grain weight of winter barley significantly varied across years, from 43.56 g in 2021/22 to 49.79 g in 2022/23 (Table 2). During the all years of investigation, Nonius cultivar achieved the highest average 1000 grain weight (48.89 g; 46.73 g and 51.01 g) compared with other tested barley cultivars. Average 1000 grain weight observed in the three-year period was the highest at Nonius cultivar (48.87 g), while the lowest was obtained by Bc Srećko variety (44.42 g). Malting barley is expected to have 1000 grain weight of 40 and 46 g and test weight of 68 to 75 kg/hl (Paunović et al., 2006).

According to the two year average 1000 grain weight of barley cultivars changed from 49.22 g (2013/14) to 32.93 g (2014/15), while the average 1000 grain weight was 41.08 g (Rajičić et al., 2020). Climatic conditions are particularly important during grain pouring because the lack of moisture and high temperatures during this period affect the reduction of the 1000 grain weight (Przulj et al., 2014). Đekić et al. (2017) pointed out significant differences in the mass of barley grains depending on both the year and the genotype.

The test weight of winter barley significantly varied across years, from 58.22 kg/hl in 2020/21 to 61.99 kg/hl in 2021/22 (Table 2). The barley cultivar Nonius has achieved the highest test weight in first year of investigation compared to other tested barley cultivars (59.68 kg/hl). During the second year barley cultivars Bc Bosut and Bc Srećko (63.14 kg/hl and 62.64 kg/hl) has achieved the highest test weight compared to Nonius barley cultivar (60.20 kg/hl). The barley cultivar Nonius has achieved the highest test weight in the three-year of investigation compared to other tested barley cultivars (61.91 kg/hl). Generally, the test weight of barleys ranged from 52 to 72 kg/hl, while in dehulled up to 80 kg/hl (Pržulj et al., 2004). From the data of Rajičić et al. (2020), the highest test weight achieved was 62.03 kg/hl in the first year (2013/14) and 68.53 kg/hl in the second year (2014/15).

Analysis of variance between observed traits of barley

The analysis of yield variance, 1000 grain weight and test weight of winter barley varieties during three growing seasons, are shown in Table 3.

Table 3 shows the impact of the year, genotype and interaction of year x genotype on yield, 1000 grain weight and test weight. Analysis of variance in barley cultivars tested showed statistically highly significant differences in yield ($F_{\text{exp}} = 106.903^{**}$), 1000 grain weight ($F_{\text{exp}} = 27.672^{**}$) and test weight ($F_{\text{exp}} = 10.547^{**}$) in relation to the growing season ($P < 0.01$). Analysis of variance was found significant effect of genotype on the 1000 grain weight ($F_{\text{exp}} = 8.925^{*}$). Statistically highly significant difference in 1000 grain weight and test weight is determined under the influence of the interaction year x genotype. The results of significance between years and yield of grain are in accordance with the results of other authors (Đekić et al., 2015; Madić et al. 2009; Rajičić et al. 2019; Bratković et al., 2023).

Table 3. Analysis of variance of the tested parameters (ANOVA)

<i>Effect of year on the traits analyzed</i>				
<i>Traits</i>	Mean sqr Effect	Mean sqr Error	F (2. 42)	p-level
Grain yield (t/ha)	11.0589	0.103	106.90	0.000**
1000 grain weight (g)	151.474	5.474	27.672	0.000**
Test weight (kg/hl)	61.254	5.807	10.547	0.000**
<i>Effect of genotype on the traits analyzed</i>				
<i>Traits</i>	Mean sqr Effect	Mean sqr Error	F (2. 42)	p-level
Grain yield (t/ha)	1.114	0.577	1.931	0.158 ^{ns}
1000 grain weight (g)	79.458	8.903	8.925	0.001**
Test weight (kg/hl)	21.766	7.688	2.831	0.070 ^{ns}
<i>Effect of the year x genotype interaction</i>				
<i>Traits</i>	Mean sqr Effect	Mean sqr Error	F (4. 36)	p-level
Grain yield (t/ha)	0.028	0.056	0.495	0.740 ^{ns}
1000 grain weight (g)	9.590	0.906	10.580	0.000**
Test weight (kg/hl)	40.387	1.079	37.444	0.000**

*Statistically significant (P<0.05); **Statistically high significant (P<0.01)

Correlation coefficients by studied environments in barley

The correlations of yield, 1000 grain weight and test weight of winter barley varieties during three growing seasons are shown in Table 4.

Table 4. Correlation coefficients of the tested parameters

<i>Traits</i>	Grain yield (t/ha)	1000 grain weight (g)	Test weight (kg/hl)
<i>Correlations between the traits analyzed in the 2020/21</i>			
Grain yield (t/ha)	1.00	0.285 ^{ns}	0.319 ^{ns}
1000 grain weight (g)		1.00	0.412 ^{ns}
Test weight (kg/hl)			1.00
<i>Correlations between the traits analyzed in the 2021/22</i>			
Grain yield (t/ha)	1.00	0.207 ^{ns}	-0.756**
1000 grain weight (g)		1.00	-0.683**
Test weight (kg/hl)			1.00
<i>Correlations between the traits analyzed in the 2022/23</i>			
Grain yield (t/ha)	1.00	0.437 ^{ns}	0.567*
1000 grain weight (g)		1.00	0.774**
Test weight (kg/hl)			1.00

Positive and medium correlations between the traits analyzed in the 2020/21 year, are shown in Table 4. Barley test weight in 2021/22 was negatively and highly significant with yield (-0.756**) and 1000 grain weight (-0.683**). Positive and significant correlations between the yield and test weight (0.567*) and highly significant between the 1000 grain weight with test weight (0.774**) were established in the 2022/23 year, are shown in Table 4.

Negative correlations of yield and 1000 grain weight are confirmed in their study of barley by Dodig (2000) and Rajičić et al. (2020). The present results confirm the statement of many authors that the traits analyzed and their correlations are genetically determined but are strongly modified by the nutrient status of the environment and weather conditions (Madić et al., 2014; Jamil et al., 2017; Bratković et al., 2018).

CONCLUSIONS

Based on the grain results during the three-year investigation on three winter barley cultivars, it can be concluded that the grain yield of barley ranged from 4.162 t/ha (Bc Bosut) to 4.701 t/ha (Nonius). During the three-year investigation on winter barley cultivars the average of grain yield was stating 4.454 t/ha and test weight of all tested genotypes was 60.52 kg/hl. The average 1000 grain weight in the study was 43.31 g, with a variation of 43.56 g in the vegetation year 2021/22 to 49.79 g in the vegetation year 2022/23. During 2020/21 and 2022/23, statistically significantly higher grain yield per area unit, as well as 1000 grain weight was achieved, compared with 2021/22 year. Very highly significant differences in yield, 1000 grain weight and test weight at investigated barley were found in relation to the year. In barley cultivars correlation coefficient between 1000 grain weight and yield was positive.

As the result of favourable weather conditions i.e. sufficient amounts of precipitation at major stages of plant development and moderate temperatures at the end of the growing season, the average grain yield of all cultivars was significantly higher in 2020/21 than in 2021/22. In all years, cultivar Nonius produced significantly higher grain yields compared to Bc Srećko and Bc Bosut.

Different responses of cultivars to variable agro-environmental conditions, particularly in terms of major grain quality indicators, require the use of many cultivars in the crop structure. On the base of studied parameters the barley cultivar Nonius was more tolerant to adverse chemical soil characteristics (low pH, low P₂O₅ content and a high content of mobile Al) and can be recommended as a suitable genotype for barley production on acid soils, especially after liming of soil.

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AGRICULTURAL LAND LOSSES IN SERBIA OVER THE PERIOD 1990-2018

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ABSTRACT

As the need for food products in the world increases and the area of available agricultural land decreases, humanity is faced with a serious problem of lack of agricultural land. That is why many scientists around the world are working on projects related to increasing the yield per unit area. The countries of the region of Western Balkans are also facing similar challenges, with the difference that depopulation is one of the main socio-economic processes in the region.

The paper shows the losses of agricultural land in Serbia according to the Pan-European CORINE Land Cover (CLC) database in the period 1990-2018. It is one of the most famous databases based on the analysis of Landsat and Sentinel satellite images covering 39 European countries. According to data from 2018, about 53% of the territory of Serbia is covered by agricultural land. Using CORINE Land Cover Changes (CHA) database the conversion of agricultural land that occurred in the periods 1990-2000, 2000-2006, 2006-2012, and 2012-2018 were monitored. Analyzing the structure of agricultural land losses, it can be concluded that the main drivers are anthropogenic activities. The urban sprawl has taken place mainly at the expense of agricultural land, as well as the construction of transport communication infrastructure and mining. Furthermore, negative demographic trends in some regions cause labour shortages resulting in the abandonment of arable land and the conversion of agricultural land into semi-natural lands. In addition, the loss of agricultural land in other countries of the Western Balkans will be shown to compare whether dominant trends are the same or not.

Keywords: agricultural land, losses, Serbia, CLC CHA, database.

INTRODUCTION

The Republic of Serbia is a country on the Balkan Peninsula with an area of 88,499 km² (including the territory of Kosovo) and about 6.65 million inhabitants according to the 2022 census, which is significantly less than in 2011 when about 7.19 million were counted (SORS, 2024).¹ In 2011, the rural population made up 40.6% of the total population. In 2023 Serbia has an unemployment rate of 9.0%, while the unemployment rate for youth (15-24) is 26% (SORS, 2024). The dominant demographic trends are negative natural growth and migration of the working-age population towards Western Europe.

In the region of the Western Balkans, Serbia is known as an agricultural country. Agriculture accounts for around 11% of Serbia's GDP, as well as 23% of total exports, and only 7% of the country's imports, creating an annual trade surplus of \$ 1.2 billion (Gajic et al., 2017). It is estimated that around two-thirds of the people fully or partially depend on agriculture or forestry for their livelihoods, while according to official statistics, approximately a fifth of the working population is employed in the agricultural sector. The age structure of the rural population is not favorable. Every fifth inhabitant of the village is over 65 years old, while in the region of southern and eastern Serbia, it is every fourth (MAFWRS, 2014). However, although the population is decreasing, the largest cities such as Belgrade and Novi Sad continue to expand, mainly at the expense of agricultural land. This statement is compatible with the known strategy of suburbanization in Central Europe, where the region of low-density housing is developing rapidly, albeit at a slower pace than in Western Europe (EEA, 2006).

The rural areas in Serbia are faced with persistent depopulation as a result of rural-urban migration, poverty in certain parts of the farming communities insufficient development and maintenance of rural infrastructure as well as the weakening of farmers' competitiveness due to small-scale farms and businesses, low technology, limited business skills. The small farm size, which is on average about 4.5 ha and only 22% of agricultural households farm more than 5 ha, delays the development of agricultural production and reduces the competitiveness of agricultural producers (MAFWRS, 2014).

Until recently, it was generally assumed that in the long-term human activity had little lasting effect on the land thanks to nature's ability to restore itself. This view remained prevalent for a long time even though farming practices have been causing irreversible damage in certain areas for centuries (EEA, 1994). The land consumption takes place thanks to intensive socio-economic processes. With higher population density the impacts are usually more intense and cause faster changes. In low-density areas, human influence is weak, and natural processes dominate. The decreasing number of inhabitants in rural areas leads to a gradual increase in natural processes compared to socio-economic ones.

Agricultural land as a resource at the global level concerning the number of inhabitants is an extremely scarce resource. The average agricultural area per capita at the global level is only 0.2 ha (Draskovic et al, 2018) compared to Serbia with 0.7 ha per capita and 0.46 ha of arable land per inhabitant. At the same time, the ratio of the area of arable land and permanent crops to the area of meadows and pastures is among the most favorable compared to other European countries (71:29%) (MAFWRS, 2014).

¹ The Kosovo region was not included in these population censuses.

In some regions of Serbia, agriculture is a core economic activity and most of the residents depend on it for basic livelihoods, for instance, the southern and southeastern regions of the country are among the poorest, while the Vojvodina region in the north is relatively more endowed as it is largely based on the developed food and agriculture industry as it is rich in fertile loamy loess soil. It is also characterized by large agricultural commercial companies and cooperatives, which have, over half of them, between 50 to 2.500 ha (FAO, 2018).

Urbanization in developing countries in comparison with developed countries has been accelerating and this has been caused by unplanned physical expansion resulting in more harmful undesirable effects on natural environments and the agricultural lands around and the trouble which is happening a serious treatment of urban-rural perspective (Parsipour et al, 2019). Urban sprawl can affect landscapes through three main processes: transformation, degradation, and fragmentation. The transformation of formerly pristine or agricultural lands into built-up areas is visually the most obvious effect. Valuable habitats and agricultural soils are lost (Scalenghe & Marsan, 2009). As an example, in the period 2012-2018, the most land in Europe was taken from agricultural areas (47% of all land taken), with a loss of 1.694 km², and from pastures (36% of all land taken), with 1.276 km² being converted to artificial areas (EEA, 2021).

This research aims to give an overview of the dynamics of agricultural land losses in Serbia in the last three decades to show dominant processes and identify the most threatening agricultural land subclasses. The obtained results will be compared with the results in neighboring countries using the same methods to determine if there are significant differences in the dominant trends.

MATERIAL AND METHODS OF WORK

The Copernicus Land Monitoring Service (CLMS) provides geographical information on land cover and its changes, land use, vegetation state, water cycle, and Earth's surface energy variables. The Programme is aimed at developing a set of European information services based on satellite Earth Observation and in-situ (non-space) data. CLC provides a European-wide mapping of land cover/land use and meanwhile constitutes a unique time series to monitor changes in European landscapes since 1990. CLC provides data for main land cover types: artificial surfaces (Code 1), agricultural areas (Code 2), forest and seminatural areas (Code 3), wetlands (Code 4), and water bodies (Code 5).

The CLC dataset represents the 39 European Environment Agency (EEA) countries including Serbia and other West Balkan countries. Serbia and Montenegro joined to CLC project in 2000 and at the same time, they created the database for the year 1990 to reach a time interval for updating land cover data and monitoring changes comparable to other CLC countries (Nestrov, Protic & Nikolic, 2007). By contrasting CLC2000 and satellite images from 2000 (IMAGE2000) with those from 1990, the CLC Changes database is created (IMAGE90). As the difference between the two datasets (CLC2000 and CLC Changes), CLC90 was a result of the use of GIS (Vulevic et al, 2022).

The basic principles of the CLC project are the visual interpretation of satellite images and supplementary data used: aerial images, topographic maps, statistical data, fieldwork, etc. Vector-based database on land cover types (CLC 1990, CLC 2000, CLC 2006, CLC 2012 and CLC 2018) as well as on changes for the periods (CHA 1990-2000, CHA 2000-2006, CHA 2006-2012 and CHA 2012-2018) were used. CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena.

The time series are complemented by change layers, which highlight changes in land cover with an MMU of 5 ha.

CLC nomenclature comprises three levels: the first level (5 items) indicates the major categories of land cover on the planet, the second level (15 items) is for uses on scales of 1:500.000 and 1:1.000.000, and the third level (44 items) is for uses on a scale of 1:100.000 (EEA, 1995). The single-date Landsat TM used in CLC 2000 was replaced by two satellite images (usually taken by IRS and SPOT-4) acquired in two different seasons (Büttner & Cosztra, 2017). In 2019, the EEA published an updated illustrated guide to the nomenclature of land cover types with a structural classification at three hierarchical levels and a differentiated level of detail (details and codes at EEA, 2019a).

Mapping of CLC-Change is carried out by applying the “change mapping first” approach. Multi-temporal images (each location was captured by at least two satellite images) were useful in separating some land cover classes (e.g., arable land and pastures). The interpretation was supported by ancillary data such as national orthophotomaps, BDOT10K (available in the WMS format), Google Earth, and city maps (Hościło & Tomaszewska, 2015).

The CLC and CHA data for Serbia were extracted using GIS software and changes in the form of polygons for all four periods were visualized. The attribute tables are exported to Microsoft Excel and classified by codes/type of change. Using the Sort & Filter and SUBTOTAL SUM tools, the individual sum of areas of all land cover types and changes that occurred by periods were calculated. By processing this data, we get a spatial and temporal insight into all the processes that take place in the field. In this way, we can have a clear overview of the structure of changes and obtain data on the causes of changes. Concerning the aim of the paper, the changes related to agricultural land have been singled out and particularly analyzed.

During the last two decades, Serbia has also faced political challenges, given that the province of Kosovo declared independence in 2006. Most of the EU countries have accepted the independence of Kosovo, so the EEA provides the CLC and CHA data separately for Serbia. However, in this paper, the data available for the Kosovo region will be integrated as part of the territory of the Republic of Serbia. However, CLC and CHA databases for Serbia are not temporally and spatially complete because CLC 1990 and CHA 1990-2000 are not available for the territory of Kosovo. In other words, the province of Kosovo has been connected to the CLC and CHA database since 2000, which is one of the limiting factors of this research.

RESULTS AND DISCUSSION

Based on CLC 2000 and CLC 2018 databases, it was noted that artificial areas in Serbia increased spatial coverage from 3.19% to 3.88%, agricultural areas decreased from 55.20% to 53.04%, forests and semi-natural areas have increased from 40.39% to 41.74%, while wetlands and water bodies are at about the same level.

In the EEA 39 countries, agricultural land occupied 42.01% of the total territory in 2000 and 41.76% in 2018, which represents a loss of 0.25% (EEA, 2019b). So, on average, they had a significantly lower intensity of losses compared to Serbia. Agricultural land-rich areas are prone to construction and soil sealing if they are located close to existing urban areas because they are inexpensive and are under pressure to be transformed into residential or commercial areas (Mann, 2009; Grigorescu et al., 2012).

Speaking of agricultural land, at level 2 of the nomenclature according to CLC 2018 dominates Arable land (2.1) with 25.94% and Heterogeneous agricultural areas (2.4) with 24.67%. When it comes to level 3 CLC 2018 database shows there are six agricultural subclasses in Serbia. Non-irrigated arable land (2.1.1) dominates with 25.94% (growth in comparison with 2000 of 1.98%), Complex cultivation patterns (2.4.2) with 12.59% (decrease by 3.44%), and Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3) with 12.08% (decrease by 0.76%) (Table 1).

Table 1: Agricultural land subclasses in Serbia for 2000 and 2018 (Level 3)

Code	Land cover type	CLC 2000		CLC 2018	
		km ²	%	km ²	%
2.1.1	Non-irrigated arable land	21202.91	23.96	22950.82	25.94
2.2.1	Vineyards	175.37	0.20	151.60	0.17
2.2.2	Fruit trees and berry plantations	104.45	0.12	324.64	0.37
2.3.1	Pastures	1806.28	2.04	1678.93	1.90
2.4.2	Complex cultivation patterns	14188.69	16.03	11143.35	12.59
2.4.3	Land principally occupied by agriculture, with significant areas of natural vegetation	11365.44	12.84	10688.69	12.08
Total		48843.14	55.19	46938.03	53.04

Source: CLC database, CLMS, 2019.

However, the CLC database only shows the area by subclass, without insight into the structure of changes between reference years. To see what has changed in the meantime, a more precise CHA database was used for the periods 1990-2000, 2000-2006, 2006-2012, and 2012-2018.

The CHA database can show the internal structure of changes and conversions from one type of land cover to another (for example, 2.3.1-2.4.2). The analysis of the CHA database can identify the causes and trends of changes. For instance, if there was a conversion of Burnt areas (3.3.4) into Natural grasslands (3.2.1) in one period, it can be concluded that there were natural revitalization processes where areas previously covered by fires were overgrown over time (Drašković et al, 2022).

The structure of agricultural losses in Serbia

A more detailed analysis of the changes which include agricultural land shows that they cover 44% of all changes. Three types of changes in which agricultural land participates are conversion of agricultural areas into other land cover types, conversion of other land cover types into agricultural areas, and internal conversion (transition from one subclass of agricultural land to another). The largest part of the structure of changes refers to agricultural land losses. The total losses in Serbia for 18 years refers to 211.36 km². Table 2 shows that 56.29 % of losses refer to conversion to artificial surfaces, 28.97% to forest and seminatural areas, and 14.18% to water bodies.

Table 2: Structure of agricultural land losses in Serbia by periods 2000-2006, 2006-2012 and 2012-2018

Changes ²	CHA 1990-2000 ³		CHA 2000-2006		CHA 2006-2012		CHA 2012-2018		Total 1990-2018	
	km ²	%	km ²	%	km ²	%	km ²	%	km ²	%
2xx-1xx	53.33	41.77	41.69	71.16	50.9	67.35	44.93	58.21	190.85	56.29
2xx-3xx	47.32	37.06	5.14	8.77	17.5	23.15	28.25	36.60	98.21	28.97
2xx-4xx	0	0.00	1.18	2.01	0	0.00	0.72	0.93	1.9	0.56
2xx-5xx	27.03	21.17	10.58	18.06	7.18	9.50	3.29	4.26	48.08	14.18
Total Loss	127.68	100.00	58.59	100.00	75.58	100.00	77.19	100.00	339.04	100.00

Source: CHA database, CLMS, 2019.

If we analyze the data on the losses of agricultural land in the period 1990-2000 (without Kosovo), we can notice that in the territory that covers a smaller area, the losses were higher compared to the averages of later periods. Losses of agricultural land in the period 1990-2000 are larger than in other periods, amounting to 127.68 km². Total losses in the period 1990-2018 were 339.04 km². In the same period, the total benefit (transition of other types to agricultural land) amounted to 97.31 km². Thus, the absolute loss of agricultural land is 241.73 km².

Figure 1 shows the most frequently occurring change type, changes more than 5 ha connected to an existing (larger than 25 ha) CLC 2012 polygon are always mapped. During the period 2012-2018 Discontinuous urban fabric (1.1.2) with an area larger than 25 ha has expanded over nearby Non-irrigated arable land (2.1.1) more than 5 ha. CHA 2012-2018 layer consists only of change polygons and both codes must be given in the attribute table (2012 and 2018) representing the processes having occurred to the given patch in reality.

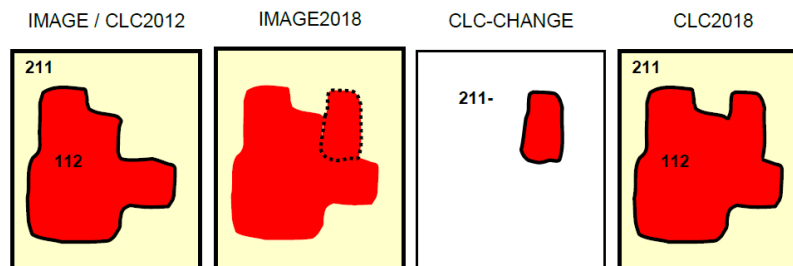


Figure 1. Simple change (growth): A settlement (1.1.2) > 25 ha grows with > 5 ha, occupying arable land (2.1.1) (Source: Büttner & Kosztra, 2017).

² x can be any code from 1 to 4 and also 5 for the first column.

³ No data for the Kosovo region.

Figure 2 shows agricultural land losses by individual land cover types in all four periods, from 1990-2018. The largest losses are related to the conversion of Non-irrigated arable land (2.1.1) and Complex cultivation patterns (2.4.2) to Discontinuous urban fabric (1.1.2), respectively 33.95 km² and 30.61 km². Complex cultivation patterns (2.4.2) and Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3) were under the expansion of Mineral extraction sites (1.3.1) with 15.42 km² and 13.33 km².

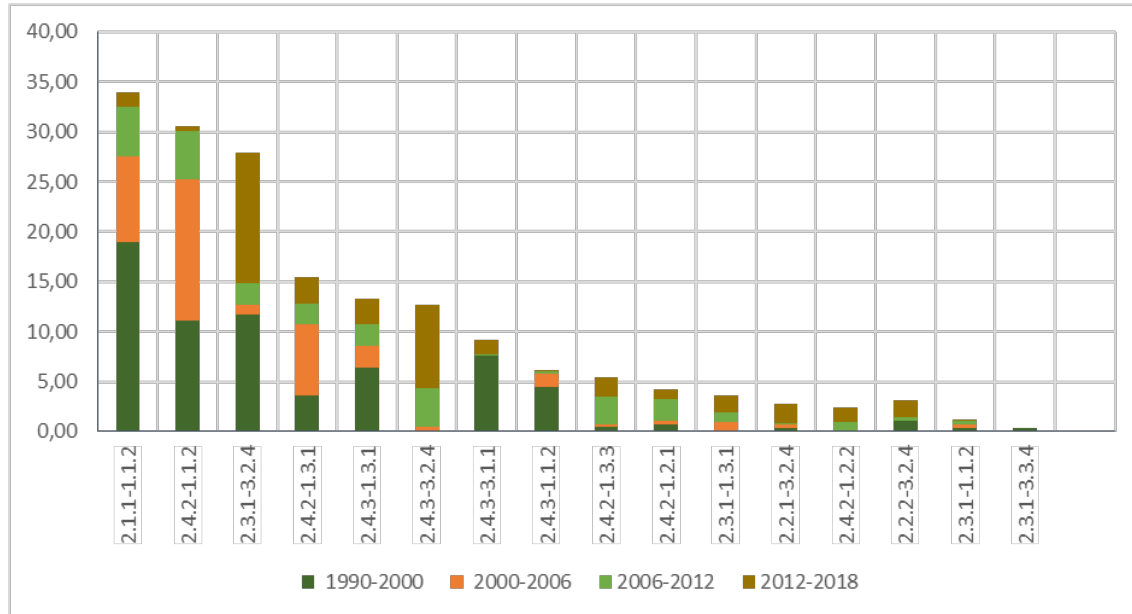


Figure 2. The largest agricultural land losses by types and periods (km²)

The conversion of agricultural land to forest may be the result of natural forest expansion or tree planting. Natural forest expansion may occur when agricultural land is abandoned, for example when a rural population declines, the land becomes sufficiently degraded that it becomes unproductive as agricultural land, or more productive agricultural land becomes available elsewhere (FAO, 2016). The process of leaving rural areas and overgrowing agricultural land into bushes and shrubs is taking place along with urbanization (Dražković et al, 2021). So, another important land cover change process in Serbia during all periods is the conversion of large areas of Pastures, meadows, and other permanent grasslands under agricultural use (2.3.1) and Land principally occupied by agriculture, with significant areas of natural vegetation (2.4.3) to Transitional woodland/shrub (3.2.4), with 27.86 km² and 12.64 km² (Figure 2).

Speaking about the biggest individual losses of agricultural land, it was most threatened around the Kostolac coal mine (Braničevo region, Eastern Serbia). Namely, the two largest losses of Non-irrigated arable land (2.1.1) by Mineral extraction sites (1.3.1) in terms of area were recorded at this location, namely 3.8 km² in the period 2000-2006 and 2.8 km² in the period 2006-2012. Also, the Kostolac mine expanded over agricultural land during the period 2000-2006 and 1990-2000 in the amount of 0.8 km² and 0.6 km². The total loss of agricultural land in this location alone amounts to more than 8 km² (Figure 3).

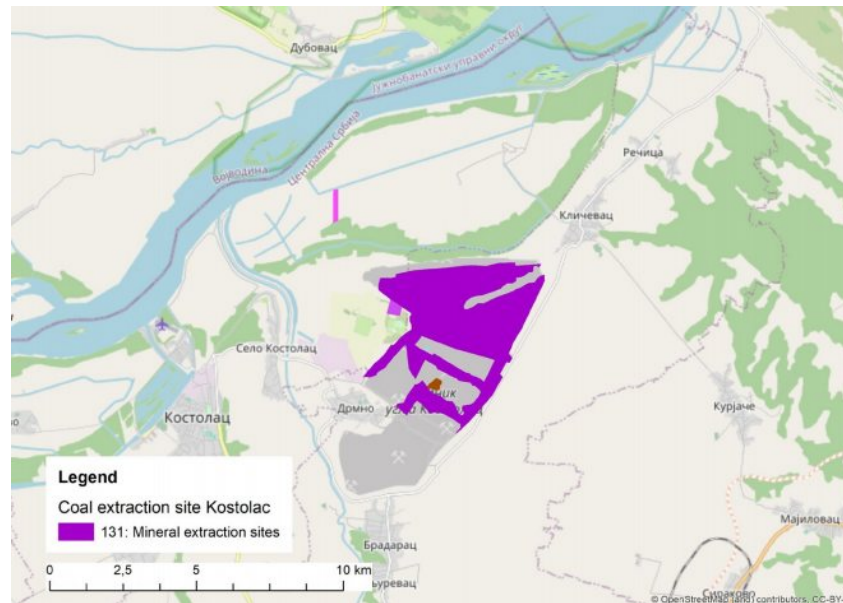


Figure 3. Spreading of Coal extraction site Kostolac (code 1.3.1) over previously Non-irrigated arable land (2.1.1) during the period 1990-2018.

However, the expansion of mining zones over agricultural land is not as common as the expansion of urban zones around larger cities. These processes have been recorded in many locations and are the biggest cause of agricultural land loss. The largest expansion of Discontinuous urban areas (1.1.2) over Non-irrigated arable land (2.1.1) was recorded around the city of Belgrade urban area. During the period 1990-2000, the area of Zemun municipality had urban expansion at many locations. The largest urban sprawl was recorded in the area of Grmovac near Ugrinovci (2.6 km²), Zemun polje (1.3 km²), Batajnica (1.2 km² and 1.1 km²), etc. Apart from Belgrade, Novi Sad expanded the most over agricultural land.

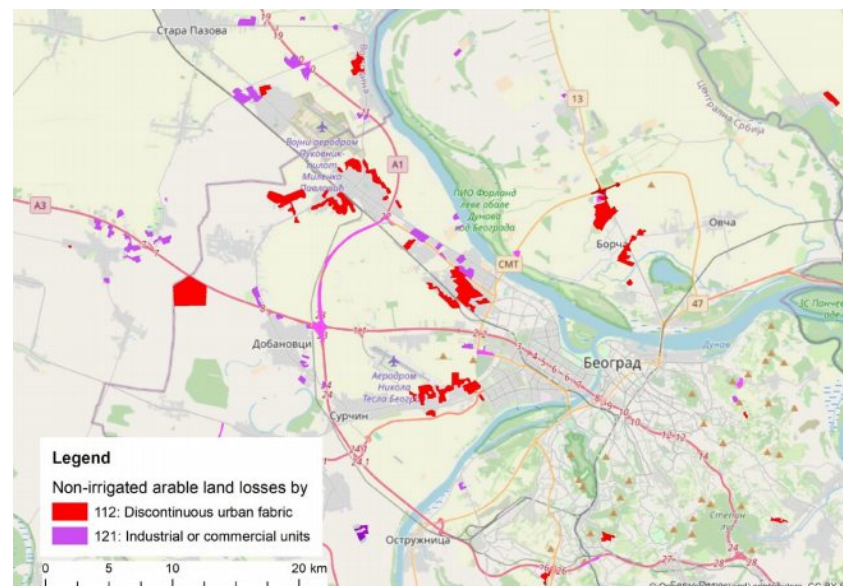


Figure 4. Spreading of Discontinuous urban areas (1.1.2) and Industrial or commercial units (1.2.1) to areas covered by Non-irrigated arable land (2.1.1) near Belgrade

Figure 4 shows that Belgrade's urban area spreads mainly towards the north, around the airport along the highway, and the road to Stara Pazova. It is flat and high-quality arable land that has been permanently lost.

Agricultural land losses in Western Balkan countries

In EEA 39 countries, agricultural land in 2018 covers an average of 41.76% of the territory (EEA, 2019b). Compared to other former Yugoslav countries, Serbia has the most agricultural land, over 50% of the country's total territory, while other countries have between 30-40%, except for Montenegro with only 16%. Considering that CLC lacks data from 1990 for some neighboring countries (Albania, Bosnia and Herzegovina, North Macedonia, Kosovo region), the period 2000-2018 was taken as the reference period for the analysis of losses/gains. According to EEA data (2019b), by comparing of CLC 2000 and CLC 2018, it is noticeable that in all states of the region, there is a trend of decreasing agricultural land. Largest losses were noted in Serbia, North Macedonia and Bosnia and Herzegovina.

Of the other neighboring countries of Serbia, only Hungary (64.7%) and Romania (56.76%) have larger area of agricultural land. In Bulgaria, Romania, and Greece there were almost no losses. Albania had less than 1% losses (0.93%), while Hungary lost 1.4% of its agricultural land in the period 2000-2018.

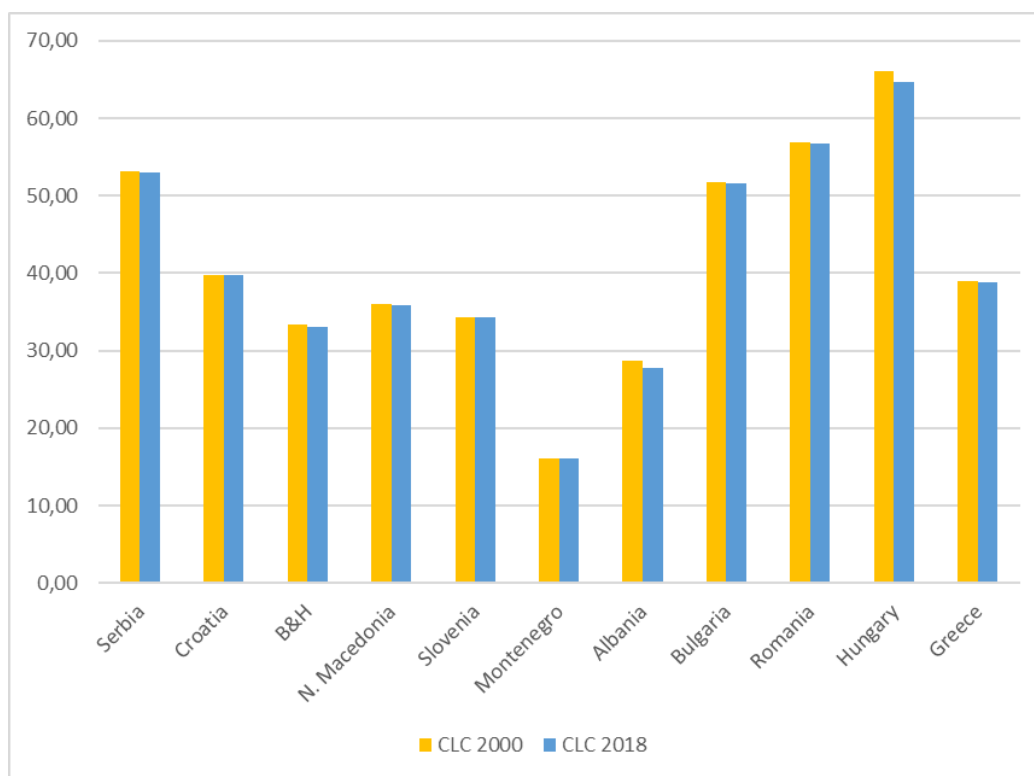


Figure 5. Western Balkan countries by agricultural land area (in %)

The situation is similar throughout Europe. According to EEA (2019b), in the period 2000-2018. in EEA39 countries, artificial areas expanded at the expense of agricultural land in the amount of 5.304 km², while forests and semi-natural areas expanded over agricultural land in the amount of 2.050 km². Wetlands and water bodies were expanded at the expense of agricultural land in the amount of 103 km² and 586 km², respectively. On the other hand, the expansion of agricultural land over other types of

land cover (e.g. wetlands) amounted to 1.243 km². Therefore, the absolute losses of agricultural land amounted to about 6.800 km². So, it can be concluded that the main cause of the loss of agricultural land in Europe is anthropogenic activities such as urban sprawl, industrial, commercial, and transport units, mine, dump, and construction sites, etc.

CONCLUSIONS

Serbia is a country rich in agricultural land, which occupies 53.04% of the territory, which is significantly more than the European countries' average of 41.76%. Like most other countries, Serbia is facing a continuous loss of agricultural land. However, compared to the EEA 39 average of 0.25% in the period 2000-2018, losses in Serbia are significantly more intense and amount to over 2%. By analyzing the CHA database and insight into the structure of changes, we can get the information that about 56% of the losses are related to the conversion of agricultural land into artificial surfaces. The most prevalent process is the expansion of discontinuous urban areas over arable land and heterogeneous agricultural areas near large cities. The pressure was especially intense in the period 1990-2000. in the vicinity of Belgrade (mostly in the territory of the municipality of Zemun) where numerous war refugees from ex-Yugoslavia built their settlements during the 1990s. However, when it comes to individual losses, the largest area covers the expansion of the Kostolac coal mine over the surrounding agricultural land in the amount of over 8 km².

The next important process is the conversion of agricultural land into forests and semi-natural areas, which account for about 29% of losses. The most endangered were pastures, which over time turn into transitional woodland/shrub, which is a consequence of the abandonment of agricultural land. The rest of around 14% of the losses relate to the conversion of agricultural land into water bodies.

Of the other Western Balkan countries, the largest losses of agricultural land in the period 2000-2018 were recorded by Slovenia with 4.6% and Bosnia and Herzegovina with 3.6%. By analyzing the structure of changes and taking into account the specific socio-economic processes, the most important driving forces that lead to the loss of agricultural land can be figured out to compare leading processes in different countries.

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IMPACT OF VARIOUS FERTILIZATION TREATMENTS ON GRAIN YIELD AND PROTEIN CONTENT IN WINTER WHEAT

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ABSTRACT

One of the most cultivated agricultural plants is certainly wheat, which is dominantly used for human nutrition in all parts of the world. The irrational use of large amounts of pesticides and mineral fertilizers negatively affects the quality of agricultural land, the environment, the quality of food and human health. The development of new cultivation technologies and the increasing use of microbiological preparations can have a positive impact on the environment. In accordance with world trends, requirements are set for agricultural production aimed at reducing synthetic agents in order to preserve the environment, produce health-safe and economically profitable food. With the development of new cultivation technologies, where the emphasis is on the reduced use of mineral fertilizers in the production of wheat, the application of microbiological fertilizers is becoming more frequent. As material for research in 2016 and 2018, two varieties of wheat selected in domestic institutions and two varieties in French selection houses were used. The varieties used for the research are: PKB Ratarica, Pobeda, Nogal and Apache. The experiment was conducted on the experimental plots of the Institute for Agro-Economics PKB in Padinska Skela. Before sowing wheat, 400 kg ha⁻¹ NPK formulation 15:15:15 was applied to the soil. In the spring sowing of wheat, UREA 46% N was used in different amounts according to the treatments. A microbiological preparation with effective microorganisms was used as supplement. The results of the research showed that wheat had the best yield in the T3 treatment with an average yield of 6.47 t ha⁻¹. The aim of the research is to determine the significant influence of different amounts of mineral and microbiological fertilizers on the production properties as well as on the chemical properties of the grains in different genotypes of wheat.

Keywords: wheat, yield, fertilizer, microbiological, protein

INTRODUCTION

Of all cultivated plants for human consumption, rice, wheat and corn are the most cultivated in the world today. Wheat is the most important and most widespread cereal in the world. It can be said that today's bread wheat is *Triticum aestivum* L. subsp. *aestivum* created by natural hybridization of domesticated *Triticum turgidum* with *Aegilops*. According to the botanical classification, wheat belongs to the family *Gramineae*, genus *Triticeae*, which contains about 300 different species (Đurić et al., 2017). Wheat is one of the most important strategic crops, as well as the most widespread grain in the world, which has great importance in human nutrition. The production of wheat with a high grain yield and appropriate quality is only possible by choosing a quality assortment, but with suitable growing conditions and appropriate production technology (Đurić et al. 2017). Wheat contributes significantly to the nourishment of humans and has been grown in various environments around the world (Kiszonas and Morris 2018). Wheat production takes place on all continents, including high-altitude areas in the tropics and subtropics (Dodig, 2010; Đurić et al., 2017). Thanks to winter and spring forms, wheat is characterized by great polymorphism. As a basic bread plant, it is represented by 53% in developed countries, and 85% in underdeveloped countries of the total world production (Peña, 2007). Wheat plays an important role in providing essential minerals, carbohydrates and proteins (Akbarabadi et al., 2015). Today, chemical fertilizers are used as the most economical means to achieve maximum production per unit area, which leads to an increase in production costs and a negative impact on biodiversity. Reduction of wheat yield can also be caused by large amounts of fertilizers, which can be harmful economically, but also ecologically as a frequent cause of agroecosystem pollution (Đekić et al. 2014b; Jelić et al. 2015). The production of wheat with high grain yield and appropriate quality is possible only by choosing a quality varieties, but with appropriate growing conditions and appropriate production technology (Đurić et al., 2015). Sustainable agriculture is a method of production that, viewed over a longer period of time, improves the quality of the environment and the resources on which production is based. Sustainable production satisfies human needs for food and fiber, contributes to economic profitability and improves the quality of life of farmers and society as a whole, with minimal use of chemicals in production. The application of microbiological fertilizers in sustainable production systems is imperative in the production of healthy food (Cvijanović et al., 2013). In the last few years, there has been an increasing number of researches related to the interactions of plants and certain groups of microorganisms with the aim of ecologically and economically profitable production (Cvijanović et al., 2012). The application of microbiological preparations affects the creation of "healthy soil", with the potential tendency of the permanent necessary for organic crop production, (Cvijanović i sar. 2010; 2010a).

Wheat production has not been able to keep pace with the increase in world population (1.87% per year in the period 1961-1990) despite the slowdown in the growth of the world's population, which has increased by 1.35% per year in the previous 25 years. The highest production of wheat per capita was in 1990 (112 kg), while today it is somewhat less, around 90 kg (Knežević et al. 2016). Annual consumption of wheat per inhabitant varies depending on the region, from 20 kg in Central America and Africa south of the Sahara, 70 kg in India, to over 150 kg in the Middle East (Shewery Hey, 2015), while in the Republic of Serbia it is about 130 kg (Knežević et al. 2018).

The most populous countries, such as China, India and Russia, had the largest areas under this grain on average. In China, an average of 23 million ha were sown, yielding an average of 6.55 t ha⁻¹. In India, over 30 million ha were sown with a yield of 3.42 t ha⁻¹. In Russia, the area under wheat was more than 28 million ha with a low average yield of 2.93 t ha⁻¹. In Europe, the area under wheat was 62 million ha with a yield of 4.26 t ha⁻¹ (Table 1).

Table 1. Areas, production and yield of wheat in the period from 2017-2022.

Region		2017	2018	2019	2020	2021	2022
China	000 ha	24.480	24.268	23.732	23.383	23.570	23.522
	t ha ⁻¹	5.48	5.41	5.62	5.74	5.81	5.85
	000 t	134.246	131.446	133.601	134.256	136.949	137.726
India	000 ha	30.785	29.650	29.318	31.357	31.125	30.458
	t ha ⁻¹	3.19	3.36	3.53	3.43	3.52	3.53
	000 t	98.510	99.869	103.596	107.860	109.586	107.742
Russia	000 ha	27.517	26.472	27.558	28.864	27.918	29.354
	t ha ⁻¹	3.12	2.72	2.70	2.97	2.72	3.55
	000 t	86.002	72.136	74.452	85.896	76.060	104.233
Europe	000 ha	61.879	60.613	62.387	61.529	62.882	62.749
	t ha ⁻¹	4.40	3.99	4.26	4.14	4.28	4.50
	000 t	272.381	242.187	266.129	254.796	269.344	282.723

Source: (<https://www.fao.org/faostat/en/#data/QCL>)

MATERIAL AND METHODS

In order to assess the impact of the application of NPK fertilizers and the microbiological preparation EM Aktiv (trade name) on wheat yield, a two-year experiment was set up with four varieties of wheat, four different types of fertilization in four repetitions, on the experimental plots of the PKB Agroecconomics Institute, Padinska skela. As research material during 2016/2017, 2017/2018. Wheat varieties selected in domestic institutes (Institute PKB Agroecconomics and Institute of Field and Vegetable Crops, Novi Sad) and two varieties of French selection houses (Florimond Desprez and Limagrain) were used. The test was carried out on the following varieties: PKB Ratarica, Pobeda, Nogal and Apache. The plots were laid out according to a randomized plot design in four replications. The pre-crop in both research years was corn. All measures in production technology were applied in optimal agrotechnical terms (tillage, sowing, spring topdressing, harvest). The obtained measurement results were statistically processed using the method of analysis of variance as a four-factor split-plot experiment in the DSASTAT program. The significance of differences between treatments was tested with the LSD test at the significance level of $p < 0.01$ and $p < 0.05$ (Hadzivuković, 1991). Plant samples were taken from the middle of the plots. Grain samples necessary for the calculation of productive and qualitative characteristics of grain were taken after harvest from the entire plot. To ensure proper nutrition, 400 kg ha⁻¹ of NPK (15:15:15) was incorporated with soil tillage prior to wheat sowing (Table 2). In treatment T1, there was no foliar treatment because that treatment was the control. In treatment T2, the foliar treatment was performed when the wheat was in the flowering phase, in treatment T3, the foliar treatment was performed in the flowering phase, in treatment T4, the foliar treatment was performed in the phase of flattening, flowering and grain filling. All foliar treatments were at a dose of 6l·ha⁻¹.

Table 2. Variants of fertilization on the experimental plot

Treatments	Before sowing NPK (kg ha ⁻¹)	In nutrition UREA (kg ha ⁻¹)	EM Aktiv (6 l ha ⁻¹)	Total nutrients N : P ₂ O ₅ : K ₂ O
T 1	400	150	-	129 : 60 : 60
T 2	400	150	1 time	129 : 60 : 60
T 3	400	100	2 times	106 : 60 : 60
T 4	400	50	3 times	83 : 60 : 60

RESULTS AND DISCUSSION

Grain yield is the result of many physiological changes during the development of plants, which are directly influenced by many factors. The yield of wheat grains is influenced by various factors, primarily genotype characteristics, soil fertility and applied agrotechnical measures. Wheat yields vary depending on applied agrotechnical measures: sowing dates, nutrition, protection and agro-meteorological conditions (Pepo, 2007). In addition to the choice of varieties and soil properties, agroclimatic conditions and applied agrotechnics have a significant influence on the yield per unit of area and total production. In the course of its development, wheat goes through a series of stages in the stages of organogenesis and physiological stages, according to a strictly established chronological order that leads to the growth of plants, the development of all necessary organs and the increase of biomass and plant volume (Milošev, 2000). Sugar et al. (2016) concluded that the maximum grain yield was achieved with nitrogen treatments of 80 and 160 kg ha⁻¹, and that a higher amount of nitrogen did not lead to a further increase in yield in any year.

In 2017, the average grain yield was 6.48 t ha⁻¹, and 6.54 t ha⁻¹ in 2018. The impact of variety as a significant factor on yield was at a statistical level of $p < 0.05\%$, while the significance of other factors was not determined.

Ratarica variety achieved the highest yield (6.98 t ha⁻¹) in 2017, while the yield was 5.91% lower for the Pobeda variety, 6.24% lower for Nogal variety and Apache variety by 20.55%.

The highest yield in 2018 was achieved with the Ratarica variety (6.84 t ha⁻¹), with the Pobeda variety it was lower by 9.44% t ha⁻¹, the Apache variety gave a lower yield by 10.14%, while the Nogal variety recorded the lowest yield by 22.36% lower than the Ratarica variety.

Table 3 shows the average yields per treatment for all varieties that were carried out in 2017. The highest yield per treatment was in treatment T3 (6.69 t ha⁻¹), while in T4 it was lower by 1.82% (6.57 t ha⁻¹), in T2 the yield was lower by 3.56% (6.46 t ha⁻¹), and in T1 the yield was lower by 7.38% (6.23 t ha⁻¹).

In 2018, the highest yield per treatment for all varieties was recorded in treatment T4 (6.45 t ha⁻¹), which is 3.03% higher than T2 (6.26 t ha⁻¹), also lower yields were obtained in treatments T1 (6.09 t ha⁻¹) which was lower by 5.92%, and in treatment T3 (6.08 t ha⁻¹) which was lower by 6.08% compared to T4.

On average for both years, all cultivars and all treatments, the wheat yield on average was the highest in the T4 treatment (6.51 t ha⁻¹), which was higher compared to all three other treatments T3 (6.38 t ha⁻¹) by 2.03%, T2 (6.36 t ha⁻¹) by 2.35%, and T1 (6.16 t ha⁻¹) by 5.68%.

Table 3. Wheat yields in the two growing seasons (2017-2018)

Years (A)	Varieties (B)	Fertilization (C)				$\bar{X}_{A \times C}$	$\bar{X}_A$
		T1	T2	T3	T4		
2017	Ratarica	6.63	7.07	7.38	6.85	6.98	6.48
	Pobeda	6.46	6.17	6.62	7.13	6.59	
	Nogal	6.29	6.52	6.64	6.85	6.57	
	Apache	5.54	6.08	6.10	5.44	5.79	
$\bar{X}_{A \times B \times C}$		6.23	6.46	6.69	6.57		
2018	Ratarica	6.63	7.13	6.78	6.82	6.84	6.54
	Pobeda	6.28	5.65	6.18	6.88	6.25	
	Nogal	5.59	6.08	5.25	5.44	5.59	
	Apache	5.88	6.19	6.10	6.67	6.21	
$\bar{X}_{A \times B \times C}$		6.09	6.26	6.08	6.45		
$\bar{X}_C$		6.16	6.36	6.38	6.51		
Average 2017-2018							6.51
A^{ns}		B^*	C^{ns}	$A \times B^{ns}$	$A \times C^{ns}$	$B \times C^{ns}$	
F - test		9.68	3.91	0.48	0.02	2.62	1.60
LSD 5%		0.27	0.34	0.27	0.48	0.38	0.54
LSD 1%		0.24	0.46	0.36	0.65	0.51	0.72

The importance of wheat is mainly attributed to its ability to grind the grain into flour and semolina. By grinding wheat, the anatomical parts of the grain are separated. Wheat flour mainly consists of: starch (70–75%), water (12–14%), protein (8–16%) and other components such as dietary fiber (2–3%), lipids (2%) and ash (1%) (Egesel et al. 2013). The quality of wheat flour depends on the content and characteristics of these components, which differ depending on the variety of wheat. Bekić et al. (2016) determined that the biomass of basil plants and the oil content of the seeds can be increased by applying effective microorganisms, and Filipović et al. (2016) that the use of effective microorganisms in the production of basil increases the yield and quality of dry matter.

Cereal proteins play an important role in human nutrition, due to their nutritional composition and functional properties. Wheat proteins are a group of compounds that are found in the grain immediately after starch. Baking properties and quality of wheat (*Triticum aestivum* L.) and wheat flour depend on the amount and quality of protein from the wheat grain.

The protein content of bread wheat is one of the most important chemical indicators of flour quality. Wheat seed proteins, however, are also the most common cause of allergies, so the composition of wheat proteins as well as their functional characteristics are attracting the attention of researchers and manufacturers (Rasheed et al., 2014).

The influence of variety and year was statistically significant on protein content, while fertilization was highly significant at the level of ($p < 0.01\%$). The interaction between (year x fertilization) and (year x variety) was statistically significant at the level of ($p < 0.05\%$), and the interaction between (variety x fertilization) was highly statistically significant at the level of ($p < 0.01\%$) (Table 4).

The highest protein content in 2017 was expressed by the variety Nogal (13.66%), and the lowest by the variety Ratarica (13.14%), while in 2018 the variety Ratarica had the highest protein content (13.86%), and Apache variety with the lowest protein content (13.44%). The protein content of the Nogal variety in 2017 was determined to be 0.14% higher than the Pobeda variety (13.64%), and 3.48% higher than the Apache variety (13.20%) and the Ratarica variety (13.14%) by 3.95% (Table 4).

As for fertilization in 2017. the biggest impact was the treatment T3 (13.97%). Compared to treatment T1. the protein content was higher by 6.39%. compared to T2 by 4.17% and T4 by 6.47%. Between treatments T4 (13.12%) and T1 (13.13%) there was no statistically significant difference in the crude protein content. In 2018. treatment T3 (13.90%) had the greatest impact. as in 2017. The protein content in treatment T3 was higher by 3.57% compared to T1 (13.42%) by 0.87%. while compared to T2 (13.78%) by 0.87%. and compared to the T3 treatment (13.60%) by 2.20%.

Cvijanović (2002) in a three-year study of foliar treatment of wheat plants with a mix of free-living bacteria. determined that there was an increase in the content of total proteins in the grain on average from 4.57% to 7.38%.

Table 4. Total protein content in different wheat varieties

Years (A)	Varieties (B)	Fertilization (C)				$\bar{X}_{A \times C}$	$\bar{X}_A$
		T1	T2	T3	T4		
2017	Ratarica	13.02	13.39	13.28	12.86	13.14	13.41
	Pobeda	13.19	13.26	14.06	14.03	13.64	
	Nogal	13.64	13.69	14.44	12.88	13.66	
	Apache	12.68	13.29	14.10	12.72	13.20	
$\bar{X}_{A \times B \times C}$		13.13	13.41	13.97	13.12		
2018	Ratarica	13.79	14.19	13.47	13.98	13.86	13.67
	Pobeda	13.40	13.52	13.98	14.10	13.75	
	Nogal	13.72	14.09	14.00	12.80	13.65	
	Apache	12.78	13.32	14.15	13.52	13.44	
$\bar{X}_{A \times B \times C}$		13.42	13.78	13.90	13.60		
$\bar{X}_C$		13.27	13.59	13.93	13.36		
Average 2017-2018							13.54
A*		B*	C**	A x B*	A x C*	B x C**	
F - test		25.60	4.72	20.82	4.14	3.40	11.05
LSD 5%		0.23	0.24	0.18	0.34	0.26	0.37
LSD 1%		0.16	0.34	0.24	0.48	0.35	0.49

CONCLUSION

On the basis of two-year research on the impact of top dressing and application of microbiological fertilizer on wheat grain yield (*Triticum aestivum* sp.) and protein content in wheat grain. we can say that the average grain yield was 6.51 t ha⁻¹ with significant differences due to the impact treatment. and the dominance of the genotype. The Ratarica variety had a higher grain yield in both examined years. in comparison to all four cultivated varieties. Statistically significant differences in yield were determined by fertilization levels and varieties. The highest yield was found in treatments with a smaller amount of fertilizer and more foliar treatments. In 2017 it was treatment T3 (6.69 t ha⁻¹). while in 2018 the highest yield was achieved with treatment T4 (6.45 t ha⁻¹). The total protein content of the wheat grain was the highest in the T3 treatment. In 2017 the highest protein content was in the Nogal variety (13.66%). while in 2018 it was in the Ratarica variety (13.86%). Finally. it can be concluded that the most positive impact on yield and protein content is reflected in the T3 treatment (400 kg ha⁻¹ before sowing. 100 UREA kg ha⁻¹ and two foliar treatment with the microbiological fertilizer EM Aktiv). Application of microbiological preparations in wheat production can enable stable production of wheat with high grain yields. which is very important from the aspect of human nutrition.

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THE IMPORTANCE OF SMALL FARMS IN PRESERVING OF AUTOCHTHONOUS RACES

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ABSTRACT

The answer to current and future breeding demands and goals in the production of food of animal origin is the breeding of autochthonous races of domestic animals. Given that the existence, preservation and sustainable use of the gene pool is crucial for the biodiversity of any country, the most important activities for our country are the management and preservation of genetic resources, both animal and plant. The subject of this paper is the presentation of the current state of a large number of autochthonous breeds of domestic animals in the Republic of Serbia, as the most important source of animal genetic resources. Statistical data from the Domestic Animal Diversity Information System (DAD-IS) in the Food and Agriculture Organization (FAO) were used in the paper. Numerous conditions of the cattle in the last two decades were analyzed and selection and breeding programs for the observed species were presented.

Also, by applying qualitative research methods - the case study method and the description method, autochthonous species and breeds in the ethno village of Vila Jefimija were presented. Breeding of domestic mountain horses, Balkan donkeys, domestic cattle of the Busha breed, sheep race Pramenka and the local Vitoroga Žuja breed, as well as Balkan goats, poultry of the Kosovo singer breed on the farm of the ethno village of Vila Yefimija represents an impressive gene pool. However, the number of cultivated populations is small. The ethnic village of Villa Jefimija was presented as an impressive gene pool of Serbian autochthonous races in private property. This farm is an example of breeding practices for the preservation and presentation of genetic resources, which, given the analysis, leads to the conclusion that greater support and engagement of entities responsible for the implementation of the breeding program of autochthonous species and breeds of the Republic of Serbia is needed.

Key words: autochthonous races, animal diversity, breed variability, ethno village.

INTRODUCTION

Today, food production is a strategic priority for every country in the world, and for that reason genetic resources are one of the most valuable and strategically important reserves that every country possesses. In his doctoral dissertation, Grittner (2020) states that different reports confirm a severe decrease in genetic diversity. This happens both in developed countries and in developing countries, and the causes are numerous. The variability of the species is a prerequisite of the sustainability of production in times of global climate changes, the emergence of diseases and resistant pests, and adaptability to market demand. Due to economic interest, species and breeds of animals, as well as species and varieties of plants are grown that meet the requirements of intensive production. The cultivation of a small number of animal and plant species that have been selectively developed in the direction of specialized production is favored. In this way, man leads to the irreversible loss of genetic variability and causes the erosion of the genetic resource. This leads to the impoverishment of a nation which can't respond in the future to market demands and increase productivity in food production.

Genetic resources represent a key component of biological diversity. Since that the existence, preservation and sustainable use of the gene pool is most important for the biodiversity of any country, the most important activities for our country are the management and preservation of genetic resources, both animal and plant. Genetic resources in animal husbandry are represented by autochthonous and local breeds of domestic animals, as well as exotic commercial breeds. Genetic reserves of domestic animals include certain breeds, strains and lines of domestic animals, which are kept in the form of a minimum number of domestic animals, doses of sperm, eggs or embryos, in accordance with the law regulating animal husbandry.

The answer to current and future breeding requirements and goals in the production of food of animal origin is the preservation of autochthonous breeds of domestic animals. The subject of this paper is the presentation of the current state of a large number of autochthonous breeds of domestic animals in the Republic of Serbia, as the most important source of animal genetic resources. A number of individuals over the past two decades have been analyzed. Also, the ethnic village of Vila Jefimija was represented as an impressive gene pool of Serbian autochthonous species in a private property. The ethnic village of Vila Jefimija is an example of breeding practices for the preservation and presentation of genetic resources, and conducted analysis leads to the conclusion that greater support and engagement of entities responsible for the implementation of the breeding program of autochthonous species and breeds of the Republic of Serbia is needed.

MATERIAL AND METHODS

Statistical data of the Statistical Office of the Republic of Serbia, as well as statistical data of the Domestic Animal Diversity Information System (DAD-IS) in the Food and Agriculture Organization (FAO) were used in the work. Qualitative research methods were also used - the method of description and the case study method, in which autochthonous species and breeds were presented in the ethnic village of Vila Jefimija.

RESULTS AND DISCUSSION

In Serbia, there are several autochthonous breeds of cattle, sheep, pigs, poultry, dogs, bees, and pigeons that are adapted to the climate and conditions of traditional farming in this area.

According to Rulebook of the List of Genetic Reserves of Domestic Animals, the Way to Preserve Genetic Resources of Domestic Animals, as well as on the List of Autochthonous Breeds of Domestic Animals and Endangered Autochthonous Breeds ("Official Gazette of RS", No. 33/2017-35, 104/2021-28, 30/2022-32) the criteria for determining the endangeredness of the breed were determined. The rulebook contains a list of autochthonous breeds of domestic animals and endangered autochthonous breeds in the Republic of Serbia (table 1), as well as a list of genetic reserves of domestic animals (table 2).

Cultivation of old autochthonous breeds and strains takes place in certain protected natural resources such as SRP "Zasavica", Monument of the nature "Bojčinska šuma", Park of the nature "Palić" and SRP "Ludoško jezero". Also, an increasing number of individuals and farmers are engaged in this type of production (Trailović and Savić, 2019).

The paper presents an individual farm - the ethnic village of Vila Jefimija, owned by Nenad Ordić, which bases its production on the cultivation of different indigenous domestic breeds. The farm is located in the mountainous area of the village Preobraženje at an altitude of 550 m. The economy of the ethnic village of Vila Jefimija represents an important and significant source of the gene pool of autochthonous races in the Republic of Serbia.

This farm lists the breeding of indigenous breeds of domestic animals as a unique genetic heritage and claims that these breeds are part of the national heritage and identity.

Table 1. The list of autochthonous breeds of domestic animals and endangered autochthonous breeds in the Republic of Serbia

Species	Breed
Cattle	Podolian, Busha
Buffalo	Domestian buffalo
Horses	Domestic-Mountain Pony, Nonius
Donkey	Balkan donkey
Pig	Mangulica, Moravka, Resavka
Sheep	Bardoka, Vlashko-Vitorog sheep, Pirot improved, Karakachan sheep, Krivovirska, Svrlijshka, Lipska, Sjenica, Tsigai, Čokanska, Sharmountain
Goat	Domestic Balkan, Domestic white goat
Poultry	Svrlijig hen, Sombor crested, Sombor kapork, Banat Naked Neck, Kosovo singer
Turkey	Domestic turkey
Duck	Domestic duck
Goose	Domestic goose
African chicken	Domestic perl
Pigeon	50 breeds
Bee	<i>Apis mellifera carnica</i>
Dog	Sharmountain, Serbian hound, Serbian tricolor hound

Table 2. The list of genetic reserves of domestic animals

Animal species	Minimum number of animals
Cattle/buffalo	300
Horse/donkey	350
Sheep/goat	250
Pig	200
Poultry	300

Domestic mountain horse

Selection measures in the breeding of ungulates in central Serbia are still based on a small number of heads, especially when they refer to autochthonous ungulate breeds such as the Domestic mountain horse and the Balkan donkey (Đermanović et al., 2014). Thanks to the existing descriptions, the Domestic mountain horse is defined as a special breed in relation to the mountain horses in the surrounding area (B&H and Bulgaria).

On the farm of the ethnic village of Vila Jefimije, 9 Domestic mountain horses are raised, one of which is Karakachan mountain horse breed. It is believed this is only specimen in Serbia. Due to the suspicion about of origin of this individua, this breed cannot be preserved by mating strategy and maintain its original characteristics.

A detailed genetic analysis will determine his true origin. Based on that, the assumption will be confirmed whether this specimen of horse originates from the Tarpan. In that case, it will be sold to the United States.

Its specific characteristics are:

- dark, almost black in color;
- lower jaw is shorter than the upper one:
- bite is correct, in place;
- medium size, the height of the withers is about 128 cm;
- legs are shorter and thin;
- extremely temperamental.

His two offspring are currently being raised on the farm, and more progenies is expected in the near future.



Picture 1. Karakachan mountain horse

According to the available DAD-IS data for the 2008, the number of Domestic mountain horses was 80-100 head and therefore it is classified as an endangered breed. As an important genetic resource, it is included in the program for the protection and preservation of genetic resources. The program was successfully implemented. The latest FAO data for the year 2022 indicate that the number of the population is 1,000-3,000 individuals.

Table 3. Review of the number conditions of breeding individuals of Domestic mountain horse in RS (2012-2022) (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	44	74	112	95	156	300	989	1100	2700	2434	1976
Male breeding head	5	5	4	11	25	25	50	50	65	663	632
Total	49	79	116	106	181	321	1039	1150	2765	3097	2608

According to table 3, we can conclude that in the last five years there has been an increase in the number of breeding cattle. Marković et al. (2021) state that today the largest number of individuals of Domestic mountain horse is raised in Stara, Suva and Šar mountains, the Pešter plateau and Prokletije. Observing the population trend of the Domestic mountain horse, we can say that the condition of the population has improved significantly and now this is a potentially endangered autochthonous breed.

Balkan donkey

The presence of donkeys on the territory of Serbia is at an unsatisfactory level. The main problem lies in defining the racial composition of donkeys. All donkeys on the territory of Serbia are officially called "Balkan donkey", although Serbia is only part of a large area where lives the population of donkeys spread throughout the Balkans. This means that all Balkan countries (Albania, Bosnia and Herzegovina, Bulgaria, Greece, North Macedonia and Montenegro) raise Balkan donkeys. However, it is a very interesting fact that according to the international DAD-IS list, only Serbia and Montenegro (from the time when they were one country) declare that they have this breed of donkeys (Grittner et al., 2021).

It was determined that there are two gene pools in the total sample, the first of which represents a heterogeneous breed of the Balkan donkey and includes two subpopulations, and the second includes a certain number of individuals in the population in Zasavica and is clearly different from the Balkan donkey breed. Considering the phenotypic characteristics of the individuals from the second gene pool, the assumption is that these individuals belonging to the uncharacterized Banat donkey race (Stanišić et al., 2017).

Stanišić et al. (2014), studying the exterior of two populations of the domestic Balkan donkey, determined that the average height of the withers was 103.5 cm (population A) and 104.0 cm (population B). Urošević et al. (2019) suggest that, in relation to the height of the withers, donkeys in our country can be divided into three groups: a) short - height of the withers up to 105.00 cm, b) normal height - 105.10-130.00 cm and c) high - ridge height above 130 cm.

It is also necessary to determine and taxonomically confirm the affiliation of two Balkan donkeys which are raised on the farm of the ethnic village of Vila Jefimija. With the development of transport and many other modern conveniences, raising donkeys has unfortunately lost its importance. The significance of this number is small, but the owner of this farm is a great enthusiast and announces a significant increase in the number of this species.

According to the data of FAO, DAD-IS (2022), an increase in the number of breeding individuals of the Balkan donkey was recorded in the last five years. According to the same sources, the size of the population in the last 13 years was between 500 and 1000 heads.

Regardless of the slight increase in the number of breeding heads, this breed is considered a potentially endangered breed according to the regulations of the Republic of Serbia (Official Gazette No. 33; 2017).

Table 4. Review of the number conditions of breeding individuals of Balkan donkey in RS (2012-2022) (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	111	189	218	259	307	411	511	537	593	581	515
Male breeding head	10	5	12	17	25	25	30	30	30	135	103
Total	121	194	230	276	332	436	541	567	623	716	628

Busha cattle

Busha is considered as an autochthonous breed of cattle of the Balkan Peninsula and was cultivated throughout the entire territory of the country in the past, with the exception of some parts of the Pannonian Plain. The program of Busha preservation as a genetic resource began in 1993 with an estimated population size of 1,000 to 100,000 heads. Today, based on the registry data, the size of the controlled Busha population is around 500 to 1000 heads of all categories, of which there are 1919 breeding heads in 2022 (Table 5).

The registry recording for Busha in Central Serbia was started in 2009 and so far, 635 breeding heads have been registered in it. We are of the opinion that for this race in Serbia, the importance of this race is established as part of the national identity.

On Yefimija's farm there are bulls, cows and male and female calves - a total of fourteen heads. Cows give an average of 3 to 3.5 l of milk per day. The farm produces cheese of specific quality with a high percentage of milk fat. Although the daily milk yield is low, the quality of this milk can maintain, but also influence the increase in the number of Busha cattle.

Table 5. Review of the number conditions of breeding individuals of Busha cattle in RS (1999-2022), (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	380	185	270	416	896	827	1083	1077	1701	1613	1605
Male breeding head	20	5	4	16	20	20	25	25	35	371	314
Total	400	190	274	432	916	847	1108	1102	1736	1984	1919

Karakachan breed of Pramenka

There are two autochthonous breeds of sheep in Serbia: Pramenka and Cigaja. There are 11 strains within the Pramenka breed: Svrljig, Sjenica, Krivovir, Piro, Bardoka, Karakachan, Vlaško-Vitoroga, Lipška and Šarplanina. On the other hand, Cigaja includes two strains: Sombor and Chokan (Grittner, 2020).

Out of a total of four herds of Karakachan sheep in Serbia, one herd is located in the ethnic village of Vila Jefimija. However, the fact that the number of these sheep was drastically reduced in 2022 (13) compared to 2021 (60) is worrying. the owner of this farm states that the state did not protect and subsidize such efforts. Small farms cannot live only on enthusiasm and their responsibility, but the support of the state is decisive for such farms.

According to the population trend represented by the Ministry of Agriculture, Forestry and Water Management on the territory of Serbia, Karakachan sheep numbered around 200 individuals in 2018. In 2019, the presence of 233 Karakčan sheep was recorded in the municipality of Dimitrovgrad alone. In 2009, the Institute for the Monitoring of Rare Breeds and Seeds in Europe estimated that there are about 100 Karakachan sheep in Serbia, which is three times less than the estimate made by the Ministry of Agriculture, Forestry and Water Management on the territory of Serbia (Grittner et al., 2021).

Table 6. Review of the number conditions of breeding individuals Of Karakachan sheep in RS (2012-2022) (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	130	84	67	152	183	170	203	201	2018	289	357
Male breeding head	20	-	1	10	10	10	10	10	10	6	10
Total	150	84	668	162	193	180	216	211	228	295	367

According to FAO data, DAD-IS (2022), the number of Karakachan sheep ranged between 300 and 500 heads in the period from 2014 to 2022. The status of the endangered breed is also emphasized by the small number of breeding heads of this strain of Pramenka (table 6).

The population size is declining, and it has the status of an endangered species. For this reason, the primary breeding goal should be to preserve the breed and increase the number of the population of all strains of Pramenki, including the Karakachan sheep.

Vitoroga žuja breed of sheep

On the farm of the ethnic village of Vila Yefimija, another strain of Pramenka is grown - Vitoroga žuja (ten heads in total). This strain of Pramenka is still cultivated only on a few farms in Vojvodina. It is a Serbian autochthonous breed of sheep, however, because of our lack of concern for autochthonous breeds, Hungarians registered this breed as their own. Scientists, but also enthusiasts who know the importance of autochthonous races, claim that such an omission is a significant loss, both of the gene pool and of the heritage of our country.

The farm owner Nenad Ordić states that growing this strain of Pramenka represents only his enthusiasm without any economical benefit. This strain of Pramenka has survived solely because of its resistance and adaptability to modest housing and feeding conditions. The cultivation of Vitoroga žuja is still based on the aforementioned principles without the influence of modern scientific achievements.

Data from FAO, DAD-IS (2022) reveals that the size of the population of Vitoroga žuja is between 500 and 1,000 heads. In order to preserve this strain of Pramenka, the size of the population should not be less than 1,500 heads. The data from Table 7 indicate that this breed belongs to the endangered status and that a special strategy is needed for its preservation.

Table 7. Review of the number conditions of breeding individuals of Vitoroga žuja in RS (2012-2022) (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	219	425	466	438	814	645	813	834	901	1065	1076
Male breeding head	10	10	14	10	20	20	25	58	6045	48	48
Total	229	435	480	448	834	665	838	892	6946	1113	1124

Balkan long-haired goat

A registered herd of 15 Balkan long-haired goat is raised on the farm of the ethnic village of Vila Jefimija. Cekić et al. (2018) list only 145 registered heads of this breed, while there is no other data. Since the number of highly productive, adapted breeds of goats in our country has increased, it is necessary to provide incentives to the owners of endangered locally adapted goat breeds. Breed of goats, thus helping to partially cover the economic difference between these, low-productivity and other high-productivity, imported breeds. only in this way breeders would be encouraged to continue to keep endangered breeds.

By analyzing the number state of goats on the territory of Serbia, especially breeding goats (table 8), it can be concluded that there is a need to intensify protection measures and to work on new projects and measures. This confirms the position of this locally adapted breed of goats as a critical endangered population.

Table 8. Review of the number conditions of breeding individuals of Balkan goat in RS (2012-2022) (FAO, DAD-IS, 2022)

Head	Year										
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Female breeding head	243	217	333	485	493	521	756	811	1050	1077	1217
Male breeding head	10	6	16	15	20	20	25	25	30	58	54
Total	253	223	349	500	513	541	781	836	1080	1135	1271

CONCLUSIONS

Although Serbia adopted the Law on Confirmation of the Convention on Biological Diversity in 2001, a review of the state of the populations and breeding individuals of certain breeds determined that all them are in the status of endangered or potentially endangered. The economy of the ethnic village of Vila Jefimija represents an impressive gene pool of Domestic mountain horses, Balkan donkeys, domestic Busha breed, Pramenka breed of sheep and the local strain Vitoroga Žuja, as well as Balkan goats. However, the number of cultivated populations is small. The loss of the gene pool is unacceptable due to the irreversible loss of resistance genes, adaptability and reduction of breed variability, which puts future food production in question. Support from the state must be based on expert, scientific, and economic measures.

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RESEARCH OF CONVENIENCE FOODS ELABORATED OF BROILERS USING A NOVELTY TECHNOLOGY

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ABSTRACT

Information data on the development of technological schemes for the production of products from broiler meat has been analyzed and systematized. Technological schemes for the production of convenience foods of the said raw materials have been developed. According to these schemes, it is envisaged that not the entire poultry carcass will be used for the production of convenience foods, but only its most valuable part (chest and thighs), and the rest of the carcass with a high content of bones will be further processed, namely mechanically separated. Delivering the most valuable parts of the carcass (breast, fillet, thighs, quarters) in the form of convenience foods is economically profitable. Sensorial parameters, content (by weight) of fat, protein and water, pH, microbiological parameters were studied – according to standard methods. It has been determined that natural convenience foods made of broiler carcasses are characterized by a high level of protein (16.8-22.9)%, which exceeds the lipid content and should be classified as low-calorie. The microbiological parameters of convenience foods produced from broiler carcasses were studied: the carcasses cooled using vacuum for a storage period of 7 days at an air temperature of up to 4 °C; the carcasses frozen using a vacuum for a storage period of 3 months at an air temperature not exceeding minus 18 °C. It was established that the amount of QMA&OMAO in vacuum-frozen samples of convenience foods ($4.1 \cdot 10^4 - 6.6 \cdot 10^3$) at the end of the storage period turned out to be almost an order of magnitude less than in cooled samples ($4.3 \cdot 10^4 - 6.2 \cdot 10^4$), which can significantly extend their shelf life according to microbiological parameters. The pH of cooled convenience foods, which is an indicator of the activity of physical, chemical and biochemical processes, was within acceptable limits for ripened fresh meat. The pH value of white meat (fillet, breast) was (5.64 – 5.72) units, of red meat (quarter, thigh) – (5.93-6.08) units; minced meat – 6.11 units. It is concluded that the new technology for the production of convenience foods is justified in an economic sense and makes it possible to obtain products with acceptable physical, chemical and microbiological characteristics.

Keywords: raw meats, broiler, convenience foods, natural convenience foods, restructured convenience foods.

INTRODUCTION

An urgent problem of food security for the world's population is the problem of providing protein. Despite a number of alternative options (the widespread use of plant and sea fauna derived proteins), milk and dairy proteins are basic in human protein nutrition.

The importance of meat in human nutrition is difficult to overestimate as it is a source of not only protein and calories, but also vitamins necessary for humans (especially B12), easily digestible compounds of iron and zinc. Consumption and production of meat in the world is constantly growing since the rising incomes of consumers in many of countries lead to an increase in meat consumption. Global poultry production is constantly increasing due to increasing demand for poultry meat and eggs.

Poultry is one of the most important sources of protein for human consumption worldwide and is generally accepted among various religious groups and is relatively more affordable than other animal protein sources. Additionally, poultry has less fat, cholesterol, and sodium compared to red meat. Poultry refers to the edible part of any domesticated bird species, such as broilers, ducks, turkeys, geese, guinea fowl and quail.

Well-digestible proteins (with a low level of collagen) of good nutritional quality, low fat content, the presence of vitamins, especially ones of group B, as well as minerals (iron in easily digestible form, zinc, copper, etc.) make poultry meat a valuable food product (Suleimenova et al., 2017).

A convenience food is a product made from natural or minced meat or poultry by-products, prepared for heat treatment. One of the ways to increase the production of convenience foods is the complex processing of poultry meat: dividing carcasses into parts in accordance with food preferences and gastronomic purposes, separating the most valuable parts of carcasses, separating boneless meat, using less valuable parts for the production of such convenience foods as “meats for soup”, “meats for broth”. Convenience foods with more significant muscle tissue content are traditionally popular among the domestic consumers (Zubareva et al., 2015), and so different types of convenience poultry meats are expedient to be developed.

Currently, the most common source of animal protein in the human diet is broiler meat, and the poultry processing industry is recognized as the most successful branch of the meat industry. Poultry effectively converts feed into meat; poultry meat is the cheapest and accessible to all segments of the population (Donskova et al., 2018). It is low in cholesterol and fat, and the fat is less saturated than the fat in red meat. Poultry does neither require long-term cooking, nor contains allergens. All over the world, fewer and fewer poultry carcasses are sold undivided, and the production of highly processed poultry products is becoming increasingly important. Technologists have succeeded in using poultry meat instead of slaughter mammals' red meat to produce a wide variety of products. Specialists in the poultry processing industry continue to develop new poultry products: fried, baked, marinated, smoked, breaded and not breaded, with and without bones etc. (Gushchin et al., 2015).

Deep processing allows the use of low-value parts of carcasses, as well as rejected carcasses of egg and breeding hens. In particular, the said carcasses are used to produce highly nutritious bone broths and some textured products (Zmiievska et al., 2014). A new direction in poultry meat processing is the production of ready-to-consume meals.

The first stage in the production of deeply processed products is the production of boneless meat, that is, the deboning of poultry carcasses and its parts. At large enterprises, manual deboning is increasingly being replaced by automated one. In this case the content of bone remains in the ground meat is of paramount importance. Recently, more and more advanced separators for deboning poultry carcasses and parts of poultry carcasses have been produced (Augusti, 2022; Gushchin, 2023). The bones in these devices remain virtually unharmed so the amount of bone inclusions is minimal. Separated meat obtained using such machines is widely used in the production of convenience foods – the main and widespread product of deep (comprehensive) processing of poultry (Abaldova & Ovcharenko, 2015; Yeresko et al., 2017).

The market for convenience foods is one of the fastest growing segments of the meat processing industry, and it is important to note that consumers can have both low and high income levels (Krylova & Mandzhieva, 2014). Numerous marketing studies have noted that the most common products in Ukraine are poultry products. Convenience foods of poultry meats occupy second place in this segment, which is determined by the availability, as well as the everyday nature of consumption of this type of product (Borodina, 2012).

Natural convenience foods from broiler chicken carcasses are characterized by a high level of protein, which significantly exceeds their lipid content. The ratio of protein to fat in convenience foods is: in the breast – 1.00:0.23; in quarter – 1.00: 0.76; in fillet – 1.00:0.11 and in thigh 1.00:0.52, that is, they are primarily a source of protein and should be classified as low-calorie. The ratio of protein and lipids in the quarter is optimal (Gonotsky, 2008). The division of natural convenience foods products from broiler chicken meat into white and red meat was considered and it was found that the pH of red meat averages 6.05 units, white – 5.70 units. These indicators correspond to the standards for fresh ripened meat (Volkov et al., 2014).

The safety indicators of convenience foods include microbiological indicators that reflect the state of the products under study, since the latter are contaminated with various microorganisms (Vlasenko et al., 2008; Bogatko, 2019; Quintavalla & Vicini, 2002).

One of the promising areas for the production of meat products is the creation of convenience foods of poultry meats of minced ones with the addition of other components according to certain formulations. In their production, melange, egg powder, wheat bread, soy and milk protein preparations, blood plasma, onions and vegetables (cabbage, potatoes, carrots), as well as bread flour and spices are used. Natural convenience foods of minced meat alone are rarely produced, in particular due to the unsatisfactory structure of minced meat, as well as for economic reasons (Molokanova & Lukomsky, 2011; Gonotsky & Fedina, 2008; Gushchin et al., 2002).

The above information allows for a reasonable approach to the development of convenience foods of poultry.

MATERIAL AND METHODS OF WORK

The following research objects were used:

- poultry carcasses (broiler chickens);
- convenience foods (parts of carcasses, minced meat).

During the research, the following indicators were determined:

- content of fat (by mass) – according to the standards DSTU 8380:2015 "Meat and meat products. Method for measuring the mass fraction of fat" and DSTU ISO 1443:2005 "Meat and meat products. Method for determination of total fat content" (ISO 1443:1973, IDT);
- content of protein (by mass) – according to the standard DSTU ISO 937:2005 "Meat and meat products. Determination of nitrogen content (reference method)" (ISO 937:1978, IDT);
- content of water (by mass) – according to the standard DSTU ISO 1442:2005 "Meat and meat products. Method for determining moisture content (control method)" (ISO 1442:1997, IDT);
- pH – according to the standard DSTU ISO 2917 – 2001 "Meat and meat products. Determination of pH (reference method)" (ISO 2917:1999, IDT);
- microbiological indicators – according to the standards DSTU ISO 6579:2006 "Microbiology of food products and animal feed. Method for detection of *Salmonella spp*", DSTU 8381:2015 "Meat and meat products. Organization and methods of microbiological research", DSTU 8446:2015 "Food products. Methods for determining the number of mesophilic aerobic and facultative anaerobic microorganisms".

Statistical processing of the obtained results was carried out on the basis of calculating the arithmetic mean values and the mean square error. All experimental data are the results of 3-5 parallel determinations.

RESULTS AND DISCUSSION

There are general rules for anatomical processing, which provide for the selection from cartridge carcasses of parts that are better for the development of muscle tissue, energy value, for sale in their natural form, supplemented by differences that exist in some countries, due to national characteristics of meat consumption and the range of products produced (Gonotsky et al., 2010).

We have developed a technological scheme shown in Figure 1 providing for a transition from the stage of manufacturing large-piece, portioned, small-piece, boneless and meat-and-bone convenience foods to the production of convenience foods prepared for culinary processing. This is convenient for organizing the production of all types of convenience foods in one workshop, it should be noted that by changing the anatomical division scheme of poultry carcasses, without using breeding, spices, or food additives, it is possible to obtain additional types of natural convenience foods, ensuring an integrated and rational use of raw materials.

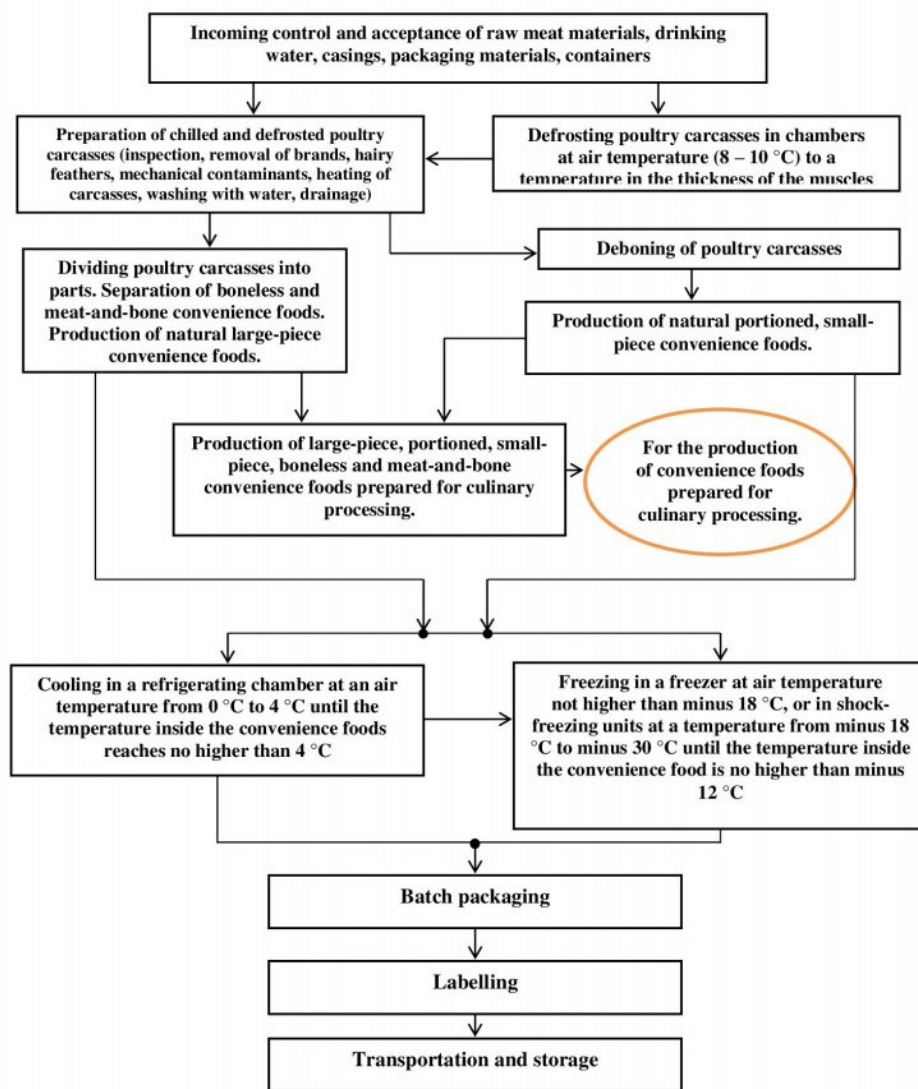


Figure 1. Technological chart of production of natural convenience foods

The authors have also developed a technological chart for the production of convenience foods, prepared for cooking (Figure 2). This technological chart, in contrast to the one for the production of natural convenience foods, provides for the processing of large-piece, portioned, small-piece, boneless and meat-and-bone convenience foods by injecting with pickling brines (pickling). In addition, the surface of convenience foods prepared for culinary processing is treated with mixtures of spices, decorative toppings, marinades, and sauces. Poultry carcasses are deboned by hand, desinewed, hemorrhages, remains of bone, cartilage, and connective tissue being also removed to obtain deboned poultry meat. Prepared unsalted raw materials for convenience foods (large-sized, portioned, small-piece) are weighed, then subjected to appropriate processing (injection, pickling, etc.) followed by storage in chambers with or without further surface treatment.

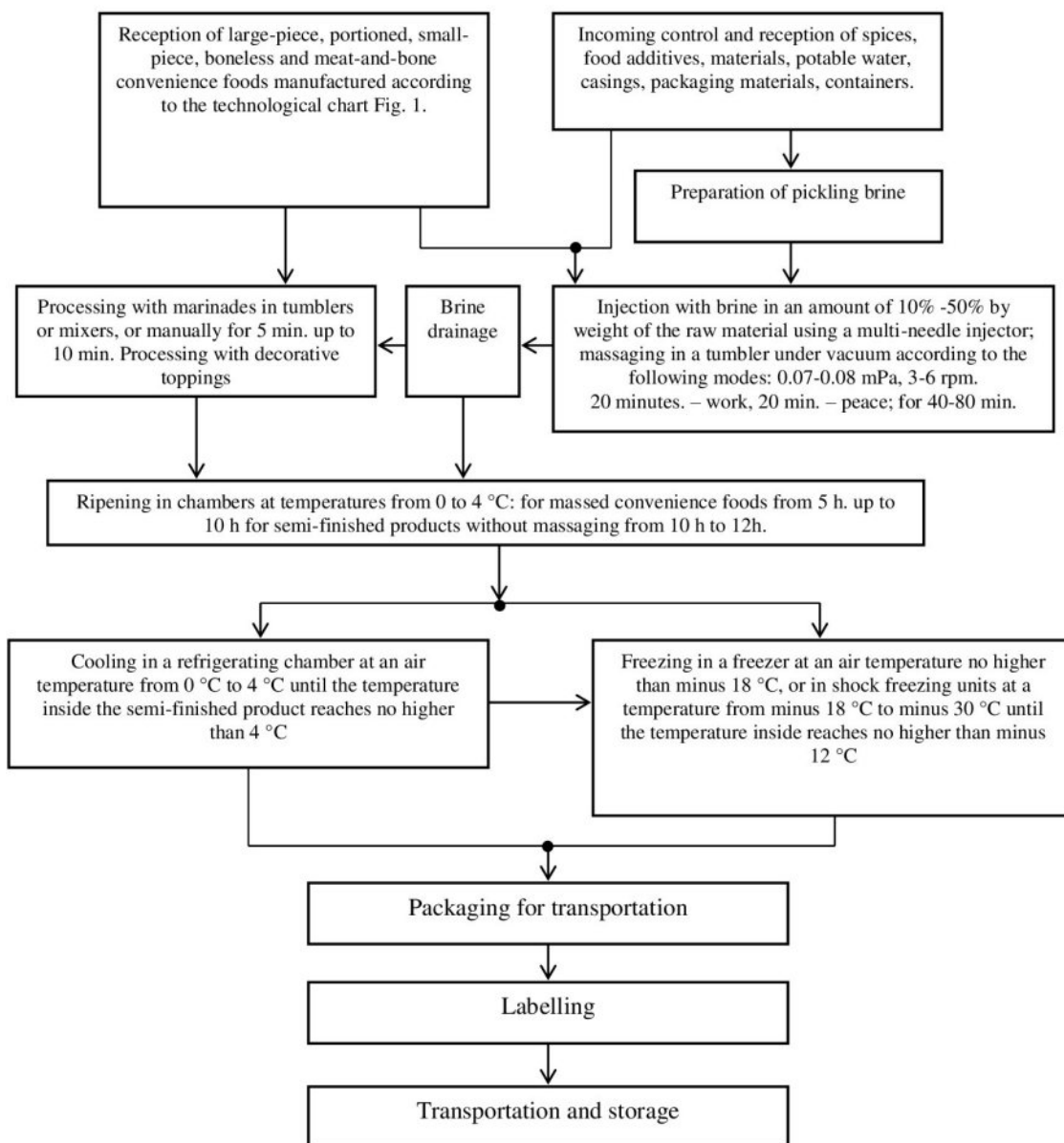


Figure 2. – Technological chart for the production of convenience foods, prepared for cooking

In order to treat meats intended for manufacturing convenience foods, prepared for cooking the authors have developed proper brines and marinades their formulations being specified in Table 1 and Table 2 correspondingly.

Table 1 – Formulations of pickling brines

Pickling ingredients	Mass, kg, in 100 l of pickling brine		
	Formulations		
	1	2	3
Sodium chloride	9.0	8.0	8.0
Phosphates of food quality	3.0	-	1.7
Concentrate or isolate of soya protein	-	-	5.0
White sugar	2.0	1.8	-
Fresh garlic without hull, ground	-	1.0	-
Black pepper, ground	-	0.45	-
Nutmeg, ground	-	0.2	-
Mustard powder	-	0.55	-
Cinnamon powder	-	-	0.3
Cold potable water	76.0	78.0	75.0
Flake ice	10.0	10.0	10.0
Total:	100	100	100
Pickling brine in % to unsalted raw materials (by mass)	From 15.0 до 20.0		

Table 2 – Formulations of marinades for culinary convenience foods (prepared for culinary processing)

Ingredients, food additives	Mass, kg, in 100 l of marinade					
	Formulations					
	1	2	3	4	5	6
Sodium nitrite	9.0	9.0	9.0	9.0	9.0	9.0
Red paprika, ground	1.3	-	1.4	0.975	-	-
Carrot, ground	0.1	-	-	-	-	-
Red hot chili pepper, ground	0.275	-	-	-	-	0.2
Black pepper, ground	0.15	-	-	0.425	-	-
Mustard powder	0.25	-	-	0.525	-	-
Dextrose	0.775	0.775	0.175	-	0.85	1.25
Monosodium glutamate (taste enhancer E 621)	0.275	0.275	0.175	0.275	0.4	-
Thicker (E 415)	0.225	0.225	0.225	0.225	0.225	0.225
Stabilizer (E 500)	0.15	0.15	0.15	0.15	0.15	0.15
Tomatoes, ground	-	0.9	-	-	0.675	-
Fresh garlic without hull, ground	-	0.525	0.325	-	0.425	-
Fresh onions without hull, ground	-	0.65	0.5	-	0.775	-
Parsley, ground	-	-	0.55	-	-	-
Maltodextrin	-	-	-	0.6	-	-
Lemon extract	-	-	-	0.325	-	-
Coriander, ground	-	-	-	-	-	0.325
Curcuma, ground	-	-	-	-	-	0.425
Fenugreek, ground	-	-	-	-	-	0.5
Laurel leaves, ground	-	-	-	-	-	0.2
Modified starch	-	-	-	-	-	0.225
All spices and materials	12.5	12.5	12.5	12.5	12.5	12.5
Cold potable water	87.5	87.5	87.5	87.5	87.5	87.5
Total:	100.0	100.0	100.0	100.0	100.0	100.0

After carrying out the full massaging cycle, the raw materials are placed in metal or plastic containers and sent to refrigeration chambers to keep the raw materials from 5 to 10 h at a temperature of 0 to 4 °C or left in the mixer/tumbler for the same period of time. Massaging modes can be changed, adjusted and applied to specific equipment and production requirements. It is allowed not to massage convenience foods. In this case, after injecting, the raw materials are placed in refrigeration chambers for aging (ripening) for 10 to 12 h at temperature from 0 to 4 °C. Then the convenience foods are sent for processing with spices (if necessary), packaging and packaging.

When preparing convenience foods in marinades, at the end of massaging, marinade is added to the massager in an amount of no more than 20% of the mass of unsalted raw materials (before injecting) (Verbytskyi et al., 2020).

Restructured convenience foods are portioned products made from minced meat, prepared in accordance with a formulation. Restructured convenience foods are cutlets, schnitzels, steaks and meatballs, croquettes, dumplings, meatballs, rump steaks, minced meat, etc. The technological process for the production of restructured convenience foods consists of the following operations: preparation of raw materials, preparation of minced meat, forming of convenience foods, placing on trays, cooling or freezing. The authors have developed a technological chart for the production of restructured convenience foods has been developed, which is shown in Figure 3.

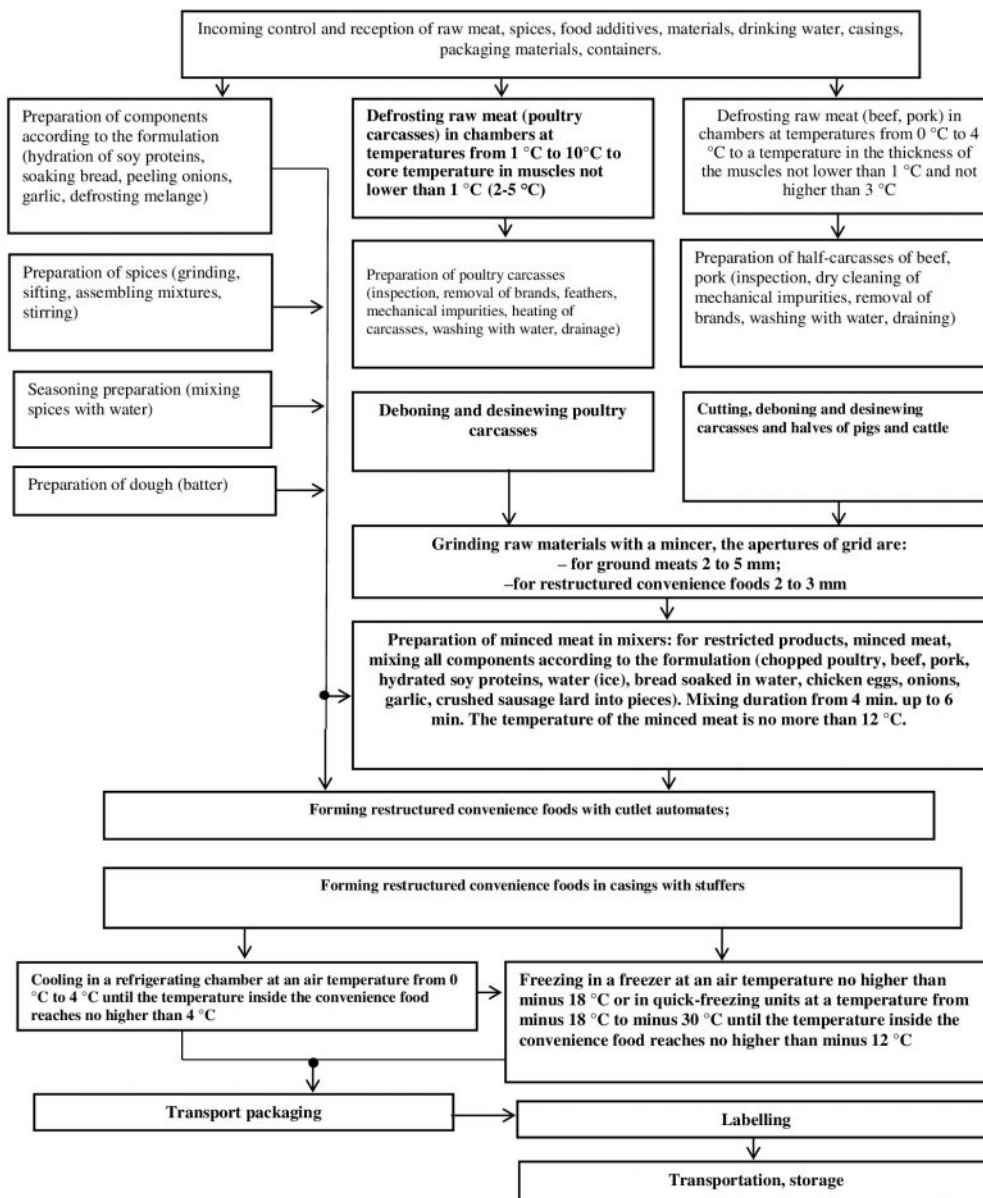


Figure 3 – Technological diagram for the production of restructured convenience foods

Raw meat (hand-deboned poultry meat, raw poultry fat, lean pork, pork cutlet meat, beef cutlet meat) is ground on a grinder its grid apertures being of the diameter of 2 to 3 mm. Before mincing, it is recommended to cool the lard to temperature 0°C to 4°C or freeze to a temperature from minus 2°C to minus 4°C. Unsalted sausage lard, intended for the production of steaks and schnitzels, is crushed using lard slicers, cutters, or manually or other machines into pieces no larger than 4 mm in size – for steaks; for schnitzel – pieces no larger than 6 mm. During the preparation of minced meat for convenience foods, raw meat, hydrated soy proteins, fresh chopped onions, fresh chopped garlic, spices, bread soaked in water, hen eggs are weighed in accordance with the formulation. Preparation of minced meat for convenience foods is carried out in minced meat mixers, into which all components are placed, according to the formulation. Mixing of the ground meat components is carried out for 4 to 6 min to the formation of a homogeneous mass.

At the end of mixing, lard is added this chopped into pieces. The mixing shall continue for 2 to 4 min until pieces of lard are evenly distributed in it. To reduce the temperature of restructured convenience foods, when mixing in minced meat with a mixer, it is recommended to add crushed flake ice instead of 20% water. The temperature of ground meat shall not exceed 12 °C. When mechanically deboned poultry meat is used comprehensive method of determination of bone inclusions in meat products shall be used (Usatenko & Verbytskyi, 2022).

In the scope of this work the natural convenience foods of broiler chicken meat have been chosen to be the first object to be studied and the results of the research of the properties of the said products are presented below. The convenience foods of poultry meats prepared for cooking and restructured ones shall become the subjects of further studies.

The developed technological charts involve using not the entire poultry carcass for the production of natural convenience foods, but only the most valuable parts, for example, the breast and thighs, and the rest of the carcass with a high content of bones is sent to the mechanical department. Selling the most valuable parts of a carcass in the form of convenience foods is economically beneficial for both the consumer and the enterprise: the consumer buys meat without bones (fillet) or with a small content of them, the enterprise sells it at a higher price than whole carcasses, and from the carcass parts that remain during mechanical separation, the edible tissues are completely removed. The physical and chemical parameters of the most common convenience foods were studied the research results are presented in Table 3.

Table 3 – Physical, chemical composition and energy value of natural convenience foods from broiler chicken meat

Convenience food	Content, % (by mass)				pH	Ratio protein to fat	Energy value, kcal/100 g
	Water	Protein	Fat	Ash			
Breast	76.2±1.80	18.8±0.85	4.2±0.52	0.8±0.03	5.72±0.04	0.22	114.9
Hinte quarter	67.3±2.01	17.3±0.93	14.7±0.61	0.7±0.02	5.93±0.03	0.85	203.2
Fillet	73.2±1.86	22.9±0.74	2.9±0.55	1.0±0.04	5.64±0.02	0.13	120.0
Thigh	65.7±1.91	21.1±0.80	12.4±0.60	0.8±0.04	6.08±0.03	0.59	198.1

Based on research results, it was determined that natural convenience foods made from broiler chicken carcasses are characterized by a high level of protein – from 16.8 to 22.9%, which exceeds the lipid content. The protein to fat ratio of convenience foods indicates that they are primarily a source of protein and should be classified as low-calorie. The ratio of protein and lipids in carcass quarters is optimal.

The microbiological parameters of natural convenience foods produced from broiler chicken carcasses were studied. To establish the shelf life of products, a number of studies of microbiological indicators were carried out: convenience foods cooled using vacuum during a storage period of 7 days at an air temperature of up to 4 °C; convenience foods frozen using a vacuum for a storage period of 3 months at an air temperature not exceeding minus 18 °C. The results of studies of cooled and frozen natural convenience foods are presented in Tables 4 and 5, respectively.

Table 4 - Microbiological indicators of cooled natural convenience foods

Parameter	Norm	Result at the start of storage	Result at the end of storage
Coliforms in 0,001 g	Not allowed	Not detected	Not detected
<i>Listeria monocytogenes</i> , in 25 g	Not allowed	Not detected	Not detected
Pathogenic microorganisms incl. <i>Salmonella</i> in 25 g	Not allowed	Not detected	Not detected
Quantity of mesophyll aerobic and optional-anaerobic microorganisms (QMA&OAMO), CFU in 1 g	No more than $5 \cdot 10^6$	$5.4 \cdot 10^4$ (breast); $4.6 \cdot 10^4$ (fillet); $6.2 \cdot 10^4$ (quarter); $5.8 \cdot 10^4$ (thigh);	$5.0 \cdot 10^4$ (breast); $4.3 \cdot 10^4$ (fillet); $5.9 \cdot 10^4$ (quarter); $5.7 \cdot 10^4$ (thigh);

It was established that the QMA&OAMO of vacuum-cooled convenience foods from broiler chicken carcasses is in the ranges: from the beginning of storage – the value is from $4.6 \cdot 10^4$ CFU/h to $6.5 \cdot 10^4$ CFU/h; by the end of storage for a period of up to 7 days at a temperature from 0 °C to 4 °C – the value from $4.3 \cdot 10^4$ CFU/h to $6.2 \cdot 10^4$ CFU/h. An insignificant decrease in the amount of QMA&OAMO is observed. It was also established that in samples with reduced initial insemination in the frozen state at a temperature of minus 2 °C to minus 3 °C, the growth of QMA&OAMO is significantly inhibited, which allows preserving the quality of convenience foods with the use of vacuum according to microbiological standards for 10 days.

Table 5 – Microbiological characteristics of frozen natural convenience foods

Parameter	Norm	Result at the start of storage	Result at the end of storage
Coliforms in 0,001 g	Not allowed	Not detected	Not detected
<i>Listeria monocytogenes</i> , in 25 g	Not allowed	Not detected	Not detected
Pathogenic microorganisms incl. <i>Salmonella</i> in 25 g	Not allowed	Not detected	Not detected
Quantity of mesophyll aerobic and optional-anaerobic microorganisms (QMA&OAMO), CFU in 1 g	No more than $5 \cdot 10^6$	$5.1 \cdot 10^4$ (breast); $4.9 \cdot 10^4$ (fillet); $5.9 \cdot 10^4$ (quarter); $6.1 \cdot 10^4$ (thigh);	$5.4 \cdot 10^4$ (breast); $4.1 \cdot 10^4$ (fillet); $4.3 \cdot 10^4$ (quarter); $5.6 \cdot 10^4$ (thigh);

The QMA&OAMO count of frozen samples at the end of the storage period turned out to be almost an order less than that of refrigerated samples, which makes it possible to significantly extend the shelf life according to microbiological parameters.

However, in practice it was revealed that when producing convenience foods from frozen meat, losses of nutrients occur during the process of thawing carcasses (losses of hen and broiler carcasses are 4.4% and 5.2%, respectively). When defrosting, meat juice removes proteins containing essential amino acids and minerals, including rare trace elements. The taste also deteriorates.

In the process of studying physical, chemical and microbiological parameters of natural convenience foods, active acidity (pH) was measured.

The results of studies of the activity of physical, chemical and biochemical processes by measuring the pH of cooled and frozen natural convenience foods are presented in Table 6.

Table 6 - Dynamics of changes in the pH value during processing (cooling, freezing) of natural convenience foods by morphological type and processing method

Stage of the processing	Convenience food				
	White meat		Red meat		Ground meat
	Breast	Fillet	Quarter	Thigh	
	pH				
Before cooling and freezing	5.41±0.02	5.52±0.02	5.64±0.01	5.83±0.04	5.74±0.01
After cooling	5.72±0.01	5.64±0.04	5.93±0.03	6.08±0.02	6.11±0.03
After freezing	5.83±0.01	5.79±0.04	6.04±0.01	6.23±0.04	6.34±0.03

It was established that the pH level of cooled convenience foods, which is an indicator of the activity of physical, chemical and biochemical processes, was within acceptable limits for ripened fresh meat. Thus, the pH value of white meat (fillet, breast) was (5.64-5.72), red meat (quarter, thigh) – (5.93-6.08) units; minced meat – 6.11. When defrosting convenience foods, a slight increase in pH was observed.

CONCLUSIONS

Three types of convenience foods made of broiler chicken meat namely natural convenience foods, convenience foods prepared for cooking as well as restructured convenience foods are considered. Technological charts for the production of the said convenience foods have been developed.

The physical and chemical parameters of the natural convenience foods have been studied. It has been determined that natural convenience foods made from broiler chicken carcasses are characterized by a high level of protein (16.8-22.9)%, which exceeds the lipid content and should be classified as low-calorie.

The microbiological parameters of the natural convenience foods produced from broiler chicken carcasses were studied: cooled using vacuum for a storage period of 7 days at an air temperature of up to 4 ° C; frozen using a vacuum for a storage period of 3 months at an air temperature not exceeding minus 18 ° C.

It was established that the amount of QMA&OAMO in vacuum-frozen samples of the natural convenience foods ($4.1 \cdot 10^4$ – $6.6 \cdot 10^3$) at the end of the storage period turned out to be almost an order of magnitude less than in cooled samples ($4.3 \cdot 10^4$ – $6.2 \cdot 10^4$), which can significantly extend their shelf life according to microbiological parameters.

The pH level of the natural cooled convenience foods, which is an indicator of the activity of physical, chemical and biochemical processes, was within acceptable limits for ripened fresh meat. The pH value of white meat (fillet, breast) was (5.64-5.72) units, red (quarter, thigh) - (5.93-6.08) units; minced meat – 6.11 units.

The results of the research were used to develop a normative document – the specification TU U 10.1-00419880-175:2023 “Natural and culinary convenience foods of meats. Specification” and the corresponding technological document “Technological instruction for the production of convenience foods and culinary poultry products”.

Complex processing of poultry meat allows to increase the profit of an enterprise by (15-30)%, depending on its equipment.

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CONNECTION OF GLOBAL G.A.P. STANDARDS AND PRECISION AGRICULTURE

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ABSTRACT

The goal of writing the paper is to point out the importance of introducing standards in the process of primary agricultural production, because its benefits are multiple: economic, ecological and social. In this case, it means more effective introduction of Global G.A.P. standards that were observed from two aspects. *The first*, which significantly contributes to the production of health-safe food that is of controlled quality, to better health of the population at the global level and to the preservation of biodiversity. *Second*, by introducing precision agriculture into primary agricultural production, it is easier to adapt to the requirements of Global G.A.P. standards. Data on the number of farms that have these certificates, as well as the area that was in the Global G.A.P. system. standards in Serbia from 2010 to 2021 show very little interest of farms in the implementation of this standard, because only 0.23% of farms and 0.97% of the area were covered by Global G.A.P. certificate in 2020 (in this year, the maximum values of the participation of the observed indicators were recorded). Finally, a schematic representation of the connection that was recognized during the research between GLOBAL G.A.P. standards and precision agriculture. The main data sources for the research are the Statistical Office of the Republic of Serbia (abbr. SORS) and internal data of GLOBAL G.A.P. organizations (obtained on request). Also, data from the literature relevant to the researched areas were used. During the research, methods of descriptive statistics, analysis and synthesis, as well as induction and deduction were used.

Keywords: GLOBAL G.A.P., certification, health-safe food, precision agriculture, environmental protection.

INTRODUCTION

In the scientific and professional literature, more and more attention is paid to the development of agriculture by encouraging the development of rural households and rural communities, while preserving natural resources and protecting the environment. Therefore, one of the ways to strengthen agricultural farms is the implementation of certificates in the production and/or processing process. In this way, agricultural producers create added value to their product, which is widespread in the Common Agricultural Policy (abbr.CAP) supported by the European Union (abbr. EU) in both developed and underdeveloped countries of Europe (Alonso & Northcote, 2013; EU, 2013; Lu, & Dudensing, 2015; FAO, 2018; Piao et al, 2019; EC, 2020; Clark et al., 2021; EU, 2021).

Many authors emphasized the positive aspects of creating added value to agricultural products from the aspect of economic development of agricultural farms, environmental preservation and the realization of goals aimed at environmental protection (Crozet et al., 2012; Alonso & Northcote, 2013; Kleemann et al., 2014; Latouche & Chevassus-Lozza 2015; Tran & Goto, 2019; Riamondi et al., 2020). In this sense, Global G.A.P. the standard is recognized internationally because it ensures good agricultural practice that promotes the production of health-safe food, the safety of workers, the preservation of animal health and the protection of the environment (Flachsbarth et. al., 2020).

Increasing the competitiveness of the agricultural and food industry, along with reaching EU quality standards and creating products with added value, Serbia realizes by adopting numerous strategic documents (SARD, 2014; NRDP, 2022). Implementation and control of activities related to the implementation of Global G.A.P. standards are under the jurisdiction of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (abbr. MAFW), group for rural development. This group continuously works on the implementation of quality schemes for agricultural and food products and their standards in order to obtain health-safe food, as well as on compliance with EU regulations (NPAA, 2022).

Serbia constantly aligns its agricultural production with Global G.A.P. standard since 2010 (SARD, 2014; Bešić et al., 2015). In Serbia, this certificate is introduced exclusively in plant production, and in 99% of cases fresh fruit is certified (significantly less vegetables), while the most common holders of group certificates are exporters of fruits and vegetables (Paraušić & Grujić Vučkovski, 2023; Grujić Vučkovski et al., 2023). In addition to the mentioned activities on the economic progress of farmers, production and export companies, it is necessary to constantly work on their education, networking of farms and strengthening of awareness about the changes that occur every day and accompany primary agricultural production (Grujić et al., 2019).

Given that agriculture is the main source of food on a global scale (Friha et al., 2021), we are seeing increasing concerns about its safety and environmental protection (Inoue, 2020). For this reason, digital devices are increasingly being used in agriculture, which significantly facilitate coping with numerous challenges. Nowadays, under the term digital agriculture, we mean the use of information technologies, satellite navigation, application of various types of sensors, monitoring of working machines, as well as their analysis (Mogili et al., 2018).

In certain situations, digital agriculture can also be called precision agriculture, which contributes to: optimizing resources (fertilizer, seeds, pesticides, fuel and water) (Višacki et al., 2018), saving working time, higher yields, better quality of the final product, reducing negative impact on the environment (Pajić et al., 2019) as well as better documentation management during the production process.

The application of digitization in agriculture most often implies the replacement of human activities in numerous processes, whereby it gives multiple positive economic, ecological and social results (Rolandi et al., 2021; Vasile, 2012; Vial, 2021).

However, digitization in agriculture has not only been introduced in primary agricultural production, but also in the food industry. The reasons why digitalization in agricultural production is more and more prevalent are found in the fact that major climate changes are occurring, on the one hand, and on the other hand, it contributes to greater data transparency (Androniceanu et al., 2022; Grujić, Subić, 2024). Also, the application of digitalization in agriculture affects the economic and political aspects of community life, and ultimately the global development of all communities (Sinitsa et al., 2021).

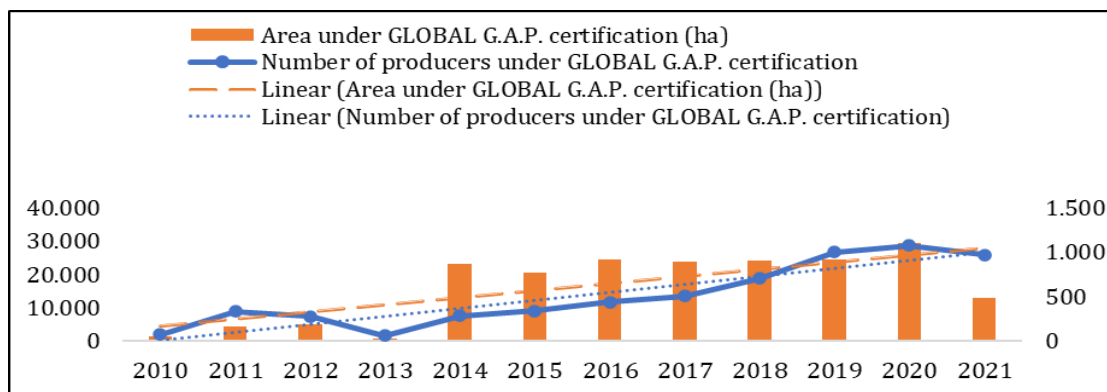
METHODOLOGY

The main sources of data are SORS and the organization GLOBAL G.A.P. Given that the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia (abbr. MAFWM) does not have data on the number of issued GLOBAL G.A.P. certificate in Serbia, we used data from GLOBAL G.A.P. organizations that we received upon request. Also, relevant literature dealing with this topic is cited.

For the purposes of the research, two indicators were analyzed, namely the number of agricultural producers and the area of used agricultural land (abbr. UAA), which is included in GLOBAL G.A.P. certificate in Serbia, while data on the total number of agricultural holdings and used agricultural area (UAA) were taken from the Census of Agriculture 2012 and the Farm structure survey 2018 published by the SORS. The mentioned indicators were analyzed for the period from 2010 to 2021, because from 2010 began with a more serious application of this certificate. During the research, the methods of induction and deduction were used, the results of the research were presented graphically and schematically, and explained by the methods of descriptive statistics. The justification of this research is contained in the fact that the production of health-safe food concerns the population on a global level, and not individual parts of the world.

RESULTS AND DISCUSSION

In the continuation of the work, a shorter statistical analysis of the movement of the number of certified agricultural producers and the area that is in the Global G.A.P. system with the trend line (Graph. 1) from 2010 to 2021 in Serbia.



Graph. 1. Number of certified agricultural producers and UAA with the Global G.A.P. certification and with the trend line in Serbia, 2010-2021

Source: GlobalG.A.P. Organization, data obtained on request and authors' calculations.

In the graph above, we can see that the average number of producers covered by the IFA certificate in Serbia in the period 2010-2021 was 508. We also see a significant decrease in the number of IFA certificate holders from 2010 to 2013, after which their continuous increase followed. until 2020 The share of certified producers in the total number of producers in Serbia in the observed period did not exceed 0.23%, and that was during 2020. The trend line for this variable shows us that Serbia is recording an increase in the number of producers who realize their primary plant production under the auspices of Global G.A.P. certificate.

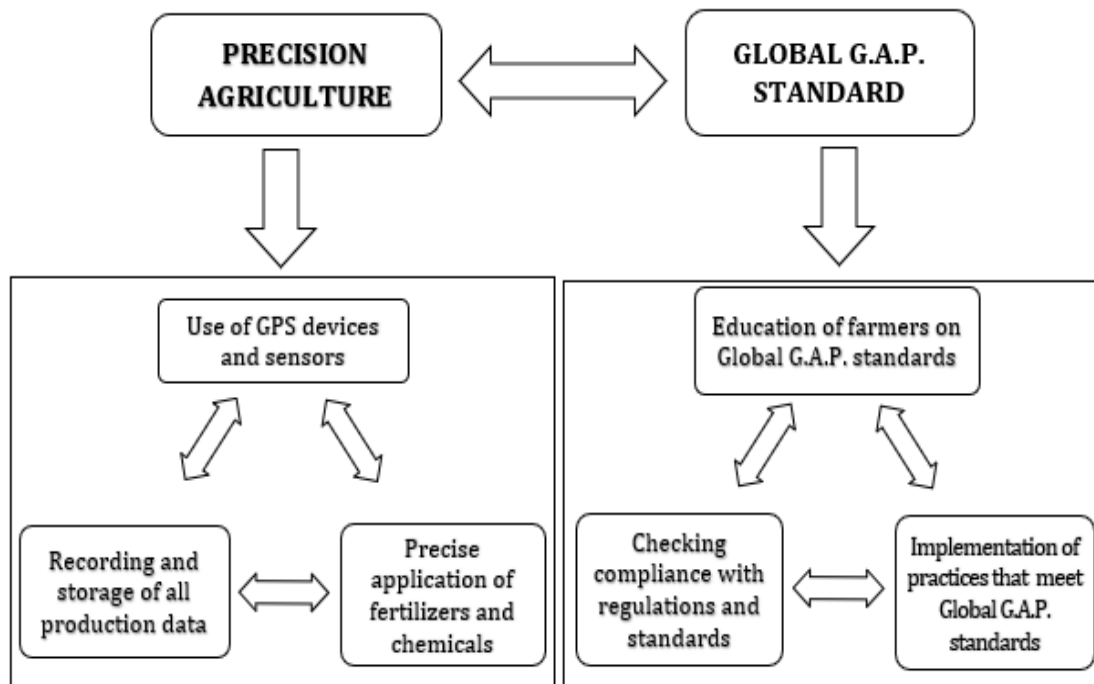
If we look at the graphic representation of the movement of the area covered by the Global G.A.P. with the certificate (Graph. 1.), we observe oscillations until 2013, when its minimum value was recorded. Since 2014 there is a sudden jump in the areas covered by this standard, but the oscillations are still present until the end of the observed period. The share of certified areas in the total used agricultural land of Serbia (abbr. UAA) for the period 2010-2021 does not exceed 1%, with the largest share in 2020 (0.97%). The trend line shows us that this indicator recorded a continuous growth of the areas covered by this certification despite the oscillations that were present.

The relationship between Global GAP production and PA can be multiple. The characteristics that connect these two complex systems are given below. By applying the Precision agriculture (abbr. PA) system, products of better quality are obtained (Kovačić, 2019) and with higher yields per unit area. The ways in which PA affects the quality of the obtained product are primarily related to the optimization of production conditions for each crop separately. This involves precisely managing irrigation systems exactly according to the needs of each plant (King et al., 2004; Pierce, 2010). Also PA includes systems for monitoring the quality of water used for irrigation (Syu et al., 2020; Brahmanand & Singh2022), which is of great importance given that the Global G.A.P. the standard requires the healthiness of the water used in agricultural production. Also, PA includes systems that enable soil analysis (Sedlar et al., 2019) and the formation of maps with different soil properties, which enables the application of fertilizers exactly according to soil needs, while avoiding excessive use of fertilizers. The PA crop protection system enables the targeted application of pesticides and herbicides (Vasić et al., 2022), which contributes to the reduced use of chemical agents, which also affects the reduction of the presence of pesticide residues on agricultural products. By integrating Global G.A.P. standards into already existing PA systems meet international standards and market requirements. Also, Global G.A.P. the standard ensures that said resources are used in a way that ensures the security of a food supply that is health-safe (Inoue, 2020).

Tracking and records. These activities represent the key aspects that enable the alignment of Global G.A.P. standard with current production. By monitoring agricultural activities, PA further facilitates this process. Modern technical systems upgraded with various devices (GPS, sensors) enable the creation of records on the basis of which all agricultural activities (sowing, irrigation, application of fertilizers, chemical protection, harvesting) can be monitored. Also, detailed monitoring of input utilization during all agricultural activities is enabled (Oljača et al., 2005), which is indicated on the product declaration. Tracking systems enable the recording of machinery maintenance, as a digital record records the dates, types of maintenance and thus ensures that the machinery is used in a correct condition (Luo et al., 2022). Precise monitoring of yield based on sensors (Chung et al., 2016) and GPS technology enables obtaining a digital image with an accurate distribution of the obtained yield on the entire plots. This documented information can be key to obtaining Global GAP certification.

Risk reduction. Crossing PA and Global G.A.P. standards, risks that are closely correlated with climate change, crop diseases and food safety issues are reduced. We are witnessing constant climate changes that predominantly affect crops whose main part of the growing season is related to the summer months. In that case, precision irrigation systems can reduce the risk of drought (Jagermeyr et al., 2017; Kang et al., 2017; Wang et al., 2021; Wu et al., 2023). Also, monitoring and control of used chemicals and fertilizers can reduce the risk of environmental pollution (Oparnica et al., 2019) and pesticide residues in food.

On Picture 1. gives a schematic representation of the stages through which the process of applying the PA and Global G.A.P standards goes.



Picture 1. Schematic representation of the stages of introduction of PA and Global G.A.P. standards

Source: Author's view.

This schematic representation allows primary agricultural producers and exporters of plant products to understand more easily how to connect these two compatible production systems. Also, the application of PA can speed up the process of obtaining GLOBAL G.A.P. certificate, and the products obtained in this way certainly meet international standards for food quality and safety and contribute to better competitiveness of domestic products on the global market.

CONCLUSION

Changes in the number of certified agricultural producers and areas covered by this standard in the observed period had large fluctuations, especially from 2010 to 2013.

With the further development of precision agriculture, it is possible to respond in a timely manner to all the changes that occur in the field, all with the aim of obtaining healthy products.

Taking into account both aspects of the research, we came to certain conclusions:

- a small number of agricultural producers who support the implementation of GLOBAL G.A.P. certificates in their production;
- insignificant share of areas included in GLOBAL G.A.P. standard in the total UAA;

- primary agricultural producers have not yet recognized the advantages of the precision agriculture system in order to obtain GLOBAL G.A.P. certificate;
- implementation of GLOBAL G.A.P. certificates in primary agricultural production, contribution to the preservation of biodiversity and landscapes, etc.

We are witnessing that PA is increasingly represented on agricultural farms in all its forms. Therefore, we believe that the implementation of GLOBAL G.A.P. standards in combination with modern agricultural systems was significant and useful in many ways.

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TOMATO CHLOROSIS VIRUS - ToCV - A POSSIBLE PROBLEM IN TOMATO PRODUCTION

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ABSTRACT

Tomato chlorosis virus (ToCV), was first identified in the mid-1990s from greenhouse-grown tomato plants that exhibited a "yellow leaf disorder" syndrome. Originally attributed to physiological or nutritional disorders, the virus was not suspected. Symptoms observed in tomato plants infected with ToCV include chlorotic areas that evolve into interveinal light yellowing, starting from the lower leaves and gradually progressing to the upper part of the plant, thus gradually yellowing is seen, from young to "old" and thickened leaves. These symptoms were observed as early as 1997 and their association with the ToCV virus was confirmed for the first time in Europe. Recently, ToCV has been detected in Northern Europe, particularly in the Netherlands and Great Britain. . Growing tomatoes in greenhouses, together with the fact that ToCV can be transmitted by *Bemisia tabaci* and *Trialeurodes vaporariorum* (*B. tabaci* is certainly dependent on a warm climate), significantly complicates the reduction of transmission. In all, 85 dicotyledonous plant species belonging to 25 botanical families have been described as natural hosts of the virus. These natural hosts include economically important vegetable crops, such as: peas, eggplant, lettuce, potato, pumpkin, sweet pepper and of course, tomato; as well as wild plants. To date, there is no commercial tomato cultivar that is resistant or tolerant to ToCV. However, experiments conducted in Spain, Brazil and Uruguay have identified several wild tomato species (*Solanum section, Lycopersicon*) containing genotypes that respond with mild symptoms or minor consequences to natural or experimental ToCV inoculation. The development of resistant or tolerant commercial varieties of tomatoes (and other crops) is urgent and necessary.

Key words: tomato, virus, symptoms.

INTRODUCTION

The plant virus family Closteroviridae includes the genera Ampelovirus, Closterovirus, Crinivirus, Velarivirus, and several unassigned species. The genus Crinivirus includes 14 family members that are transmitted by whiteflies. Most individual criniviruses cause significant disease in important crops including beans, beets, squash, lettuce, potatoes, and tomatoes, while some are asymptomatic and cause disease only when found in mixed infections with other viruses, and symptoms are often not observed. , already cause crop reduction (Tzanetakis et al., 2013).

Tomato chlorosis virus (ToCV), was first identified in the mid-1990s from greenhouse-grown tomato plants exhibiting “yellow leaf disorder” syndrome in north-central Florida, USA. It is interpreted that in the early 90s, it was also located in Taiwan. This syndrome has been observed since 1989, but was originally attributed to physiological or nutritional disorders, a virus was not suspected (Wisler et al., 1989).

The genome of ToCV is composed of two molecules of single-stranded positive-sense RNA, named RNA1 and RNA2, separately encapsidated in long, flexuous, rod-like virions. As has been shown for other closterovirids, ToCV virions are believed to have a bipolar structure. RNA1 contains four open reading frames (ORFs) encoding proteins associated with virus replication and suppression of gene silencing, whereas RNA2 contains nine ORFs encoding proteins putatively involved in encapsidation, cell-to-cell movement, gene silencing suppression and whitefly transmission. (Elvira Fiallo-Olivé and Jesús Navas-Castillo, 2019.)

Symptoms observed in tomato plants infected with ToCV include chlorotic areas that evolve into interveinal light yellowing, starting from the lower leaves and gradually progressing to the upper part of the plant, thus gradually yellowing is seen, from young to “old” and thickened leaves. In the initial phase of infection, chlorotic areas are often polygonal in shape, and are bordered by major veins. In advanced stages, interveinal yellow areas may develop reddish-brown necrotic patches. The lower leaves are curled, thickened and brittle, they are crunchy to the touch. Although there are no obvious symptoms on the fruits, there is a significant reduction in yield due to the loss of photosynthetic surface. Symptomatic plants are less vigorous, show yield losses as a result of reduced fruit growth and delayed ripening. Symptoms of ToCV on tomato are indistinguishable from those caused by a related crinivirus (eg TICV). In other hosts, the most common symptoms caused by ToCV include intervening chlorosis or mild yellowing of older leaves (Duffus et al., 1996).

MATERIALS AND METHODS

Criniviruses emerged as a major problem for world agriculture at the end of the twentieth century with the establishment of some of their vectors, the white butterfly louse, in temperate climates. ToCV is one of two criniviruses transmitted by white butterfly lice of the genera *Bemisia* and *Trialeurodes*. This includes several species of the *B. tabaci* complex, *T. vaporariorum* and *T. abutilonea* (Navas-Castillo et al., 2000). The large number of natural plant hosts and easy transmission by several species of white butterfly louse have contributed to the exponential growth of ToCV worldwide. In Spain, for example, the prevalence of ToCV in tomato crops has been reported to be very high, often at levels of 50–100% (Fortes et al., 2012). Field studies conducted in Brazil on tomato showed that the main mechanism of ToCV disease spread is primary spread, with outbreaks caused by successive influxes of viruliferous whitefly (Macedo et al., 2019).

The presence of wild and cultivated (eg, sweet pepper and potato) alternative hosts for ToCV adds a new dimension to the complexity of its epidemiology. Although there are no detailed studies on the epidemiological consequences of the presence of wild hosts or the coincidence of tomatoes with sweet peppers, potatoes or other susceptible crops for this virus, some insights can be gained from laboratory experiments. Thus, experiments using *B. tabaci* as vector and tomato or potato plants as inoculum source showed that ToCV transmission rates followed the order tomato > potato > sweet pepper (Mituti et al., 2018). These studies also showed that tomatoes are a better source of inoculum than potatoes.

RESULTS AND DISCUSION

Shortly after tomato yellow leaf disorder was discovered to be caused by a new crinivirus in the US, similar symptoms were discovered in Spain and Taiwan. These symptoms were observed as early as 1997 and their association with the ToCV virus was confirmed for the first time in Europe. Since then, the virus has been found to infect tomatoes in many areas around the world. In total, ToCV has been found in 35 countries and territories in the Americas, Europe, Asia and Africa. In the 23 years since the presence of ToCV was confirmed in the USA, a linear progression of the disease has been observed worldwide, this expansion is still noticeable: in total, an average of 1.5 new countries or areas are covered annually, the confirmation of the presence of the virus in new areas could depend from a larger research effort to diagnose and locate ToCV. However, it is evident that in recent years, in new countries, the recognition of new symptoms in a certain area by farmers, who were once the main actors in the initial warnings to scientists, when they noticed a problem based on limited crops. In this sense, ToCV represents a paradigmatic example of an emergent plant pathogen that will surely invade new areas in the near future. Recently, with the discovery of ToCV in Northern Europe, especially in the Netherlands and Great Britain, in 2018, there was a misconception that the climatic conditions in these countries were not suitable for the transmission of the virus, and its spread in these areas was not expected. Growing tomatoes in greenhouses, together with the fact that ToCV can be transmitted by *Bemisia tabaci* and *Trialeurodes vaporariorum* (*B. tabaci* is certainly dependent on a warm climate), significantly complicates the reduction of transmission. Climate change could exacerbate this situation, as geographic range, phenology, density and activity could be altered. Another worrying situation is related to the recent ToCV report in Nigeria, where the virus was simultaneously observed in seven states of the country. The spread of the virus to other tropical countries in sub-Saharan Africa will change the scenario in this vast area, whose agriculture is already seriously threatened by other insect-borne viruses (Mohammed et al., 2018).

In addition to tomato, ToCV has been found to infect a large number of different plant species. In all, 85 dicotyledonous plant species belonging to 25 botanical families have been described as natural hosts of the virus. These natural hosts include economically important vegetable crops, such as: peas, eggplant, lettuce, potato, pumpkin, sweet pepper and of course, tomato; as well as wild plants. Due to their global importance, in addition to tomatoes, sweet pepper and potato crops can be highlighted. ToCV infections on sweet pepper have been identified in: Spain, Brazil, Costa Rica and Tunisia.

The effect of the disease on sweet pepper was revealed by controlled experiments using *B. tabaci* as a vector, and these experiments showed that cultivars of the three main types of pepper grown in the Mediterranean basin (Italian, California and Lamujo) were heavily infected with the virus. Also, in addition to confirming the development of symptoms observed in the field (retardation of plant growth, twisting, yellowing between the veins and abnormal elongation of the leaves), a significant decrease in the marketable fruit yield was observed due to a decrease in the number and size of the fruits. Potato plants have also been shown to be very frequently infected with ToCV in Spain (Fortes et al., 2012), Brazil and Tunisia. Transmission experiments showed the presence of ToCV in tubers from infected plants, which then themselves produced infected plants, transmission was via *B. tabaci*, as in the case of tomatoes. Certain plant species in Brazil show symptoms of leaf curl and interveinal chlorosis on older leaves (Fortes et al., 2012).

The availability of specific and sensitive diagnostic methods is a key factor for creating control strategies against plant pathogens. In the case of ToCV, both serological and molecular diagnostic methodologies have been developed. For the serological detection of ToCV, a polyclonal antiserum produced using the viral capsid protein expressed in *Escherichia coli* has been proposed for routine diagnosis in a double-antibody enzyme-linked immunosorbent assay, but a false-negative rate of about 5% has been reported (Jackuemon et al., 2009).

Several reverse transcription-polymerase chain reaction (RT-PCR) protocols have been developed to allow rapid and specific detection of ToCV. This includes a multiplex RT-PCR assay that allows simultaneous detection of ToCV and TICV by amplifying part of the HSP70h gene of both criniviruses, followed by multiplex PCR amplification (Dovas et al., 2002). A real-time TakMan RT-PCR assay was also developed for the multiplex detection of ToCV and TICV in plants and vector whiteflies, with higher sensitivity than the conventional RT-PCR assay (Dovas et al., 2002).

To date, there is no commercial tomato cultivar that is resistant or tolerant to ToCV. However, experiments conducted in Spain, Brazil and Uruguay identified several wild tomato species (*Solanum section, Lycopersicon*) containing genotypes that respond with mild symptoms or minor consequences to natural or experimental ToCV inoculation (Gonzalez-Arcos et al., 2018).

CONCLUSION

ToCV can be considered a bona fide emergent plant virus that is still expanding its geographic area and host range using insect vectors. In addition, human-assisted movement of plant material, planting of monocultures or exotic crops, and the introduction of other agricultural practices may increase the spread of the virus. Gaining a more precise knowledge of the mechanisms involved in its transmission by the whitefly, its worldwide persistence and disease development will guide future research efforts with the ultimate goal of developing effective control measures. The true molecular and biological diversity of ToCV needs to be revealed by sequencing and generation of infectious clones of isolates from plant hosts other than tomato. The molecular mechanisms underlying the development of symptoms in ToCV-infected plants, a scarcely studied issue, should receive further attention to understand how the disease initiates and progresses in the plant after horizontal transmission by whiteflies. Almost nothing is known about the molecular determinants of ToCV transmissibility by whitefly, particularly on the insect side, and this may be extended to other criniviruses and semi-persistently transmitted plant viruses in general.

The identification of viral receptors in the white butterfly louse will be a key step in elucidating the mechanism of transmission and devising strategies to disrupt the spread of the disease. Establishing correlations between climatic variables and the distribution of the white butterfly louse complex *B. tabaci*, *T. vaporariorum* and *T. abutilonea* will help to predict areas where ToCV is likely to occur. This takes on particular importance from the perspective of climate change, which can significantly affect the spread of the virus. The development of resistant or tolerant commercial varieties of tomatoes (and other crops) is urgent and necessary.

Control of the disease caused by ToCV is based on the use of healthy seedlings for transplanting, limiting accessibility of alternate host plants that can serve as virus reservoirs and the spraying of insecticides for vector control. Although several wild tomato species have been shown to contain genotypes resistant to ToCV, there are no commercially available resistant or tolerant tomato varieties to date.

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EFFECTIVE MICROORGANISMS IN SUSTAINABLE MAIZE PRODUCTION

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ABSTRACT

Conventional food production has led to a number of problems in the environment, especially soil degradation. The sustainable method of production is also acceptable for rural areas. The goal of the work was to determine the dynamics of changes in the abundance of significant groups of microorganisms in the maize rhizosphere after the application of preparations with effective microorganisms. The experiment was set up in 2018 in the Mačva region. There were three in the research: A: different amounts of mineral nitrogen 160 and 120 kg·Nha⁻¹, B: three hybrids ZP 427, ZP 548 and ZP 648 and factor C treatment with effective microorganisms in the preparation EM Aktiv. The preparation was applied to the soil before sowing at 20 l·ha⁻¹ and twice during the growing season at 6 l·ha⁻¹. The total number of microbes (10⁷) and the number of fungi (10⁴) were determined as important parameters that are important for acidic soils. Agroecological conditions were relatively optimal, while agrochemical analyzes of the soil showed that the soil had an acidic reaction. In such conditions, the application of EM technology had positive results on the examined parameters. The tested factors had a statistically significant effect on the number of tested groups of microbes compared to the control. The number of examined parameters was higher at 120 kg N·ha⁻¹ and in the rhizosphere of hybrid ZP 427. Treatment with EM did not have a statistically significant effect on the increase of nitrogen content in the grains of the examined hybrids.

Keywords: maize, total number of microbes, fungi, effective microorganisms.

INTRODUCTION

Declining soil fertility is one of the most serious problems facing humanity as it tries to feed a growing population. In the soils of Vojvodina, a decrease in humus content from 0.5% to 1.0% was determined, which represents an extremely high decrease, and is the result of intensive processing with the use of mineral fertilizers and the neglect of the application of organic fertilizers (Vasin, 2012). The introduction of high doses of mineral fertilizers worsens the agrochemical properties of the soil as well as the accessibility of microelements (Zn, B, Cu, Mo), which noticeably lowers the quality of plant products. Soil is a hard-to-renew natural resource and all important international declarations on the use of nature emphasize the importance of soil as a universal good of humanity that must be protected by the joint action of science, politics and society as a whole, and in 2015. year according to the decision of the FAO, soil was declared a non-renewable resource (Manojlović et al., 2021).

The constant threat of degradation and loss of fertile soil prioritizes the development of strict soil protection directives promoted by the European Union. The European Green Directive has a series of requirements in food production aimed at reducing the emission of gases that affect the increase in climate change. as well as standards that define a product with a high biological value. This motivated the scientific and professional public to find new directions in food production by introducing ecologically acceptable inputs that would replace chemical preparations in nutrition to protect plants, maintain plant yields, preserve potential soil fertility and resources important for the survival of humanity.

One of the important directions is sustainable systems of agricultural production. The concept of sustainable agriculture defines a production process that must be safe for the environment, and in which a high-quality and safe final product is obtained (Figure 1). In the framework of sustainable agriculture, integral and organic are distinguished. Both systems are based on methods aimed at preserving and improving soil fertility. Therefore, research into the application of different groups of microorganisms and the interaction between microorganisms and ecosystems helped to determine their role in order to achieve the goals of sustainable agriculture.

Figure 1. Components of intensification of sustainable and conventional agriculture. and sustainable environment

Sustainable Intesification Microbial biotechnology Green tehnology Organic fertilizer High soil biodiversity Save land High yield	
Agricultural Intensification Synthetic fertilizer Nitrification Inhibitor Low soil biodiversity Low soil quality High yield	Sustainable Environment Organic fertilizer High soil biodivesity High soil quality Save land Low yield

(<https://www.organic-world.net/yearbook/yearbook-2020.html>)

Maize is called yellow gold because of its role in human and animal nutrition. in the production of food and non-food products. According to Dowsnell et al., (2019), 20 million tons of maize is used for starch, 10 million tons for ethanol fuel production, 3 million for grains and baked goods, 0.7 million for grain and hybrid seed sales. As a result of its low price compared to other crops. maize is used in large quantities in the diet of domestic animals. Maize is an important raw material for the production of bioenergetics, paper, packaging and many additives.

Together with wheat and rice. it occupies the largest area in the world. In Serbia. it is cultivated on more than one million hectares per year (https://gain.fas.usda.gov/Belgrade_Serbia). Serbia ranks fifth in maize production out of 47 CEFTA countries and most countries in the EU and CIS (Commonwealth of Independent States). The necessity to intensify its production in a sustainable way is of utmost importance. Consequently, to reduce the use of synthetic fertilizers, inoculation with different plant growth-promoting microbes as a whole or together with manure would be crucial to improve maize productivity and promote its sustainable production.

The application of different groups of microorganisms is a biotechnological alternative for increasing crop productivity, increasing the availability of nutrients. and reducing the use of synthetic fertilizers. Previous research has shown that thanks to the properties of symbiotic and free-living microorganisms, the problem of availability of nutrients can be solved, the resistance of plants to drought and infection by phytopathogenic organisms can be increased. Zheng et al. (2018) determined that the application of *Bacillus subtilis* can affect the physical, chemical and hydrological characteristics of the rhizosphere. thereby improving the drought resistance of plants in the long term. Wang et al. (2018) established the significant role of *Streptomyces albidireticul* and *Streptomyces albobiflavus* as biocontrol agents.

In the last few years. there has been an increasing number of researches related to the application of preparations with a mix of different groups of microorganisms. In practical application and scientific literature. they are known as multiple preparations with effective microorganisms that are the basis of EM biotechnology in sustainable food production. Such preparations can be used for the treatment of seeds and planting material, during the growing season. as well as on the soil (Kołodziejczyk 2014). Such diverse potential use of effective microorganisms is due to the high enzymatic specificity of microorganisms. which allows them to survive in different environments.

The aim of the work was to determine the influence of the application of effective microorganisms on the change in the abundance of significant groups of microorganisms in the maize rhizosphere and nitrogen synthesis in the grain.

MATERIAL AND METHODS OF WORK

Experimental research was conducted in 2018 in the municipality of Vladimirci, Mačva region. The area of the elementary plot is 14 m². The plots were laid out according to the plan of divided plots in four repetitions. The pre-crop was wheat. All agrotechnical measures were applied in optimal terms

Factor A: Fertilization in the fall is plowed with 30 t ha⁻¹ of manure and complete mineral NPK fertilizer formulation 15:15:15. Before sowing, fertilizer was applied with mineral nitrogen fertilizer AN 36% so that N1 - 160 kg ha⁻¹ and N2 - 120 kg ha⁻¹ were provided for plant nutrition.

Factor B Hybrids: Three hybrids were sown, of the toothed yellow grain type, selected by the Zemun Polje Maize Institute ZP 427 (FAO 400); ZP 548 (FAO 500); ZP 687 (FAO 600).

Factor C Treatments: EM Aktiv, a liquid preparation of microbiological origin. was used in the experiment. The preparation is a mixture of a large group of effective microorganisms (photosynthetic bacteria, sulfate-reducing bacteria, lactic-acid fermentation bacteria, yeasts, actinomycetes and fungi) and sugarcane molasses with the addition of microelements. The preparation represents a variant of EM technology that is part of the research of Japanese researchers Higa (1994). There were two variants in the experiments: EM 0 without the preparation -control and variant EM 1 with preparation. The preparation EM Aktiv was applied: to the soil 7 days before sowing in the amount of 30 l ha⁻¹ with water in a ratio of 1:10. During the growing season. it was applied foliarly twice in the amount of 6 l ha⁻¹ with water in a ratio of 1:100. The first treatment was in the phenological phase of 5-7 leaves, and the second after 15 days.

Before sowing, soil samples were taken to determine basic agrochemical analyses. In the stage of technological maturity of maize, samples were taken from the rhizosphere of plant roots and the total number of microorganisms was determined on soil agar 10⁻⁷, the number of ammonifiers on mesopeptone agar 10⁻⁷ and fungal dilution on Čapek's agar 10⁻⁴. All laboratory research was carried out in the laboratories of the Institute for Crops and Vegetables in Novi Sad.

For the successful production of maize. optimal agrometeorological conditions are necessary for all phenological stages of maize development. Figure 2 shows that the average air temperature in the growing season was 19.1°C, and the total amount of precipitation was 426.4 mm. The measured temperature values are higher by 1.3 °C and precipitation by 13.6 mm less than the multi-year average (1964-2018).

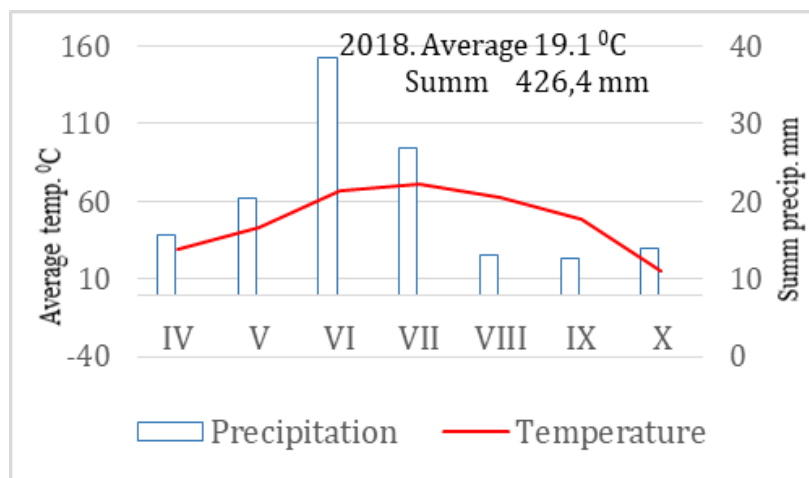


Figure 2. Average air temperature (°C) and sum precipitation (mm)

RESULTS AND DISCUSSION

Based on the results shown in Table 1, it can be seen that the soil has a very acidic reaction (rN 4.01-4.17) in KCl. The read value of the CaCO_3 content classifies the examined soil in the carbonate-free class. According to the humus content, the studied soil belongs to the class of low humus soils. According to the content of readily available phosphorus, the soil belongs to the group of low-provided soils, and according to the content of readily available potassium to the group of high-provided soils. Acidic soils occupy 30% of the total world surface (Esvaran et al., 1997). In Serbia, more than 60% of arable land has acidic soils.

Table 1. Agrochemical properties of soil

pH		CaCO_3	Humus	Total N	AL- P_2O_5	AL- K_2O
KCl	H_2O	%	%	%	mg 100 g ⁻¹	
4.01-4.17	5.15-5.45	0.00	1.86-2.30	0.158-0.184	3.1-6.6	12.74-37.79

The number of systematic groups and the value of dehydrogenase enzymes are used as the only indicators of general microbiological activity. Soils with a high humus content have a higher content of heterotrophic microorganisms. At the same time, their oxidation-reduction ability, i.e. electron transfer processes, as well as the mineralization of fresh organic matter and humus, is greater. It is a good indicator that such soils are suitable for plant production.

In addition to these basic representatives of soil biogenicity, for a detailed assessment of soil condition, damage, toxicosis, etc. the enzymatic activities of microorganisms that produce phosphatase, catalase, peroxidase, lignases, lipases and others are used. Each of these produced enzymes and microorganisms is a good indicator of the presence of substances such as lipids, lignin, organic compounds of phosphorus and others in the soil.

Microorganisms in the soil are very heterogeneous and the most numerous group of organisms. Compared to other organisms, a large part of soil biomass is made up of bacteria and fungi. These groups of microorganisms have a central role in the metabolic activity of the soil, because they participate in it with 60-90%. Many processes important for maintaining soil fertility are the result of their life activity.

The total number of microorganisms represents one of the important parameters of soil biogenicity because they represent a large group of microorganisms that participate in the processes of humification and dehumification, as well as nitrogen fixation. In their metabolic activities, they release certain nutrients found in organic matter (N, P, S, C), influence the nutrition of plants with the products of their life activity and thus participate in the creation and maintenance of soil fertility, growth, yield and health plants. The total number of microorganisms is taken as a reliable indicator when assessing the condition of the soil. A greater number of total microflora is not an indicator of a greater effective production capacity of the soil, because it depends on a number of other factors, but it certainly represents a greater potential for the formation of organic matter in the soil.

The total number of microorganisms in the study was average 350.38×10^7 (Table 2).

Table 2. Total number of microorganisms ($\times 10^7$ CFU g^{-1} absolutely dry soil)

N ($kg \cdot ha^{-1}$) (A)	Hybrides (B)	EM (C)		$\bar{X}$ A×B	$\bar{X}$ A	Factor	LSD 0.05
		EM ₀	EM ₁				LSD 0.01
160	427	205.62	263.34	234.48	258.67	A**	13.13
	548	289.65	229.51	259.58		B**	10.24
	684	293.53	270.39	281.96			9.74
	$\bar{X}$ A×C	262.93	254.41			C**	14.18
120	427	376.41	640.72	508.56	442.11		17.07
	548	417.41	346.36	382.38		A x B**	22.77
	684	361.92	508.79	435.35			13.78
	$\bar{X}$ A×C	385.57	498.63			A x C*	20.05
$\bar{X}$ B × C	427	291.01	452.03	371.52	$\bar{X}$ B		24.13
	548	354.02	287.93	320.98		B x C**	32.20
	684	327.72	389.95	359.65			29.56
	$\bar{X}$ C	324.25	376.52			A x B x C**	39.43
Average					350.38	CV %	41.80
							55.77
							16.77

Numerous factors in the environment affect microbiological activity. Some of them are called modulators, as opposed to those that are called resources and are important for growth. The modulators include pH, temperature, salinity, while the modulators are the availability of carbon and nitrogen. Different amounts and types of fertilizers have different effects on the diversity of microorganisms. A greater amount of ammonia nitrogen leads to greater acidification of the environment, which can negatively affect a greater number of bacteria, especially genera that participate in the nitrogen cycle. In the conducted research, with a lower amount of mineral nitrogen, a 70.91% higher total number of microorganisms was found. The highest total number of microorganisms was determined in the rhizosphere of hybrid ZP 427. The difference in the total number of microorganisms in relation to the state in the rhizosphere of hybrid ZP 548 was at a significance level of $p < 0.01$, and in relation to hybrid ZP 684 at a significance level of $p < 0.05$.

Treatment with effective microorganisms (EM) had a significant effect on the change in the total number of microorganisms. The difference of 16.12% was highly statistically significant compared to the control variant. In the interaction of hybrids and treatments. the highest total number of microbes was in the rhizosphere of hybrid ZP 427 (452.03×10^7). and in the interaction of the amount of mineral nitrogen and tremane. the highest total number of microbes was at a lower amount of mineral nitrogen and the hybrid ZP 427 (640.72×10^7).

The interaction between plants and microorganisms is becoming increasingly important in sustainable agriculture systems. primarily in order to transform and mobilize nutrients from the soil.

According to a number of authors. it was established that maize can significantly influence the composition and abundance of microorganisms in the rhizosphere with its root secretions. In research by Kandeler et al. (2002) determined that the diversity of the bacterial population and their activity in the rhizosphere vary under the influence of maize root exudates.

According to the data in the literature, it was determined that representatives of different genera are represented in the maize rhizosphere *Pantoea*, *Bacillus*, *Burkholderia* and *Klebsiella* (Ikeda et al., 2013). Roesch et al. (2008) found a greater number of different genera in the rhizosphere of maize roots, as well as the presence of certain types of bacteria in the tissue of roots and plants grown in field conditions. Also, many studies have shown that the application of different groups of microorganisms has a significant impact on the dynamics of changes in the total number of microbes and individual groups in the rhizosphere of different plant species (Cvijanović et al., 2007).

As soil dwellers, fungi build significant biomass in the soil, which can amount to up to 20 l th⁻¹. They are regular inhabitants of all types of agricultural land, but are most dominant in soils rich in organic matter and in acidic reaction environments.

Based on the results presented in Table 3, it can be seen that the hybrids did not have a statistically significant effect on the development of fungi, while the interaction of fertilization and hybrids at the significance level of $p < 0.05$ influenced the differences in the number of fungi. Other examined factors had a highly significant influence on the dynamics of changes in the number of fungi.

The development of fungi in the soil is simultaneously influenced by several factors, of which the amount of organic matter, the concentration of hydrogen ions, humidity, temperature, etc. are particularly significant. Fungi participate in the biodegradation of cellulose, hemicellulose and lignin in acidic soils because they have a highly developed enzyme system. This is very significant from the aspect of creating organic matter in the soil because fungi are more active in acidic environments than bacteria. Decomposition of cellulose, which makes up 50% of fresh organic matter, is done by fungi.

The average number of fungi was 73.73×10^4 (Table 3). At a lower amount of mineral nitrogen. 17.94% more fungal cells were found. Treatment with EM significantly increased the number of fungi by 8.52%. In the interaction between hybrid and treatment, the highest number of fungi was found in the rhizosphere of hybrid ZP 427 (92.16×10^4) during treatment with EM. In the interaction between fertilization and treatments, the highest number of fungi was determined in the rhizosphere of the ZP 427 hybrid (133.25×10^4), with a lower amount of mineral nitrogen.

Table 3. The total number of fungi ($\times 10^4$ CFU g^{-1} absolutely dry soil)

N ($\text{kg} \cdot \text{ha}^{-1}$) (A)	Hybrides (B)	EM (C)		$\bar{X}_{A \times B}$	$\bar{X}_A$	Factor	LSD 0.05
		EM ₀	EM ₁				LSD 0.01
160	427	101.12	51.08	76.11	67.67	A**	7.77
	548	44.05	75.41	59.73			8.55
	684	91.89	42.46	61.17		B	4.48
	$\bar{X}_{A \times C}$	79.02	56.32				6.28
120	427	23.6	133.25	78.42	79.81	C**	6.19
	548	70.1	85.78	77.94			8.22
	684	93.54	72.53	83.03		A x B*	7.76
	$\bar{X}_{A \times C}$	62.41	97.19	79.81			10.88
$\bar{X}_{B \times C}$	427	62.36	92.16	77.26	$\bar{X}_B$	A x C**	10.73
	548	57.07	80.59	68.83			14.24
	684	92.71	57.49	75.10		B x C**	10.73
	$\bar{X}_C$	70.72	76.75				14.24
Average				73.73		A x B x C*	18.58
							24.66
						CV %	27.78

The nitrogen content in maize kernels is very significant, because nitrogen is the main element in the composition of raw proteins. The nitrogen content in maize kernels and other parts of the plant is different and depends on the genotype of the plant, the amount of macro and micro nutrients. Nitrogen in the grain originates from nitrogen taken from the soil during grain filling and from nitrogen transported from the vegetative organs into the grain. The average nitrogen content in the grain of the examined hybrids was 1.43% (Table 4).

Table 4. Nitrogen content in the grain of the examined hybrids (%)

N ($\text{kg} \cdot \text{ha}^{-1}$) (A)	Hybrides (B)	EM (C)		$\bar{X}_{A \times B}$	$\bar{X}_A$	Factor	LSD 0.05
		EM ₀	EM ₁				LSD 0.01
160	427	1.29	1.34	1.34	1.44	A**	0.017
	548	1.35	1.46	1.43			0.019
	684	1.57	1.60	1.59		B**	0.019
	$\bar{X}_{A \times C}$	1.40	1.47				0.026
120	427	1.25	1.39	1.32	1.50	C	0.024
	548	1.46	1.46	1.46			0.036
	684	1.83	1.60	1.71		A x B**	0.033
	$\bar{X}_{A \times C}$	1.51	1.48				0.046
$\bar{X}_{B \times C}$	427	1.27	1.36	1.34	$\bar{X}_B$	A x C	0.041
	548	1.40	1.46	1.43			0.055
	684	1.70	1.60	1.65		B x C	0.041
	$\bar{X}_C$	1.46	1.47				0.055
Average				1.46		A x B x C*	0.072
							0.095
						CV %	3.84

The examined factors and their interactions had a different effect on the nitrogen content in the grain. Fertilization and traits of hybrids had a highly significant effect on nitrogen content in grain, while treatments and the interaction of treatments with hybrids and fertilization had no statistically significant effect on this trait. When fertilizing with 120 kg ha⁻¹, the nitrogen content in the grain was 4.16% higher than when a higher amount of mineral nitrogen was applied. The hybrid ZP 684 had the highest nitrogen content in the grain.

In the literature, there is relatively little data on the impact of EM application on the chemical composition of maize grains. However, in research on the impact of foliar application of effective microorganisms, a significant impact on the increased content of protein and oil in soybeans (Cvijanović et al., 2020) and protein in wheat was found (Cvijanović et al., 2022).

The use of effective microorganisms can have a positive effect on the quality of soil and products. which is also very important from the aspect of tourism development. By preserving the gene pool. the vitality of environmental elements. obtaining products with higher nutritional properties can be an advantage in tourism offers and the development of rural areas.

CONCLUSIONS

Based on the presented results. it can be concluded that the application of preparations with effective microorganisms is desirable because in conditions that are unfavorable for plant development and the diversity of the microbial population in the soil. they contribute significantly to the increase in abundance. They can also improve the nutritional value of the fruits.

Application of such products can be included in a sustainable production system. The recommendation would be that they become part of mandatory agrotechnical measures.

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MITIGATION OF ENTERIC METHANE

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ABSTRACT

The paper gives an overview of aspects of enteric methane emission, pointing out the importance of environmental protection. Air pollution depends on many natural and human factors. The agricultural sector is faced with challenges related to global warming and climate change, which affect human food and feed security. Increased confidence in mitigation estimation and practice is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. The discovery of new enteric methane mitigation options is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations across different sectors, and is necessary to be followed by cross-border and worldwide cooperation.

Keywords: enteric methane, ruminant nutrition, greenhouse gases, mitigation.

INTRODUCTION

Air pollution depends on many natural and human factors, and the variation of pollutants and weather changes modify the concentration of pollutants in time and space (Battista et al., 2017). To meet the increasing demand for meat and milk, the livestock industry has to increase its production, and without improving its efficiency, raised livestock, especially ruminant animals, will worsen the environmental damage, mainly from enteric CH₄ emission (Wang et al., 2023). Dairy organizations worldwide announced greenhouse gas neutrality goals. Mitigation of enteric methane emissions is necessary to achieve these goals. Many innovative solutions are being tested and considered. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations and across different sectors, followed by cross-border and worldwide cooperation.

Global climate change is affecting temperature, precipitation, and water availability, which directly affects agriculture and livestock productivity (Souza et al., 2023). Therefore, the expected decline in dry matter intake (DMI) and animal productivity and changes in water intake caused by heat stress may also affect the environmental costs of production in cattle. With the current interest in reducing CH₄ emissions in ruminant production systems to limit global warming (Arndt et al., 2022), models that predict CH₄ emissions have become an important tool to evaluate mitigation strategies (Niu et al., 2018), when other technologies are not available to measure individual enteric CH₄ emissions, (Souza et al., 2023). The agricultural sector is faced with challenges related to global warming and climate change, which affect human and animal food security. Due to climate change, periods of drought might be longer and occur more frequently, which challenges roughage production and requires changed feeding of dairy cattle by increasing the grain content of the diet, (Ivetić et al., 2023; Olijhoek et al., 2022). Also, the feeding behavior of cattle could be managed more effectively, (Ivetić et al., 2008, Ivetić et al., 2007). Land plays a key role in the global cycles of GHG (i.e., carbon dioxide (CO₂), methane (CH₄), and nitrogen oxide (N₂O), and land use change can lead to the release of such gases into the atmosphere or the removal of them from the atmosphere, (Huang et al., 2023). One of the most common forms of land use change is agricultural land conversion where agricultural lands are converted for other uses. Huang et al., (2023) reported that increasing agricultural land conversion to more than 8 % of available land led to increasing GHG emissions during the economic development process.

Livestock enteric CH₄ mitigation is an old feed energy efficiency problem with new dimensions, (Hristov et al., 2022). Governments and the public are interested in finding solutions to climate change, and it is believed that mitigation of agricultural greenhouse gas (GHG) emissions is part of the solution (US Government, 2021). In the United States, agricultural activities are responsible for the generation of GHG such as CO₂, CH₄, and N₂O, with the latter 2 gases being of primary interest: agriculture contributed 39% (CH₄) and 80% (N₂O) of their total emissions in 2019, on a CO₂-equivalent basis (USEPA, 2021). Within agriculture, livestock is responsible for 94% of all CH₄ emissions in the United States (USEPA, 2021).

Continuous research and development are needed to develop enteric CH₄ mitigation strategies that are locally applicable, also information is needed to calculate the carbon footprints of interventions on a regional basis to evaluate the impact of mitigation strategies on net greenhouse gas emissions, (Beauchemin et al., 2022).

ENTERIC METHANE

Enteric methane is a major source of greenhouse gas emissions from milk and beef production systems that contribute to global warming, (Tricarico et al., 2022). Enteric fermentation is the second largest source of methane emissions after natural gas and petroleum systems, and the second largest source of agricultural greenhouse gas emissions in the United States after nitrous oxide emissions from managed soils (US EPA, 2021), Figure 1.

Methane is estimated to have a global warming potential, global warming potential (GWP), 28–30 more than carbon dioxide over a hundred years, by the United States Environmental Protection Agency (EPA, 2021, and the Intergovernmental Panel on Climate Change - IPCC, Table 1. In Europe, 81% of agricultural methane emissions result from enteric fermentation, and 39% of those 81% are produced by dairy cows, (EEA, 2020).

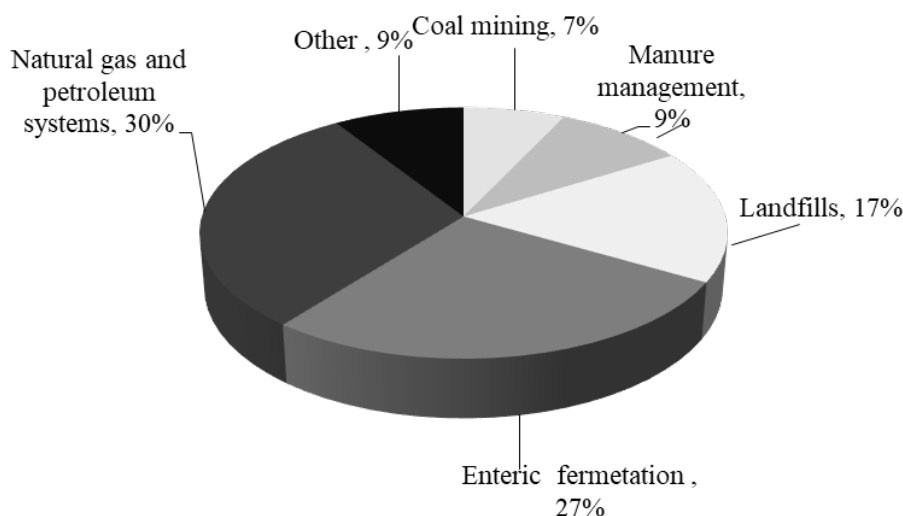


Figure 1. US methane emission by source, EPA 2020

In the AR6 report, an additional GWP for methane has been included to differentiate between methane which originates from fossil fuel sources, and methane from non-fossil fuel sources, like agriculture, Table 1.

Table 1. IPCC Sixth Assessment Report Global Warming Potentials,2021

Greenhouse Gas	100 Year Time Period			20 Year Time Period		
	AR4 2007	AR5 2014	AR6 2021	AR4 2007	AR5 2014	AR6 2021
CO ₂	1	1	1	1	1	1
CH ₄ fossil origin	25	28	29.8	72	84	82.5
CH ₄ non fossil origin			27.2			80.8
N ₂ O	298	265	273	289	264	273

Unlike other sources of greenhouse gas emissions, such as those from fossil fuel extraction and distribution that only contribute to atmospheric greenhouse gases, milk production systems are part of the biological carbon cycle and can function as a sink for greenhouse gases, thereby contributing to reverting climate change, (Le Quéré et al., 2018). Because emitted methane is continuously removed from the atmosphere by hydroxyl oxidation, its atmospheric warming effects depend on the rate of emissions increase or decrease over the last 20 years rather than the total cumulative amount emitted over that period, (Allen et al., 2018). Tricarico et al., (2022), have the opinion that if mitigation of enteric methane production greater than 0.3% annually that is sustained over time (i.e., year-over-year) could be used to offset the atmospheric warming effects of carbon dioxide and nitrous oxide emissions from milk production systems. In this way, sustained mitigation of enteric methane production becomes a valuable tool for dairy value chains to meet their greenhouse gas reduction goals. Therefore, a significant reduction in methane emissions, particularly from agricultural activities, would rapidly mitigate climate change and is a powerful lever to meet the European Union's 2050 climate targets (Dupraz, 2021).

Gloux et al, (2023) highlight that the Intergovernmental Panel on Climate Change (IPCC) defines 3 different methods, to be applied to national inventories according to data availability:

- Tier 1 methods attribute default yearly enteric methane emissions factor per dairy cow. Tier 1 methods provide aggregate estimates, and are not adequate for monitoring changes over time and taking into account the variability of dairy farming practices;
- Tier 2 methods improve the accuracy of emission factors by including feed intake estimates of a representative diet and dairy cow;
- Tier 3 methods require a precise characterization of cows' diet to account for digestibility;

Aspects of the cost of implementing mitigation strategies have to be considered, for the adoption of mitigation strategies for livestock GHG emissions. Climate change mitigation and adaptation policies play a crucial role in the political agendas of local authorities who have to support the development and implementation of innovative products or methods for ECH₄ mitigation.

MITIGATIONS METHODS

The amount of ECH_4 that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock (e.g., cattle, sheep) are major sources of ECH_4 (Ivetić et al., 2022a, Ivetić et al., 2022b, Ivetić et al., 2021) with moderate amounts produced from non-ruminant livestock (e.g., pigs, horses). World demand for animal-sourced foods and global warming concerns rise, safe and effective strategies for enteric methane mitigation in dairy cows are in high demand and De Ondarza et al., (2023) created the dataset from data collected from scientific publications identified through searches of the scientific literature for the greenhouse mitigations effects. The bibliography used by Arndt et al. (2022), covers the period from 1963 to 2018, and De Ondarza et al., (2023), supplemented with literature searches to cover the period between 2019 and 2022. Information from 797 treatments was organized in rows and 162 columns containing variables, including experimental design, animal definition, methane measurement method, dietary nutrients, and treatment responses.

Mitigation strategies were classified into 3 main categories: animal and feed management, diet formulation, and rumen manipulation, and up to 5 subcategories (Hristov et al., 2022). This large dataset with descriptive data and treatment means from in vivo dairy cow enteric methane studies can be used by public and private researchers and advisors including nutritionists, environmentalists, and economists interested in cost-effective solutions to reduce global warming without compromising dairy farm sustainability. In France, the Eco-Methane organization brings together more than 600 farmers whose emissions reduction was estimated at 11% on average in 2017 (Bleu-Blanc-Coeur - BBC, 2022). Gloux et al., (2023), reported that BBC pays farmers according to their reduction of methane emissions in CO_2eq with a financial envelope made of donations from private actors (15€/t CO_2eq on average in 2017). The main strengths of the scheme lie in the strong scientific foundations of the method for quantifying emissions and the easy participation procedure for dairy farmers, (Gloux et al., 2023). Near-infrared spectroscopy (NIRS) from cattle feces could be used as a phenotyping method to predict DMI as well as enteric methane emissions (ECH_4), (Andueza et al., 2022).

Nutritional interventions to mitigate enteric CH_4 have been thoroughly investigated and, likely, strategies based on supplementation with plant extracts (such as a combination of Capsicum oleoresin and clove essential oils) may have a higher acceptance by livestock producers compared with, for example, the use of antibiotics, (Silvestre et al., 2022). Several secondary plant compounds including tannins and saponins have been evaluated for their potential to decrease CH_4 production from ruminants (Kozłowska et al., 2020; Jayanegara et al., 2012). Also, it is well known, that the addition of dietary fat can reduce methane emissions, (Olijhoek et al., 2022).

One of the proposed additives was essential oils (EO), classified as having an uncertain CH_4 mitigation potential with no long-term effects established (Hristov et al., 2013), and Hegarty et al. (2021) concluded in their review that there is medium evidence of the potential of EO to mitigate CH_4 in vivo. Despite the limitations, a positive and strong argument for continuing the research with EO to mitigate CH_4 emission in livestock is supported by the fact that these compounds may have a higher acceptance by consumers compared with, for example, synthetic CH_4 inhibitors, (Silvestre et al., 2023).

Botanical preparations and EO are Generally Recognized as Safe (GRAS) compounds by the Food and Drug Administration (FDA; 2021). However, more research is needed to determine the long-term effects of EO supplementation, (Silvestre et al., 2023).

For a given productivity level, introducing fodder with high sources of omega 3 content such as grass or linseed in the feed ration of dairy cows both improves the milk nutritional profile and reduces enteric methane emissions per liter in France, (Gloux et al., 2023).

Many studies have compared feeding maize silage versus grass or grass-clover (starch vs. NDF) diets to dairy cattle, to study the effect on rumen digestion kinetics and CH₄ emission, (Brask-Pedersen et al., 2023). The quality and the composition of silage are important elements of a ration daily for ruminant feeding, (Ivetić 2017, Ivetić et al., 2018, Ivetić et al., 2013). It should be mentioned the application of alternative electron acceptors are organic (e.g., fumarate, malate) and inorganic (e.g., nitrate, sulfate) compounds that draw electrons away from methanogenesis and incorporate them into alternative pathways, (Beauchemin et al., 2022).

The ruminant gut structure fosters extensive enteric fermentation of their diet, (Ivetić, 2017). Enteric CH₄ emission from ruminants not only exacerbates the global greenhouse effect but also reduces feed energy efficiency for the animals and Wang et al., (2023) explained that theoretically, redirecting [H] from methanogenesis to propionate formation to reduce CH₄ production could be a promising method for reducing greenhouse gas emission from ruminants, and may also increase animal productivity. Instead of directly inhibiting methanogenesis in the rumen, redirecting the flow of [H] towards alternative sinks could be a promising strategy. The complexity of the rumen poses challenges to reducing enteric CH₄ emission, but long-term comprehensive technologies may influence the evolution of the rumen and rebuild a microecosystem in a way that would favor the production of propionate to provide more sinks to dispose of H₂, (Wang et al., 2023).

Macroalgae (seaweeds) have highly variable chemical composition, depending upon species, time of collection, and growth environment, and they can contain bioactive components that inhibit methanogenesis, (Beauchemin et al., 2022). Seaweeds have been studied by Muizelaar et al., (2023) for their ability to reduce enteric methane emissions of ruminants when fed as a feed supplement. They reported that none of the seaweeds used in the experiment affected enteric gaseous emissions and that the inclusion rate might not have been sufficient for the specific metabolites in seaweeds to affect enteric methane production.

Methane inhibitors (3-NOP and bromochloromethane) had the largest CH₄ mitigation effect (Hristov et al., 2022) and did not affect DMI, fiber digestibility, milk production, or ADG. 3-Nitrooxypropanol is the most potent CH₄ inhibitor currently available, exhibiting inhibition efficiencies of 20 % to 50 % across a range of doses, supplemental methods, diet compositions, and animal species, with no adverse impacts on diet digestion or animal performance (Hristov et al., 2015). Applied at 60 mg/kg feed DM via the TMR, 3-NOP decreased daily enteric CH₄ emission by 26%, emission yield by 27%, and emission intensity (ECM basis) by 29%, (Melgar et al., 2021). Chemical inhibitors can be easily combined with other mitigation strategies and their adoption requires them to pass safety tests for animals, consumers, and the environment, (Beauchemin et al., 2022).

Two organizations based in the United States, the Foundation for Food and Agriculture Research and the Dairy Research Institute, have developed a collaborative program Greener Cattle Initiative to align resources and fund projects to identify, develop, and validate new and existing mitigation options for enteric methane emissions from dairy and beef cattle, (Tricarico et al., 2022), shown in Figure 2.

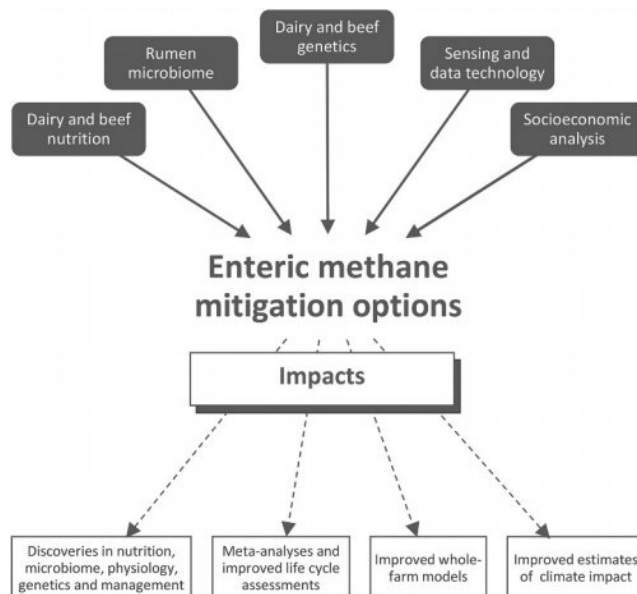


Figure 2. Areas of focus and expected impacts for research of enteric methane mitigation options for beef and dairy cattle, Tricarico et al., 2022.

Increased confidence in mitigation estimates is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. The discovery of new ECH₄ mitigation options, by itself, is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Mitigation options need to be deployed by a substantial number of dairy farmers to achieve the desired results, (Tricarico et al., 2022). For example, animal feed and health companies that develop ECH₄ inhibitors currently need to pursue regulatory pathways that were developed to establish functional claims for drugs, such as compounds to cure, prevent, treat, or mitigate disease conditions or that change bodily structures or functions (United States Food and Drug Administration, 2022). Antimethanogenic strategies may decrease total CH₄ production (absolute emissions, g/d), CH₄yield (g/kg of DMI), or CH₄ intensity (g/kg of meat, milk, or wool produced), (Beauchemin et al., 2022).

The number of monitoring tools and experiences is progressively increasing also due to improvements in the standardization of methods and the proliferation of research and accounting experiments, which bring about an increase in awareness of political subjects and the general public, (Marchi et al., 2023).

CONCLUSION

Air pollution depends on many natural and human factors. The agricultural sector is faced with challenges related to global warming and climate change, which affect human and animal food security. Increased confidence in mitigation estimation and practice is needed to develop socioeconomic innovation that encourages the adoption of mitigation options.

The discovery of new enteric methane mitigation options is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations across different sectors, and is necessary to be followed by cross-border and worldwide cooperation.

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THE INFLUENCE OF THE HOUSING SYSTEM ON WELL-BEING DAIRY CATTLE

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ABSTRACT

The results are presented for black and white dairy cows with dominant participation of the Holstein genes on two commercial farms of Al Dahra Corporation (former PKB) with different husbandry systems. The method of description was used as a method in this research. This method shows the number of dairy cattle on Al Dahra's farms in 2021/22/23. years, different housing systems, certain characteristics of milk yield and reproduction. The results are presented in the form of mean values of the observed parameters for each examined year. In the free housing system, during the three years of observation, a significantly higher number of dairy cows were raised compared to the bounded housing system (+2420; +1900 and +1825, respectively). The production and reproduction results were significantly better in dairy cows in the freestall system compared to the bounded housing system. A higher daily milk yield per head (29.0) was achieved compared to the bounded system (27.2), which resulted in a higher annual milk production - 6,889 l compared to 5,278 l, but the quality of the milk (3.6% milk fat and 3.25% protein) was the same for both presented housing systems. The duration of the service period of 127 days in the free system is significantly shorter than the duration of the service period in the bounded system (171 days). The free housing system also led to a lower insemination index for both cows (2.7) and heifers (1.9) compared to the other way of housing (3.8 for cows and 2.4 for heifers). In both Al Dahras farms, the age of dairy cow at the moment of excluding from production herd is on average 5 years for both husbandry systems, which significantly reduces the profitability of production. Housing system is a factor that strongly affects the welfare quality of dairy cows. In the management system of Al Dahra there is no monitoring, but it could be pointed out that the available investigations of housing system did not bring complete answer on all questions. However, based on this research we can recommend a free housing system with positive influence on the welfare of the animals.

Key words: animal welfare, housing systems, Holstein Friesian race, milk yield, reproduction.

INTRODUCTION

The most important breeding goal in milk production is to achieve high genetic productivity per head, but also to reduce the variability of the most economically important traits, which include milk yield and fertility. Milk yield traits, yields of milk, milk fat and protein are traits whose phenotypic variability is influenced by a large number of factors, both genetic and non-genetic. Accordingly, different models of genotype-environment interaction were experimented with, because productivity traits are quantitative traits with polygenic nature, but they are also the result of the interaction of genes and environment, with the environment affecting their variability in different degrees.

Since heritability of milk yield traits is low (about 0.25%), and genetic correlation between reproductive traits and milk yield varies from negative (-0.25) to low positive (0.5), desired phenotypic expression of milk yield traits and fertility is greatly influenced by non-genetic factors. It is precisely because of nutrition, care, accommodation, health care, and populations with a similar hereditary basis exhibit large variations in production. In addition to milk production, these factors affect the health and other, general well-being of domestic animals.

There is worldwide increasing scientific research, consumer activity, and political response towards housing condition, animal health and welfare issues (Hristov et al., 2008). There are several definitions of animal welfare. Broom (1996) defines animal welfare as follows: "welfare is the state of an animal resulting from its attempts to cope with environmental influences", which is the most widely accepted definition of welfare today. The welfare assessment methods can be broadly divided into the so-called input methods that are based on information about environmental conditions-resources and output methods that use information about the animals themselves (Erbez and Trkulja, 2020). The best method of welfare assessment should include both types of mentioned indicators (input and output) (Ostojić Andrić, 2013). The issue of well-being mostly concerns those who are directly or indirectly involved in food production - producers and consumers of animal products. In addition, the protection of the welfare of dairy cows is also related to issues of environmental protection, sustainable development and a whole range of health, hygiene, economic and social problems of a society.

Modern applied measures for increasing the productivity of cows have had a negative impact on the well-being and health of cows, which has reduced profits in the dairy industry. Endemic disease, such as lameness and mastitis, as well as different metabolic disorders, infertility and shorter life time, are some of the consequences of disturbed welfare on dairy farms (FAWC, 2009). In an attempt to determine the reasons, it was taken into account that the industrialization of dairy cattle significantly reduced the living space for cows, insufficient or completely denied movement (bound system), which led to the impossibility of manifesting natural forms of behavior and social interactions. This kind of farm management, but also due to some other applied technologies aimed at increasing productivity, there was a negative impact on animal health, as well as on certain economically important characteristics of cattle.

In spite of many different variations of existing housing systems, they can be broadly classified into two major groups: the loose (LHS) and the tie-stall system (THS). The main difference between them is reflected in the freedom of movement, which is by default better in LHS and thus support more natural cow housing. Still, the results of several studies show that both systems are characterized by advantages and disadvantages (Ostojić Andrić et al., 2022).

In Serbia, tie system is predominant, since it enables individual treatment of every animal, but at the same time is strong contrast to natural habitat of cattle. Ostojić-Andrić et al. (2013) found a significant influence of the housing system on the welfare quality of dairy cows in Serbia. The test was carried out on six farms, with a capacity of 30 to 900 cows, with a free and bounded housing system. The research results prove that the welfare quality of dairy cows is significantly influenced by the holding system and that the free system has an advantage when comfort, ease of movement and the health condition of the cows are emphasized. The same authors pointed out the inadequacy of accommodation and the lack of comfort by determining the value of the indicator.

Black and white, low land attle has important place in Serbia's cattle production. Especially because of high share in total milk production, in spite of relatively low share in total number of heads of cattle. However, it should be noted that management failures are possible in both housing systems, which can seriously compromise the quality of cow welfare (Novaković et al., 2009). All this points to the importance of examining milk yield traits in high-milking herds such as black and white dairy cows with dominant participation of the Holstein gene in different housing systems. Ostojić-Andrić et al. (2011) pointed this by analyzing indicators related to cow hygiene (dirty feet and udders) and diseases (dystocia). Presentation of the currently available capacities, milk yield parameters and some reproduction parameters of Holstein-Friesian cows on the farms of the Al Dahra Corporation shows the impact of two systems of keeping both on the well-being of cows and on the profitability of production.

MATERIAL AND METHODS

The influence of the holding system was examined on two commercial farms of Al Dahra Corporation (former PKB). On one farm there is a bound system of keeping, while on another farm there is a free system of keeping dairy cows. The results are presented for black and white dairy cows with dominant participation of the Holstein gene. Investigated sample of cows were under different conditions of housing, nutrition and care. Farms were of various capacities.

The method of description was used as a method in this research. This method shows the number of dairy cows on Al Dahre farms in 2021/22/23. year, housing systems, certain characteristics of milk yield and reproduction, as well as various causes of death of freshly calved cows. The results are presented in the form of mean values of the observed parameters for each examined year.

RESULTS AND DISCUSSION

Formerly a European conglomerate PKB, today part of the international corporation Al Dahra, conducts cattle production on two farms.

The number of black and white dairy cows with a dominant part of Holstein genes on Al Dahra farms in Serbia in 2023 is 4065. Table 1 shows the number of dairy cows in the last three years (2021/22/23) on farms with two housing systems.

Table 1. Number of dairy cows on Al Dahra farms in 2021/22/23.

Years	Number of dairy cows			
	Free housing system	Bound housing system	Differ.	Total
2021	3600	1180	+2420	4540
2022	3100	1200	+1900	4300
2023	2945	1120	+1825	4065

In breeding and selection programs, economically important ones have a special importance milk yield traits such as duration of lactation, milk yield, yield and milk content fat and protein. Fertility traits are gaining more and more importance in genetics

improvement of dairy cattle, considering that they significantly affect the economic efficiency of milk production (Lazarević, 2019).

According to Ostojić Andrić et al. (2011) housing system is a factor that strongly affects the welfare quality of dairy cows, especially in regard to health condition and expression of behaviour. In Serbia, like in most countries, bound housing system is predominant, since it enables individual treatment of every animal, but at the same time is strong contrast to natural habitat of cattle. In the free housing system, during the three years of observation, a significantly higher number of dairy cows were raised compared to the bounded housing system (+2420; +1900 and +1825, respectively). The total number of dairy cows (4,540, 4,300 and 4,065, respectively) is devastating considering that in 2010, 21,568 head of cattle were raised, of which 8,721 were dairy cows (Stojić et al., 2010).

Examining the keeping of the Holstein-Friesian breed during 2011 in the Belgrade region, Stojić et al. (2012) determined that their average milk production per day in the milk was 21.96 kg, per day of life 10.63 kg and per productive day 19.75 kg. In this research, in the free system a higher daily milk yield per head (29.0 kg) was achieved compared to the bounded system (27.2 kg). The amount of milk was higher for 1,8 kg which resulted in a higher annual milk production (6,889 kg compared to 5,278 kg). The results are consistent with the research of Popović et al. (2015) who found a highly significant influence of non-genetic factors (farm, year, calving season) on the variability of milk yield and production characteristics of black and white cattle ($P < 0.01$).

Table 2. The relationship between some characteristics of milk yield on Al Dahra farms in relation to the housing system

Year	Housing system*	Cows number	Daily milk yield, kg	Annual milk yield, kg
2021	A	3600	28,8	6.480
	B	1180	26,2	4.585
	Differ.	+2420	+2,6	+1895
2022	A	3100	28,6	6.893
	B	1200	27,6	5.382
	Differ.	+1900	+1,0	+1513
2023	A	2945	29,5	7287
	B	1120	27,8	5867
	Differ.	+1825	+1,7	+1420
Average	A	2135	29,0	6889
	B	1666	27,2	5278
	Differ.	+469	+1,8	+1611

* A – Free housing system; B – Bounded housing system

Examining the milk and reproductive characteristics of the cows of the Holstein-Friesian breed, Lazarevic (2019) determined that in lactation, with average duration of 373.89 days, the average milk yield was 9,452.52 kg with 3.48% milk fat and 3.23%

protein. Comparison of the above mentioned results with milk yield of the tested dairy cows of the same breed at Al Dahre farms indicates significantly lower values (-1611 kg) (table 2), but the milk quality is competitive with 3.6% milk fat and 3.25% protein (table 4).

Table 3. The relationship between some characteristics of reproduction on Al Dahra farms in relation to the housing system

Year	Housing system*	Service period	Insemination index for cows	Insemination index for heifers
2021	A	140	3,6	2,0
	B	190	4,2	2,6
	Differ.	-50	-0,6	-0,6
2022	A	124	3,2	1,9
	B	170	3,8	2,3
	Differ.	-46	-0,6	-0,4
2023	A	118	3,0	1,9
	B	154	3,3	2,2
	Differ.	-36	-0,3	-0,3
Average	A	127	2,7	1,9
	B	171	3,8	2,4
	Differ.	-44	-0,9	-0,5

* A – Free housing system; B – Bounded housing system

Dedović et al. (2020) stated that in the population of black and white cows, the duration of the service period was 98.78 days, which is significantly shorter than the service period of cows on observed farms, although the duration of the service period of 127 days in the free system is shorter 44 days than duration of the service period in the bounded system (171 days). However, the duration of the service period on the surveyed farms is significantly shorter compared to the research by Trifunović et al. (2005) and Gouda et al. (2017) (141.35 days and 165.8 days, respectively). The free housing system also led to a lower insemination index for both cows (2.7) and heifers (1.9) compared to the other way of housing (3.8 for cows and 2.4 for heifers) (table 3). Trifunović et al. (2005) established in the population of black and white cattle the mean values of the general average for the insemination index of 2.44.

Table 4. Important indicators of milk production during 2021-22-23 at Al Dahra farms

Milk fat content, %	3,6
Protein content, %	3,25
Average number of lactation	2,6
Age at excretion	5 година
Remount herd	35%

This confirms that fertility traits in Holstein-Friesian populations expressed significant variability. Conclusion can be made that long-term unilateral selection aimed at improving milk yield traits had a negative impact on fertility traits, but management also has a decisive role.

Novaković et al. (2009) examined 331 cows that originally belong to the European type of black and white cattle and they are in the final phase of intensive breeding with the Holstein-Friesian breed. They determined that the average age of cows at the time of exclusion was $2,265 \pm 463.26$ days or 6.21 ± 1.27 years. In Al Dahra, the age at exclusion is significantly lower, i.e. around 5 years on average, which significantly reduces the profitability of production.

Also, Novaković et al. (2009) claim that prolonging of production life of animal reduces the percentage of remount in the herd, which enables more strict selection in regard to other traits and additional income from sale of breeding material.

Stojić et al. (2012) examined the causes of exclusion of cows from the herd in Holstein-Friesian breed. The research was conducted on a sample of 3,060 excluded cows during 2011 on seven big dairy farms in the Belgrade region. The mentioned authors determined that at the time of exclusion the cows were on average 5.18 years old, and they spent an average 1,112 days in production, of which 978 days were in dairying.

In addition to the improvement of housing conditions of highly milking cows, the dairy profile (genetics), regular control of the genital apparatus, artificial insemination technique, nutrition, drying and body condition have a great influence on the fertility and should not be ignored (Lyubimov et al., 2020). Novaković et al. (2009) recommend, beside the effort invested into increase of the level of production, it is necessary to consolidate certain physical qualities of cows using selection, in order to contribute to increase of production and prolonging of the lifetime period of cows in the herd. The mentioned authors claim this is especially important if stress effects of intensive rearing system are taken into consideration, as well as housing conditions and exploitation conditions. Study of the body development and type should be more in focus of the attention through defining of certain breed type of animal which would be most suited for the breeding purpose. Body development/condition and type should be considered in relation to rearing conditions and realized production.

Holding systems are part of the management of milking cow farming technology and the results obtained in the research are expected. In their research, Lyubimov et al. (2020) confirmed the high impact of cultivation technology on milk yield traits and fertility traits.

Ostojić Andrić et al. (2022) conclude that the initial hypothesis of the better welfare quality in the loose system can be accepted if taking into account that the majority of the farms with loose system were classified into a better category compared to the tie-stall system. However, by perceiving values and relations of welfare parameters between housing systems in more detail, it can be concluded that the welfare quality parameters were not exceptional in any of them.

Although the Al Dahra farm adopted a free system of keeping cows, there is no monitoring that would emphasized all the advantages of this system.

CONCLUSIONSS

Housing system is a factor that strongly affects the welfare quality of dairy cows. The milk yield of cows on a farm with a free system is significantly higher in each year, which indicates the great influence of the housing system as a non-genetic factor on milk properties. The examined reproductive traits were also better in cows and heifers in the free housing system. Certain reproductive traits were better compared to previous research.

Given that the content of fat and protein, as well as the year of excluding and the remount of the herd did not different between the herds, it could be pointed out that the available investigations of housing system did not bring complete answer on all questions. However, based on this research we can recommend a free housing system with positive influence on the welfare of the animals.

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EXAMINATION OF POMOLOGICAL AND TECHNOLOGICAL CHARACTERISTICS OF SOME SWEET CHERRY FRUIT VARIETIES

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ABSTRACT

Sweet cherry, along with strawberry, represents the earliest seasonal fruit and is mostly consumed fresh. One of the most important characteristics of cherries is the size of the fruit, which greatly influences its market value. The dominant shape of cherry fruit is heart-shaped, but nowadays elongated and round fruit shapes are increasingly common, which may indicate the presence of modifier genes. The assortment of cherries worldwide is diverse, numbering over 2000 varieties, but in our region, only a few dominant ones are used. During the implementation of this research, pomological and technological characteristics of six cherry varieties were examined at the Krnule locality, Mačva district. The varieties analysed were 'Burlat', 'Grey Star', 'Carmen', 'Ferovia', 'Kordia' and 'Regina'. The aim of this research is to determine the differences among the mentioned cherry varieties, and the evaluation were conducted during the vegetation period of 2022. Pomological measurements (stalk length, fruit weight, stone weight, yield, shape index) and chemical analyses (total acidity content, soluble solid content, sweetness index) were performed on the examined fruits varieties. The weight, thickness, and width of the fruit defined the 'Carmen' and 'Grey Star' varieties. The 'Regina' and 'Ferovia' varieties are distinguished by the content of soluble solids and sweetness index. The 'Kordia' variety is distinguished by the fruit flesh ratio and elongated shape of the fruit, as well as the length of the stalk, while the 'Burlat' variety is predominantly determined by the pH value of the juice.

Keywords: sweet cherry, fruit weight, fruit characteristics.

INTRODUCTION

Sweet cherry (*Prunus avium* L.) is a perennial fruit species and belongs to the Rosaceae family. Alongside strawberries, cherries represent the earliest seasonal fruit. The market value of cherry fruits is largely dictated by the quality of the fruit. The quality is reflected in its size and the weight of the fruit. The weight of the fruit can be singled out as the most important pomological characteristic, as it depends on a large number of other properties, primarily yield, which is the goal of every production (Kappel et al., 1996). They suggest that “perfect” cherry varieties should have a fruit weight of 11-12 g. The length of the stem is also of great importance in cherries and is an important characteristic in cherries because manual harvesting is easier with varieties that have longer stalk, and there is less incidence of fruit rot (Milatović et al., 2011). The length of the stem is very important for the manipulation and transportability of the fruits. It allows the fruits to stay fresh longer and represents a limiting factor during the transport of cherry fruits over longer distances. Cherry fruits are mainly used for table consumption, both in Serbia and around the world. However, cherry fruits can also serve as raw material in the food industry, for making jams, marmalades, and compotes, as well as for distillation, i.e., making alcoholic derivatives. The soluble solids content in some varieties grown in the Danube region varied from 12.7 to 19.0% (Nenadović-Mratinić 2009). The placement of cherry fruits on the market largely depends on the growing conditions, regularity of fruiting, timing of fruit ripening, as well as resistance to diseases and pests. The quality of the fruits is also greatly influenced by weather conditions, namely the presence of precipitation during fruit ripening. The ‘Burlat’ variety is not resistant to the occurrence of precipitation during the ripening and harvesting of fruits, therefore its fruits are prone to cracking when precipitation occurs during that period. The modern system of cherry cultivation is based on the appropriate choice of rootstock and variety, higher planting density, and the application of adequate pomotechnical measures (Rakićević et al., 2009). There is a large number of old and newly created cherry varieties in the world, but still, no variety is perfect (Nikolić et al., 1999). The aim of this research was to determine the pomological and technological characteristics of five different cherry varieties. All examined varieties were grafted onto the vegetative rootstock Gisela 5 and are located in a production orchard in Mačva. The results of the work are presented through the most important technological and pomological characteristics of the examined varieties, as well as the possibilities of their cultivation in a dense scope on the vegetative rootstock Gisela 5. The results of the research presented through the most important pomological characteristics of these varieties have the basic task of giving an exact assessment of the properties and possibilities of cultivating new varieties on the rootstock Gisela 5 in our conditions.

MATERIALS AND METODS

The research was conducted in a production orchard at the Lauš family farm in Krnule (N 44.5937586, E 19.761469166666668), during the vegetation period of 2022. The orchard was established in 2018. on the Gisela 5 vegetative rootstock. This study used six high-quality cherry varieties: ‘Burlat’, ‘Carmen’, ‘Grey Star’, ‘Kordia’, ‘Ferovia’, and ‘Regina’. The examination was carried out on 5 trees of each variety. The following parameters were analyzed: fruit weight, fruit dimensions, stone weight, yield (randman), fruit shape index, total acid content, soluble solids content, sweetness index, and fruit juice pH. The analyses were conducted in two parts; the first part involved pomological measurements of the fruits of the examined varieties, and the second part

their chemical analysis. The fruit measurements were performed in the microscopic laboratory of the Academy of Vocational Studies Šabac, and included measurements of fruit dimensions (length, width, height), fruit weight with and without the stone, and stalk length. The fruit weight was measured on an analytical scale, and the fruit dimensions were measured using a caliper. Calculations were performed on a sample of 50 fruits per variety. The stone weight and its proportion in the total fruit weight were calculated mathematically. Also, the fruit flesh and the fruit shape index were calculated using formulas. The fruit flesh was calculated by dividing the weight of the fruit without the stone by the weight of the fruit with the stone. The measurement of the fruit shape index was performed according to the following formula. The soluble solids content was measured using a digital refractometer (Atago Pocket, Japan). The method for total acid content is based on neutralization titration with a sodium hydroxide solution in the presence of the phenolphthalein indicator. The sweetness index of the fruits of the examined varieties was obtained mathematically, by the ratio between soluble solids content and the content of total acids. The pH value of the examined varieties was measured using a pH meter with an electrode (Geprüfte Sicherheit WTW pH530).

RESULTS AND DISCUSION

The examined varieties are listed in Table 1, arranged chronologically according to the ripening time. The weight of the cherry fruit is a complex characteristic that is influenced by many factors, most notably by the variety and the fruitfulness of the tree (Gonçalves et al., 2006), as well as by the degree of fruit maturity (Drake and Elfving, 2002).

Table 1. Fruit weight, stone weight and fruit flesh percent of different cherry varieties

Cultivar	Fruit weight (g)		Stone weight (g)		Fruit flesh percent (%)	
	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd
'Burlat'	10,50 c	0,85	0,92 c	0,11	91,13 b	1,09
'Grey Star'	12,74 b	1,07	1,21 b	0,34	90,49 bc	2,49
'Carmen'	13,98 a	1,62	1,34 a	0,23	90,29 bc	1,78
'Ferovia'	10,52 c	0,89	0,92 c	0,23	91,14 b	2,29
'Kordia'	10,57 c	1,17	0,65 d	0,90	93,82 a	0,74
'Regina'	9,96 c	1,40	0,98 c	0,20	90,00 c	2,18
a-c - different letters indicate statistically significant differences between cultivars at $p \leq 0.05$,						

After measuring, the fruit weight of the examined varieties ranged from 13.98 g ('Carmen') to 9.96 g ('Regina'), and similar results for the 'Regina' variety were obtained by Milatović et al. (2011). From the presented results obtained through processing and statistical analysis of the fruits, we can conclude that the 'Carmen' variety had the largest fruits compared to the other examined varieties. While in the varieties 'Burlat', 'Kordia', and 'Ferovia', there was no significant impact of the variety on the fruit weight. The proportion of the stone in the fruit weight varied and ranged from 6.18% ('Kordia') to 10.00% ('Grey Star'). Based on the classification made by Toth et al. (1996), only one variety had a medium stone proportion in the fruit weight (6 – 7.50%), which was the 'Kordia' variety (6.15%), while the other examined varieties had a high stone proportion in the fruit weight (over 7.50%). The fruit flesh of all examined varieties was over 90%. The variety with the lowest fruit flesh was 'Regina' (90.00%), and the 'Kordia' variety (93.82%) had the highest fruit flesh, which could be assumed based on the proportion of the stone in the fruit weight, which is statistically significantly different compared to the other examined varieties.

Table 2. Fruit length, width, thickness, shape index and stalk length of different cherry varieties

Cultivar	Fruit length (mm)		Fruit width (mm)		Fruit thickness (mm)		Fruit shape index		Stalk length (mm)	
	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd
'Burlat'	21,68 c	0,93	28,36 c	0,96	22,14 c	0,94	0,74 e	0,04	41,36 e	4,67
'Grey Star'	25,22 a	0,99	29,70 b	1,05	25,14 a	0,99	0,85 c	0,06	48,84 cd	5,83
'Carmen'	25,08 a	1,10	30,88 a	1,53	25,54 a	1,12	0,79 d	0,56	47,50 d	7,14
'Ferovia'	24,40 b	0,99	27,06 d	1,36	23,18 b	0,91	0,95 b	0,07	54,88 b	5,26
'Kordia'	25,74 a	1,81	27,02 d	1,69	21,40 d	1,49	1,15 a	0,11	58,22 a	6,33
'Regina'	23,84 b	0,95	25,94 a	1,63	22,86 b	0,85	0,96 b	0,63	52,12 bc	4,93

a-d - different letters indicate statistically significant differences between cultivars at $p \leq 0.05$,

For the 'Kordia' variety, the fruit length was the largest (25.74 mm), while the smallest fruit length was of the 'Burlat' variety (21.68 mm), where the research results did not significantly deviate from the results obtained by Kulina and Radović (2016) (Table 2). The fruit width ranged from the largest 30.88 mm ('Carmen') to 25.94 mm ('Regina'), slightly lower fruit width dimensions for the 'Regina' variety were obtained by Kulina and Radović (2016), as well as Milatović et al. (2011). The smallest measured fruit shape index was for the 'Burlat' variety (0.74), and the largest for the 'Kordia' variety (1.15), which can be confirmed by the results obtained by Milatović et al. (2013). Among the examined varieties, the stalk length ranged from 41.36 mm for the 'Burlat' variety to 58.22 cm for the 'Kordia' variety. The results obtained from the research differ from the research findings for the 'Kordia' variety by Milatović et al. (2011). Of the varieties examined, the majority had a long stalk (over 45 mm). Only the 'Burlat' variety had a medium-long stalk (41.36 mm). The total acid content (Table 3) is expressed through the content of malic acid in the examined fruits and ranged from 0.66 g/100 ml ('Burlat') to 0.97 g/100 ml ('Carmen'), identical research results for the 'Kordia' variety were obtained by Milatović et al., (2011).

Table 3. Soluble solids content, titratable acids, sweetness index and juice pH of different cherry varieties

Cultivar	Soluble solids content (°Brix)		Titratable acids (g/100 ml)		Sweetness indeks (TSS/TA)		Juicce pH	
	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd	$\bar{X}$	Sd
'Burlat'	15,95 d	0,02	0,66 e	0,01	23,94 a	0,57	3,96 ab	0,01
'Grey Star'	11,83 f	0,01	0,89 bc	0,01	13,25 c	0,21	3,65 b	0,28
'Carmen'	13,68 e	0,20	0,97 a	0,01	14,00 c	0,20	3,73 ab	0,01
'Ferovia'	17,31 c	0,02	0,84 c	0,01	20,44 b	0,33	3,88 ab	0,01
'Kordia'	17,59 b	0,03	0,72 d	0,02	24,34 a	0,81	3,75 ab	0,01
'Regina'	19,19 a	0,03	0,93 ab	0,02	20,50 b	0,55	3,98 a	0,01

a-e - different letters indicate statistically significant differences between cultivars at $p \leq 0.05$,

The soluble solids content in the fruits of the examined varieties ranged from the lowest in the 'Grey Star' variety (11.83) to the highest in the 'Regina' variety (19.19), almost identical results for the soluble solids content for the 'Regina' and 'Kordia' varieties were also obtained by Milatović et al. (2011), in their three-year study. Statistical processing of the data determined that there is a significant difference in the soluble solids content among all the examined varieties. It was confirmed that the soluble solid content is higher in varieties that ripen later compared to earlier ones.

Callahan (2003) and Coombe (1976) emphasize that taste is the most important factor in fruit quality. Regardless of its attractive appearance, fruit that does not taste good will not be repurchased by consumers. Consumers prefer fruit that is sweeter, with more intense flavors, and is firm but softens before eating. Based on the sweetness index, a large number of studied varieties (4 varieties) are classified in the second group with a sweetness index ranging from 18 to 32, indicating medium storage ability, while the remaining varieties (2 varieties) fall into the first group with a sweetness index less than 18, indicating they have a good storage ability. The variety with the lowest sweetness index of 13.25 is 'Grey Star', and the variety with the highest index of 23.94 is 'Burlat'. As for the pH value of the juice of the examined varieties, it ranged from 3.73 ('Carmen') to 3.99 ('Regina').

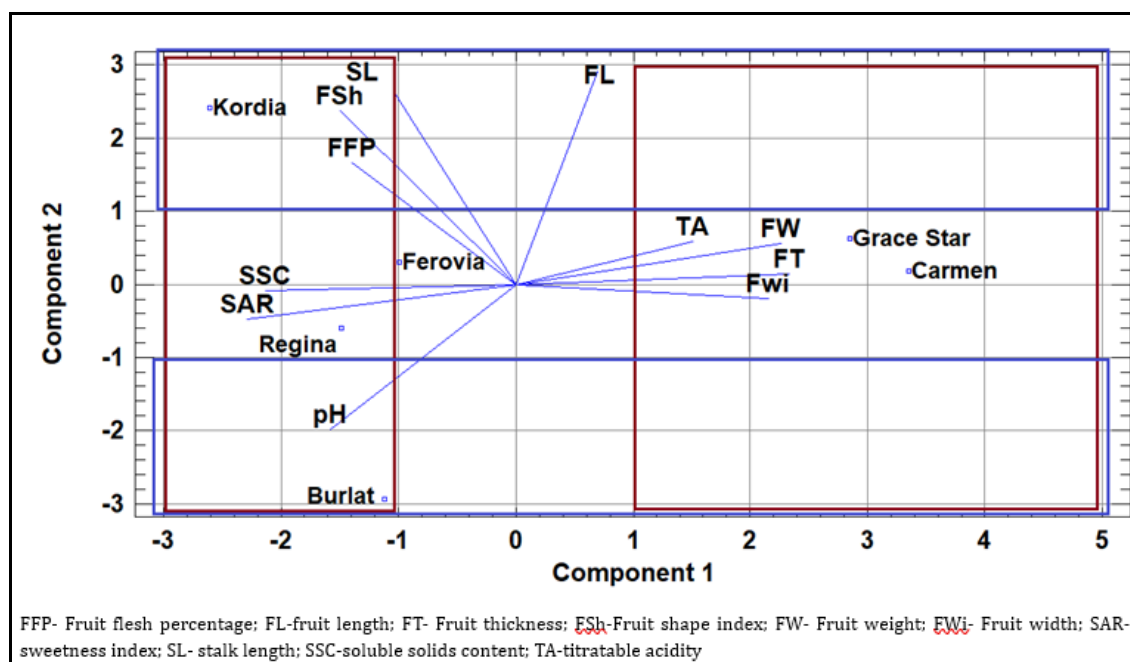


Figure 1. Principal component analysis (PCA) biplot depicting the relationship between examined variables and the cherry varieties

In the Figure 1 are presented results of the principal component analysis with relationship between examined variables and cherry varieties. The weight, thickness, and width of the fruit defined the 'Carmen' and 'Grey Star' varieties. The 'Regina' and 'Ferovia' varieties are distinguished by the content of soluble solids and sweetness index. The 'Kordia' variety is distinguished by the fruit flesh ratio and elongated shape of the fruit, as well as the length of the stalk, while the 'Burlat' variety is predominantly determined by the pH value of the juice.

CONCLUSION

Based on a one-year examination of the pomological and technological characteristics of six selected cherry varieties, the following conclusions were reached. Among the examined varieties, a significant difference in fruit weight was determined, primarily in the 'Carmen' variety (13.98 g) which stood out as the variety with the largest fruit. The fruit flesh of the examined varieties was statistically different, where the 'Kordia' variety (93.82%) took precedence over the other examined varieties. The greatest value of stalk length was observed in the 'Kordia' variety (58.22 mm), and the lowest in the 'Burlat' variety (41.36 mm).

The fruit shape index was the lowest in the 'Burlat' variety (0.74), and the highest in the 'Kordia' variety (1.15), leading to the conclusion that the shape index of the varieties ranged from round shape ('Burlat', 'Carmen'), then slightly flattened ('Grey Star', 'Ferovia', 'Regina') to elongated shape in the 'Kordia' variety. A significant difference in the soluble solids content was determined among all examined varieties, where the 'Regina' variety had the highest, and the 'Grey Star' variety had the lowest content. A statistically significant difference was also observed in the content of titratable acids where the 'Carmen' variety (0.97 g/100 ml) stood out compared to the other examined varieties, while the 'Burlat' variety (0.66 g/100 ml) had the lowest content. The sweetness index is an important factor when it comes to the consumptive value of the fruit, where the 'Burlat' variety stood out with the highest index (23.94), while the 'Grey Star' variety had the lowest index (13.25). Overall, the cherry varieties with the best characteristics for consumptive use and cultivation in our conditions can be recommended are 'Ferovia' and 'Regina'.

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ECONOMIC ASPECTS OF TOMATO PRODUCTION ON FAMILY FARMS IN THE REPUBLIC OF SERBIA

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ABSTRACT

Agriculture is one of the most important activities in the Republic of Serbia, and the production of vegetables, which is carried out on about 90,000 hectares, is of great importance for the total value of production and the participation of the agricultural sector in the country's GDP. According to the results of research conducted by the Institute for Science Application in Agriculture, in the period 2015-2019, one of the most profitable lines within the vegetable production is the production of tomatoes. The total area under tomatoes ranged between 7,000 and 10,000 hectares, while the production ranged between 110,000 and 170,000 tons, while the average yield ranged between 14.20-16.60 t/ha in the period above mentioned period. The gross margin of tomato production was between 1.5-2.1 million dinars per hectare.

The following methods were used in the present research calculation based on variable costs, sensitivity analysis, surveys and desk research. The aim of the paper is to show the trend of changes in the area under tomatoes, total and average yields of tomatoes based on the analyzes done, as well as to investigate the economic aspects of tomato production as one of the most represented vegetable crops in the Republic of Serbia. By applying sensitivity analysis, the impact of price and yield changes, as well as certain most common costs, on the amount of the gross margin in tomato production was determined. Based on all of the above, it was determined that the increase in price and yield led to a 77% increase of the gross margin in tomato production, while the decrease in price and yield led to a decrease of the gross margin by 60%. In the structure of variable costs, the costs of seedlings had the largest share (56.53 %), followed by the costs of contracted services (18.42 %).

Keywords: economic aspects, tomato production, gross margin, sensitivity analysis, family farms.

INTRODUCTION

The importance of the agricultural sector in the Republic of Serbia is reflected in its contribution to the country's economy, where the agricultural sector accounts for 8.2% of the total GDP, with 14.8% of the workforce employed in the agricultural sector. According to the data of the Statistical Office of the Republic of Serbia, in the structure of agricultural production, plant production has the dominant share of around 70%, while the production of vegetables is conducted on about 120,000 hectares, which is approximately 3.5% of total plant production. The key carriers of agricultural production are family farms. Small-scale farms prevail in the Republic of Serbia, boasting an average land size of 5.5 hectares, notably smaller than their peers in the EU. The vegetable production sector, characterized by its high intensity and profitability, holds considerable potential for driving agricultural sector growth (Petrović et al., 2021). However, its success is intricately tied to the overall level of economic development. Notably labor-intensive, vegetable production demands significant workforce engagement (Rajić et al., 2023). Vegetable production facilitates the efficient utilization of land and irrigation systems, allowing for the rotation of two to three types of vegetables throughout the year (Zdravković i sar., 2014; Cvijanović et al., 2023). In addition to outdoor production, vegetable production is also possible in unfavorable climatic conditions, thanks to the use of indoor production systems such as greenhouses (Moravčević, 2014; Ilin et al., 2014). Tomato is one of the most common vegetable plants both in the world and in the Republic of Serbia, being also one of the most profitable vegetable crops (Cvijanović et al., 2023).

The subject of this paper is an analysis of tomato production, as one of the most common vegetable crops in the Republic of Serbia, and the presentation of the economic aspects of this production on family farms. The aim of the research is to look at the profitability of tomato production based on the analysis of data.

MATERIAL AND METHODS OF WORK

This paper focuses on the analysis of data collected by the Institute for Science Application in Agriculture (ISAA) on the gross margin of tomato production. For the purpose of this research, 235 family farms ili households on which tomato production is dominant, were surveyed.

The analysis of areas and production of the tomato was made based on the data published by the Statistical Office of the Republic of Serbia. Gross margin analysis was made by using the data from a survey carried out by the Institute for Science Application in Agriculture. Comparisons of individual parameters were performed between two regions, Serbia North (includes the region of Vojvodina and the Belgrade region) and Serbia South (includes the region of Southern and Eastern Serbia and the region of Šumadija and Western Serbia) in accordance with the methodology applied by the Statistical Office of the Republic of Serbia. Using the collected data on gross margins, the economic aspects of tomato production on selected family farms were monitored and analyzed in order to improve the profitability of farms.

Gross margin is determined as the difference between the selling price per unit of product and variable costs per unit of product and it is the first indicator of profit potential, i.e. it indicates the contribution of each unit of product to the covering of the fixed costs and obtaining the gross profit (Gogić, 2014; Savić et al., 2020). There are two approaches to determining gross margin.

The first combines the value of production and total variable costs, and according to the second, the gross margin is determined as the difference between the value of externally sold products and variable costs that lead to an outflow of funds (Ivanović et al., 2018). For the purposes of this paper, gross margins were calculated according to the first approach.

RESULTS AND DISCUSSION

In the Republic of Serbia, tomatoes are grown on about 8,000 hectares, and the average yield is about 14 t/ha. Tomato production is possible both outdoors and in a protected area. Tomato is a very widespread food all over the world due to its multiple uses. In the Republic of Serbia, the largest part of the tomato yield is realized in greenhouse production, but outdoor production is also present. Greenhouse production is most prevalent in the territory of Leskovac, Mačva district and in the vicinity of Belgrade, so these are the places where the largest quantities of tomato are produced.

Table 1. Areas under tomato in the Republic of Serbia and the regions of Serbia North and Serbia South for the period 2015-2019

Regions	Republic of Serbia			Serbia North			Serbia South		
Year	Land area (in ha)	FBIN* (%)	CBIN** (%)	Land area (in ha)	FBIN* (%)	CBIN** (%)	Land area (in ha)	FBIN* (%)	CBIN* (%)
2015	8,869	-	-	3,504	-	-	5,365	-	-
2016	10,065	113.49	113.49	4,014	114.55	114.55	6,051	112.79	112.79
2017	10,917	123.09	108.46	4,362	124.49	108.67	6,555	122.18	108.33
2018	8,629	97.29	79.04	3,218	91.84	73.77	5,411	100.86	82.55
2019	7,888	88.94	91.41	2,818	80.42	87.57	5,070	94.50	93.70

* Fixed base index numbers

** Chain base index numbers

Source: Authors' calculation based on data collected from the ISAA survey on selected family farms

Table 1 gives an overview of the areas under tomatoes in the Republic of Serbia, as well as in regions of Serbia North and Serbia South in the period 2015-2019, as well as calculated fixed and chain base indexes. Based on the data presented, it can be seen that the area under tomatoes was the largest in 2017 and amounted to 10,917 hectares, while it was the smallest in 2019, when amounted to 7,888 hectares. In 2019, the area under tomatoes was 11.06% less compared to the base year of 2015. The area under tomatoes in the regions of Serbia North and Serbia South changed in proportion to the changes in the territory of the whole of Serbia, so the largest area under tomatoes in the region Serbia South amounted to 6,555 hectares, and in the region Serbia North 4,362 hectares in 2017, when also the area under tomatoes was the largest in the entire country in the analyzed period. Since in 2019 the smallest areas under tomatoes were recorded on the territory of the entire country, it was also the case for the region of Serbia North and Serbia South. In 2019, in the region of Serbia North, the area under tomatoes was at the level of 2,818 hectares, and in the region of Serbia South at the level of 5,070 hectares. Based on these data, it can be concluded that the areas under tomatoes, in the analyzed period, are larger in the region of Serbia South (about 60% of the total area under tomatoes) than in the region of Serbia North.

According to the chain index calculations, the largest increase in the area under tomatoes occurred in 2016, accounting for 13.49%, while the largest decrease was in 2018, which was 20.96% compared to the previous year.

The decrease in the area under tomatoes was more pronounced in the region of Serbia North, which is confirmed by the fact that in 2019 there were 20% fewer hectares under tomatoes compared to 2015, while the decrease in the region of Serbia South amounted to only 5.5%.

Table 2. Tomato production in the Republic of Serbia, regions of Serbia North and Serbia South for the 2015-2019 period

Region	Republic of Serbia			Serbia North			Serbia South		
Year	Yield (t)	FBIN (%)	CBIN (%)	Yield (t)	FBIN (%)	CBIN (%)	Yield (t)	FBIN (%)	CBIN (%)
2015	147,021	-	-	78,202	100.00	-	68,819	-	-
2016	160,456	109.14	109.14	86,799	110.99	110.99	73,657	107.03	107.03
2017	170,764	116.15	106.42	93,666	119.77	107.91	77,098	112.03	104.67
2018	131,869	89.69	77.22	68,254	87.28	72.87	63,615	92.44	82.51
2019	111,639	75.93	84.66	56,123	71.77	82.23	55,516	80.67	87.27

Source: Authors' calculation based on data collected from the ISAA survey on selected family farms

Table 2 shows the production of tomatoes in the analyzed period 2015-2019 in the Republic of Serbia and the regions of Serbia North and Serbia South. The highest production in the Republic of Serbia was achieved in 2017, when 170,764 tons of tomatoes were produced, while the lowest production was recorded in 2019 and was at the level of 111,639 tons. Looking at individual regions, the highest production was also achieved in the region of Serbia North in 2017, when it amounted to 93,666 tons of tomatoes, as well as in the region of Serbia South, when 77,098 tons of tomatoes were produced. Taking into account the areas where tomatoes are grown in the Serbia North and Serbia South regions, it can be concluded that the production in the Serbia North region is significantly higher compared to the Serbia South region. The share of area in the North Serbia region amounts to about 40% of the total area under tomatoes, and 55% of the total production of tomatoes in the Republic of Serbia is produced in North Serbia. As for the total yield of tomatoes, it can be concluded that there is a decrease in total production, which is primarily the result of a decrease in the area under this crop. Given that there was a significant reduction in the area under tomatoes in the region Serbia North, the total production of tomatoes in both regions was equal in 2019.

The indicators obtained by calculating the base index show that the most significant deviation in the amount of tomatoes produced in the Republic of Serbia was in 2019, when the total production decreased by 24.07% compared to the base year 2015, while the most significant increase was recorded in 2017, and was 16.15%. The indicators obtained by calculating the base indices for the regions of Serbia North and Serbia South match the indicators obtained for the territory of the entire country. In both regions, the most significant increase in produced quantities, compared to the base year of 2015, was recorded in 2017, and amounted to 10.99% in the region of Serbia North, and 7.03% in the region of Serbia South. The largest decrease in produced quantities was recorded in 2019, which amounted to 28.23% in the region of Serbia North, and to 19.33% in the region Serbia South. Looking at the chain indices, it can be concluded that the changes by regions also follow the changes that occurred at the level of the Republic of Serbia. The largest increase in the quantity of produced tomatoes occurred in 2016, when in both regions, and on the territory of the entire country, it amounted to about 10%.

The largest decrease in the produced quantities occurred in 2018, when in the territory of the Republic of Serbia there was a decrease in production by 22.78% compared to the previous year. At the regional level, these reductions were smaller, in the region Serbia North 12.78% and in the region Serbia South 17.49%.

Table 3. Average tomato yield in the Republic of Serbia, regions of Serbia North and Serbia South for the 2015-2019 period

Region	Republic of Serbia			Serbia North			Serbia South		
Year	Yield (t/ha)	FBIN (%)	CBIN (%)	Yield (t/ha)	FBIN (%)	CBIN (%)	Yield (t/ha)	FBIN (%)	CBIN (%)
2015	16.60	-	-	22.30	-	-	12.80	-	-
2016	15.90	95.78	95.78	21.60	96.86	96.86	12.20	95.31	95.31
2017	15.60	93.98	98.11	21.50	96.41	99.54	11.80	92.19	96.72
2018	15.30	92.17	98.08	21.20	95.07	98.60	11.80	92.19	100.00
2019	14.20	85.54	92.81	19.90	89.24	93.87	10.90	85.16	92.37

Source: Authors' calculation based on data collected from the ISAA survey on selected family farms

Average tomato yields recorded a constant decline in the analyzed period. The highest average yield of tomatoes on the territory of the Republic of Serbia was achieved in 2015, when it was 16.60 t/ha, and in the same year, the highest average yields were also achieved in the regions of Serbia North (22.30 t/ha) and Serbia South (12.80 t/ha) (Table 3). The lowest average tomato yield was achieved in 2019, when it was 14.20 t/ha at the level of the Republic of Serbia. By comparing the average yields in the regions of Serbia North and Serbia South, it is noticeable that the yields in the region Serbia North are significantly higher, by about 45%. The reason for higher yields is primarily due to more favorable climatic conditions (temperature and sunshine), as well as irrigation, which is much easier to provide in the territory of Vojvodina than in the rest of Serbia, due to the great river potential and suitable terrain.

By analyzing the indicators obtained based on the calculation of base indices, it can be concluded that the average yield of tomatoes in the territory of the Republic of Serbia is constantly decreasing. Thus, in 2019, the average yield was by 14.46% lower compared to 2015. A constant decrease in the average yield also occurs in individual regions of Serbia North and Serbia South. The largest decrease in the average yield, which was expressed through indicators of base indices, was recorded in the region of South Serbia, so in 2019, compared to the base year 2015, a decrease of 14.84% was recorded, which is close to the decrease at the level of the entire country, while the largest decrease in the same year in the region of North Serbia was 10.76%. The indicators obtained by calculating the chain indices also show a decrease in the average yield of tomatoes for each analyzed year. The chain indices calculation showed that the largest decrease in the average yield was recorded in 2019, both in the territory of the Republic of Serbia and in the regions of Serbia North and Serbia South. Compared to 2018, in 2019, the average yield in the territory of the Republic of Serbia, decreased by 7.19%, in the region of Serbia North by 6.13%, and in the region of Serbia South by 7.63%.

According to the calculations based on variable costs in the production of tomatoes on family farms in the Republic of Serbia for the analyzed period 2015-2019, average annual production value, variable costs and gross margin were calculated. Changes of financial indicators of tomato production, based on calculations from variable cost calculations for 1 hectare, are shown in table 4.

Table 4. Economic indicators of tomato production for the 2015-2019 period
(calculation for 1 hectare)

Year	2015	2016	2017	2018	2019
Production value (RSD)	3,247,666.67	3,118,794.44	2,905,340.48	2,991,860.95	4,074,818.18
FBIN (%)	100.00	96.03	89.46	92.12	125.47
CBIN (%)	100.00	96.03	93.16	102.98	136.20
Variable costs (RSD)	1,178,514.10	1,226,457.88	1,369,428.57	1,285,035.55	1,987,284.13
FBIN (%)	-	104.07	116.20	109.04	168.63
CBIN (%)	-	104.07	111.66	93.84	154.65
Gross margin (RSD)	2,069,152.57	1,892,336.56	1,535,911.91	1,706,825.40	2,087,534.05
FBIN (%)	100.00	91.45	74.23	82.49	100.89
CBIN (%)	100.00	91.45	81.16	111.13	122.31
Share of gross margin in production value (%)	63.71	60.68	52.87	57.05	51.23

Source: Authors' calculation based on data collected from the ISAA survey on selected family farms

Table 4 shows the most significant financial indicators from the calculation of variable costs of tomato production for the period 2015-2019 (calculated for 1 hectare). The value of tomato production in 2015 amounted to 3,247,666.67 dinars/ha, while it recorded a decline in the next three years. In 2019, there was an increase in the value of production, when at the same time the highest value of tomato production was achieved in the amount of 4,074,818.18 dinars/ha. Observing the indicators calculated on the basis of base indices, it can be concluded that in 2019 the value of production increased by 25.47% compared to the base year of 2015. In the other analyzed years, a decrease in the production value was recorded compared to the base year (in 2016 by 3.97%, in 2017 by 10.54%, in 2018 by 7.88%). Indicators obtained on the basis of chain indices show that in 2016, compared to 2015, the value of production decreased by 3.97%. In 2017, the value of production was 6.84% lower compared to 2016, while in 2018, there was a slight increase in the value of production compared to 2017 by 2.98%. The biggest increase between the analyzed years was in 2019, when the value of tomato production was 36.20% higher compared to 2018.

Variable costs recorded a continuous increase compared to the base year 2015. In 2015, the lowest variable costs of tomato production were achieved and amounted to 1,178,514.10 din/ha, while the highest were in 2019 when they amounted to 1,987,284.13 din/ha. The fixed and chain base indices show that in 2016 variable costs were 4.07% higher compared to the base year 2015, while in 2017 there was an increase in variable costs compared to the base year by 16.20%, and compared to the previous year by 11.66%.

In 2018, there was an increase in variable costs by 9.04% compared to the base year 2015, and 6.16% decrease compared to the previous year. In 2019, variable costs were the highest, i.e. by 68.63% higher compared to the base year and by 54.65% higher compared to the previous year.

The gross margin for tomato production was the highest in 2019, when it amounted to 2,087,534.05 dinars/ha, and a similar result was achieved in 2015. In other years, the gross margin was lower, while the lowest value was recorded in 2017, when it amounted to 1,535,911.91 dinars/ha. The indicators obtained based on the calculation of base indices show that the gross margin in tomato production was in constant decline in all analyzed years, except in 2019 when it was at the level of 2015. In 2016, the gross margin was 8.55% lower compared to the base year. In the following two years, it recorded even greater reductions, in 2017 by 25.77%, and in 2018 by 17.51%. The indicators obtained based on the calculation of chain indices show that the biggest changes between the observed years were recorded in 2017, when the gross margin decreased by 18.84% compared to the previous year. Also, a more significant change occurred in 2019, when the gross margin increased by 22.31% compared to the previous year.

Based on the obtained ili collected financial indicators of tomato production on farms in the Republic of Serbia in the period 2015-2019, it can be concluded that the indicator of the participation of the gross margin in the value of tomato production was the highest in 2015, when it amounted to 63.71%. This indicator was significantly higher in 2015 compared to 2019, when higher production value and gross margin were achieved, but the share of gross margin in production value was the lowest in the analyzed period and amounted to 51.23% of production value. This was due to the faster increase in variable costs compared to the increase in the value of production.

In the period 2015-2019, the selling price of tomatoes, achieved by the family farms included in the survey, ranged from 35.93 to 48.07 dinars/ha. The lowest price of tomatoes was in 2017, while the highest was in 2019. Based on this fact, it can be concluded that the yield had a significant impact on the gross margin values, because the price in certain years was higher compared to 2015, while the gross margin was lower. The selling price of tomatoes was 38.97 din/ha in 2015, 40.36 din/ha in 2016 and 46.86 din/ha in 2018.

In the sensitivity analysis of the gross margin of the most represented vegetable crops in the Republic of Serbia for the period 2015-2019, it was shown how the gross margin in the production of the analyzed five types of vegetables changes with the changes that occur in the factors that form the value of production and variable costs. When it comes to the value of production, it was analyzed how changes in prices and yields affect the change of the gross margin. The sensitivity analysis took into account the absolute changes in prices and yields, if the mentioned parameters change by 10% or 20%. This kind of analysis is needed primarily because of the seasonal character of tomato production, and the price variations that arise as a consequence (Petrović et al., 2022).

Analysis of sensitivity of gross margin to changes in prices and yields in tomato production for the period 2015-2019, based on the five-year price average, yield and gross margin realized on the surveyed farms, is shown in Table 5.

Table 5. Sensitivity analysis of gross margin in tomato production according to changes in prices and yields

Yield (kg/ha)		Price (RSD/kg)				
		-20%	-10%	Average	+10%	+20%
		33.63	37.84	42.04	46.24	50.45
-20%	62,463.54	676,666.93	939,263.63	1,201,860.34	1,464,457.04	1,727,053.75
-10%	70,271.48	939,263.63	1,234,684.92	1,530,106.22	1,825,527.51	2,120,948.81
Average	78,079.42	1,201,860.34	1,530,106.22	1,858,352.10	2,186,597.98	2,514,843.86
+10%	85,887.36	1,464,457.04	1,825,527.51	2,186,597.98	2,547,668.45	2,908,738.92
+20%	93,695.30	1,727,053.75	2,120,948.81	2,514,843.86	2,908,738.92	3,302,633.98

Source: Authors' calculation based on data collected from the ISAA survey on selected family farms

Based on collected surveys of gross margins on farms where tomato is the dominant crop for the period 2015-2019, the average price, average yield and average gross margin in tomato production were calculated. The average price of tomatoes for this five-year period was 42.04 dinars/kg, the average yield was 78,079.42 kg/ha, while the average gross margin in tomato production was 1,858,352.10 dinars/ha. As it could be expected, when reducing the price of tomatoes and yield by 20%, there is a significant reduction in the amount of gross margin in tomato production - by about 65%, while due to an increase in price and yield by 20%, there is an increase in the value of the gross margin by about 77%. Based on this, it can be concluded that price and yield changes significantly affect the gross margin in tomato production.

CONCLUSIONS

Tomato production in Serbia was carried out on about 8,000 hectares in the period 2015-2019, with minor fluctuations in covered area for individual years. In 2017, the area under tomatoes was the largest (10,917 hectares), while in 2019 it was at the level of 7,888 hectares. In the region of Serbia South area under tomatoes was larger than in the region of Serbia North. The total production of tomatoes was declining, both due to the reduction of area under this crop, and to the drop in the average yield. The average tomato yield in 2019 was 14.20 t/ha, which was about 2.5 t/ha less than in 2015, when the highest average yield was also recorded. The value of gross margin for tomato production varied in the analyzed period and ranged from about 1,500,000 din/ha to slightly more than 2,000,000 din/ha. The highest value of gross margin in tomato production was recorded in 2019, when also the highest price was achieved, as well as the highest average yield on the analyzed farms. Price and yield have a significant impact on the amount of gross margin in tomato production as well. Based on the sensitivity analysis, it was determined that an increase in prices and yields led to an increase of the gross margin by 77%, while a decrease in prices and yields led to a gross margin decrease by about 60%. Based on all of the above, it can be concluded that the production of tomatoes on family farms in the Republic of Serbia is profitable, and that the gross margin is increasing year by year. Also, it was determined that the gross margin, and thus the profitability of this production, mostly depend on the price and the realized yield, which was proven by sensitivity analysis. For this reason, the recommendation to producers is not to save money on inputs that are needed in production, in order to ensure a good yield and quality of the product, which will result in a high price, because the yield and price are more important to the realized profit

than the variable costs. Also, something that tomato producers should pay attention to, especially when it comes to production in a protected area, is the availability and cost of labor. It is precisely the availability of labor that is the main cause of the decrease in the area under tomatoes in the analyzed period. The recommendation would be for the majority of activities to be carried out by members of the family farm, with minimal involvement of additional labor, and production should be coordinated with the capabilities of members of the family farm, given that it is a highly intensive production. Tomato producers should also pay attention to the seasonal character of production, where the production of tomatoes on much smaller areas in a protected area could bring a higher profit in the second quarter of the year, compared to the production of tomatoes during the summer in the open field, when it is current and significant import of this product from the surrounding countries (Republic of North Macedonia, Greece and Albania), at significantly lower prices. As a main conclusion, it can be said that tomato production is sustainable, and that with good organization of work within the family farm, it can bring significant profit that can have an impact on the survival of the family farm as a whole.

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PURPLE-LEAF LETTUCE CULTIVAR SEEDLING PRODUCTION UNDER DIFFERENT LIGHT TREATMENTS

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ABSTRACT

One of the major challenges in the production of lettuce (*Lactuca sativa* L.) seedlings is to get quality seedlings, which can be difficult in conditions of low light. This paper aimed to study the effects of multispectral white and monochromatic blue light-emitting diodes (LEDs) lighting on development and chlorophyll content in *Viola* curly purple-leaf lettuce cultivar seedlings, compared to standard cultivation in greenhouses. The research was performed in December 2023/January-February 2024 at the Institute for Vegetable Crops Smederevska Palanka, Serbia. Seeds were sowed in containers filled with commercial substrate. In the phase of three leaves, six containers with plants were placed in phytochambers (three containers per LED), while three containers were kept in the greenhouse for control. Plants were cultured in phytochambers for 25 days with a 9/15 h and 10/14 h (light/dark) photoperiod, to simulate outdoor conditions. Morphological growth parameters were measured after 11 and 25 days, while chlorophyll content was measured after 4, 11, 18 and 25 days. Results of this study show that plants' morphological parameters and chlorophyll content were significantly influenced by LEDs. During lettuce cultivation in phytochambers, it is necessary to be cautious regarding lighting duration. Our results indicate that extended exposure to LEDs negatively affects *Viola* lettuce seedlings' development, leading to plant elongation and deformation. Such seedlings are not able to grow into healthy and quality plants. Additionally, extended artificial illumination affects one of the most advantageous traits of the *Viola* lettuce cultivar - purple leaves. Exposure to LEDs for more than 10 days leads to the loss of anthocyanin, and accordingly purple color in leaves. In order to produce quality seedlings, we recommend exposing *Viola* lettuce cultivar seedlings to monochromatic blue and multispectral white LEDs only for four and 10 days, respectively.

Keywords: *Viola* cultivar, LED light, plant development, chlorophyll, cultivation.

INTRODUCTION

The lettuce (*Lactuca sativa* L.) belongs to the family Asteraceae, which includes about 32 000 currently recognized species. This is the most cultivated plant worldwide and one of the most consumed vegetables in the human diet (Perez-Lopez et al., 2013; Kim et al., 2016). According to the Food and Agriculture Organization of the United Nations, the global lettuce reached 29 million tones. The most production is reached in China, followed by United States, Spain, Italy, and Japan.

The increasing global population and projected rise in urban residents have led to a high demand for vegetables, particularly lettuce. Due to the increasing population, there is a greater demand for vegetables and products grown on arable land (Kozai, 2016). In many world regions, lettuce is commercially produced outdoors, but in recent years, indoor lettuce gardening has become an important trend in commercial horticulture. Indoor lettuce production in protected and controlled environments can reduce threats related to outdoor output and offer the ability to produce vegetables during the cold season (Zabeltitz, 1986).

One of the major factors affecting lettuce cultivation is light (Smith, 1982). Light intensity and quality are especially important as they provide energy for photosynthesis and influences signaling pathways that regulate plant growth and development in the complex process of photomorphogenesis, including seeds germination, phototropism, and flowering time (Fan et al., 2013; Son and Oh, 2013, 2015; Huché-Thelier et al., 2016; Urestarazu et al., 2016; Hasan et al., 2017). In nature, plants utilize light to adapt their morpho-anatomical and physiological features and regulate gene expression to adapt to the ever-changing light conditions in their environment effectively (Landi et al., 2020). Under low-light greenhouse conditions, such are those found in Balkans during the winter, lettuce growth can be slow. Therefore, setting up appropriate light intensities is one of the major challenges in lettuce production during winter.

The cultivation and transplanting of seedlings are commonly used in agriculture for cultivating vegetables and economic crops. Therefore, producing high-quality seedlings is crucial for efficient plant cultivation, which provides numerous benefits including control of growing conditions, disease and pest management, plant breeding opportunities, efficient land usage, transplanting flexibility and precise timing for planting and harvesting (Balliu et al., 2017; Dusadeerungsikul et al., 2020). Lettuce can be successfully grown in controlled indoor growing systems owing to its small size and relatively short growing period (Xu, 2019). However, one of the major challenges in lettuce production is getting high-quality seedlings, as it can be difficult in conditions of low light. Although quality, quantity and duration of light are controlled in greenhouses (Gruda, 2005), due to greenhouse glazing material, superstructure, and shading, the ambient photosynthetic daily light can be reduced by up to 50% (Hanan, 1998).

The effects of light quality on managing lettuce growth and development have been extensively studied and reviewed (Chen et al., 2004; Möglich et al., 2010; Shu et al., 2016; Yadav et al., 2020; Farooq et al., 2022). Numerous studies have shown that the potential of light-emitting diodes (LEDs) represents an effective light source for indoor horticulture production (Bula et al., 1991; Muneer et al., 2014; Naznin et al., 2016; Wang et al., 2016; Paz et al., 2019; Xu, 2019; Tsai et al., 2021; Chen et al., 2023; Hernández-Adasme et al., 2023; Jin et al., 2023; Miao et al., 2023). However, few studies and reviews have assessed the role of light quality on young seedling development (Yadav et al., 2020; Frąszczak and Kula-Maximenko, 2021; Hernández-Adasme et al., 2022; Wei et al., 2023).

This paper aimed to study the effects of multispectral white and monochromatic blue light-emitting diodes (LEDs) on the development and chlorophyll content in *Viola* curly purple-leaf lettuce cultivar seedlings, compared to standard cultivation in greenhouses with the purpose of reaching a commercial plant seedling.

MATERIAL AND METHODS OF WORK

The research was performed during December 2023/January-February 2024 at the Institute for Vegetable Crops Smederevska Palanka, Serbia (44°22' N, 20°47' E, 110 m above sea level). This study used commercial curly purple-leaf lettuce (*L. sativa* var. *capitata* L.) variety *Viola* obtained from the Institute for Vegetable Crops Smederevska Palanka (Serbia) as plant material. This is a medium luxuriant, intensely colored leafy type of lettuce, with a wrinkled surface and rim of the leaf. Primary leaves are large and flat with the surface of the soil. The rosette is dark in color, with large leaves covered with anthocyanin. The lettuce variety *Viola* belongs to the early maturing spring salads. The average time for maturity reached is 65 days. This variety blooms slowly into a flowering tree.

Seeds were sown in 9 styrofoam containers, with 104 seeds per container. The containers were filled with the commercial substrate (Pindstrup Mosebrug A/S, Denmark). In the phase of three leaves, six containers with plants were placed in phytochambers (three containers per LED), while three containers were kept in the greenhouse for control. For lighting in phytochambers, we used light-emitting diodes (LEDs): multispectral white light (MWL, 350-700 nm) and monochromatic blue light (MBL, 440 nm). Plants were grown in the phytochambers for 25 days at a temperature of $23 \pm 2^{\circ}\text{C}$ with 9/15 h and 10/14 h (light/dark) photoperiod to simulate outdoor conditions.

Morphological growth parameters, such as the number of leaves and biomass, were measured on the 11th and 25th days after the plant removal to phytochambers. Plant biomass was measured using an IoT-Line Precision Balance 572-31 technical scale (Kern & Sohn GmbH, Germany). Chlorophyll content was measured on the 4th, 11th, 18th and 25th days after plant removal to phytochambers, using a Portable Chlorophyll Meter CM-B (BioBase Industry, Shandong, Co., Ltd). The measurements are expressed in SPAD units. Measurements were performed on three containers per light condition and on five plants per container. The plants left in greenhouse conditions were analyzed at the same time and in the same way.

A two-factor ANOVA analysis model was used to examine the influence of the type of light and length of lighting on lettuce morphological and chemical properties. Duncan's test was performed to determine the significance of mean differences ($p < 0.05$) between the type of light and length of plant exposure using SPSS software version 22.0 (IBM Corporation, New York, NY, USA). Different lowercase letters (a, b, c) denote statistically significant differences ($p < 0.05$) between the type of light. Different uppercase letters (A, B) denote statistically significant differences ($p < 0.05$) between the length of plant exposure to different light.

RESULTS AND DISCUSSION

Results of our research indicate that the number of leaves and the biomass of the *Viola* lettuce seedlings were significantly influenced by the type of light and the length of exposure of the plants. In addition to the individual influence, the interaction of these factors had a statistically significant effect on lettuce biomass (Table 1).

Table 1. Analysis of variance for leaf number and biomass of *Viola* lettuce seedlings

Source of variation	df	Leaf number			Plant biomass (g)		
		SS	SM	F	SS	SM	F
Lighting (L)	2	15.267	7.633	13.928**	5.304	2.652	53.02**
Replications	4	0.556	0.139	0.253 ^{ns}	0.347	0.087	1.734 ^{ns}
Exposure length (E)	1	23.511	23.511	42.899	4.862	4.862	97.2**
L × E	2	2.822	1.411	2.575 ^{ns}	0.780	0.39	7.801
Error	80	43.844	0.548		4.002	0.05	
Total	89	86.000			15.296		

**Significant at $p = 0.01$ level, ^{ns}Non significant

As a key environmental factor, light can play both positive and negative roles in plant growth, morphology and metabolism regulation (Ruban, 2015; Landi et al., 2020; Ptushenko et al., 2020; Samuolienė et al., 2021). In our research, the lowest biomass and number of leaves were found in plants grown under daily light in greenhouse conditions (Figures 1 and 2). Long-term exposure to MBL may influence plant growth and development and induce changes in photosynthesis (Huché-Thelie et al., 2016). In our research, lettuce exposure to MWL and MBL positively affected morphological growth parameters. After 11 days of growing in phytochambers with a 9/15 h (light/dark) photoperiod, the *Viola* lettuce variety achieved the highest biomass under MBL. The number of leaves in plants grown under MWL and MBL was significantly higher compared to plants grown in the greenhouse conditions.

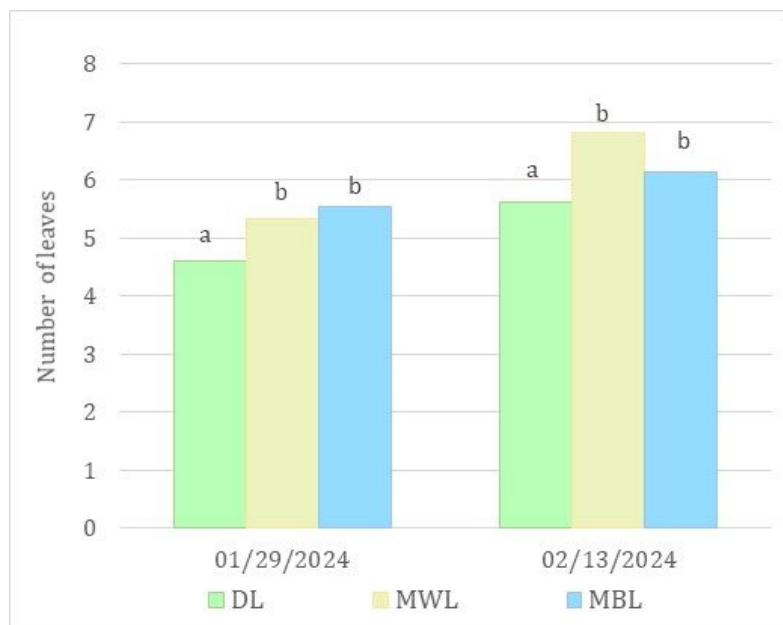


Figure 1. Average values of the number of leaves in *Viola* lettuce seedlings grown under daily light (DL), multispectral white light (MWL) and monochromatic blue light (MBL).

Note: Different lowercase letters within column (a, b) denote statistically significant differences ($p < 0.05$) between the type of light.



Figure 2. Average values of biomass in *Viola* lettuce seedlings grown under daily light (DL), multispectral white light (MWL) and monochromatic blue light (MBL)

Note: Different lowercase letters within column (a, b, c) denote statistically significant differences ($p < 0.05$) between the type of light.

From the 11th to the 25th day, the plants were grown under an extended light regime of 10/14 h (light/dark) photoperiod, which corresponded to the light regime of the plants grown in the greenhouse. After that, the plants were analyzed again. The obtained results indicated that the plants grown in phytochambers had a significantly higher number of leaves and biomass compared to the plants grown in the greenhouse (Figures 1 and 2). In studies by Ohaski et al. (2007), Matysiak and Kowalski (2019), and Arif (2022), plants grown under MWL had a higher number of leaves relative to MBL, but similar plant biomass. In our research, there was no difference in biomass and number of leaves between plants exposed to MWL and MBL (Figures 1 and 2). However, exposure of *Viola* lettuce variety seedlings to MBL for more than 10 days negatively affected growth and development, causing stem elongation (creeping stems) and deformation of plants.

In our research, it was observed that different types of light, length of plant exposure, and their interaction also influenced the chlorophyll content in lettuce seedlings (Table 2, Figure 3).

Four days after *Viola* lettuce seedlings exposure to LEDs, no significant difference regarding chlorophyll content was observed between seedlings grown in phytochambers under MWL and MBL. However, seedlings grown under MWL and MBL had significantly higher chlorophyll content compared to those grown under natural daily light in greenhouse conditions. The highest chlorophyll content was measured in seedlings grown under MWL 11 days after seedlings exposure, while plants grown under MBL and daily light had significantly lower chlorophyll content. However, during these 11 days, the gradual loss of purple color due to reduced anthocyanin synthesis was noticed in leaves of lettuce seedlings grown under MWL, especially MBL (Figure 4a-d).

Table 2. Analysis of variance for chlorophyll content (SPAD units) in *Viola* lettuce seedlings

Source of variation	Chlorophyll content (SPAD units)			
	SS	df	MS	F
Lighting (L)	331.059	2	165.53	17.921**
Replications	4.114	4	1.029	0.111 ^{ns}
Exposure length (E)	1200.647	3	400.216	43.329**
L × E	545.784	6	90.964	9.848**
Error	1514.806	164	9.237	
Total	3596.409	179		

**Significant at $p = 0.01$ level, ^{ns}Non significant

According to Landi et al. (2020), MBL causes a decrease in chlorophyll content in many species. The results of our research did not support that statement. Throughout the experiment, we observed that lettuce seedlings grown under MBL for 18 days had the highest chlorophyll content. Similarly, Arif (2022) determined that plants grown under MBL had the highest relative chlorophyll amount. After 25 days of our research, there was no significant difference in chlorophyll content between seedlings grown under MWL and MBL. However, the chlorophyll content in these seedlings was significantly higher compared to the seedlings grown under daily light in greenhouse conditions.



Figure 3. Average values of chlorophyll content (SPAD units) in *Viola* lettuce seedlings grown under daily light (DL), multispectral white light (MWL) and monochromatic blue light (MBL)

Note: Different lowercase letters within column (a, b, c) denote statistically significant differences ($p < 0.05$) between the type of light. Different uppercase letters within column (A, B) denote statistically significant differences ($p < 0.05$) between the length of plant exposure to different light.

Despite the benefits of using MWL and MBL lighting for growing lettuce seedlings, including increased leaf number, biomass, and chlorophyll content, there are also some disadvantages. Extended exposure to LED lights can have a negative impact on the development of *Viola* lettuce seedlings, causing stem elongation and plant deformation (Figure 4e). This results in seedlings that are unable to grow into healthy and high-quality plants. Consumers prioritize leaf color as the foremost visual aspect when making a purchase decision. In that context, *Viola* lettuce seedlings grown under MWL and MBL did not achieve a satisfactory purple color. The extended artificial illumination with LEDs caused stress and led to a complete loss of purple color in *Viola* lettuce seedling leaves 10 days after exposure (Figure 4d). However, after seedling planting into natural daily light, all the plants that previously lost their purple color, have recovered it (Figure 4f).

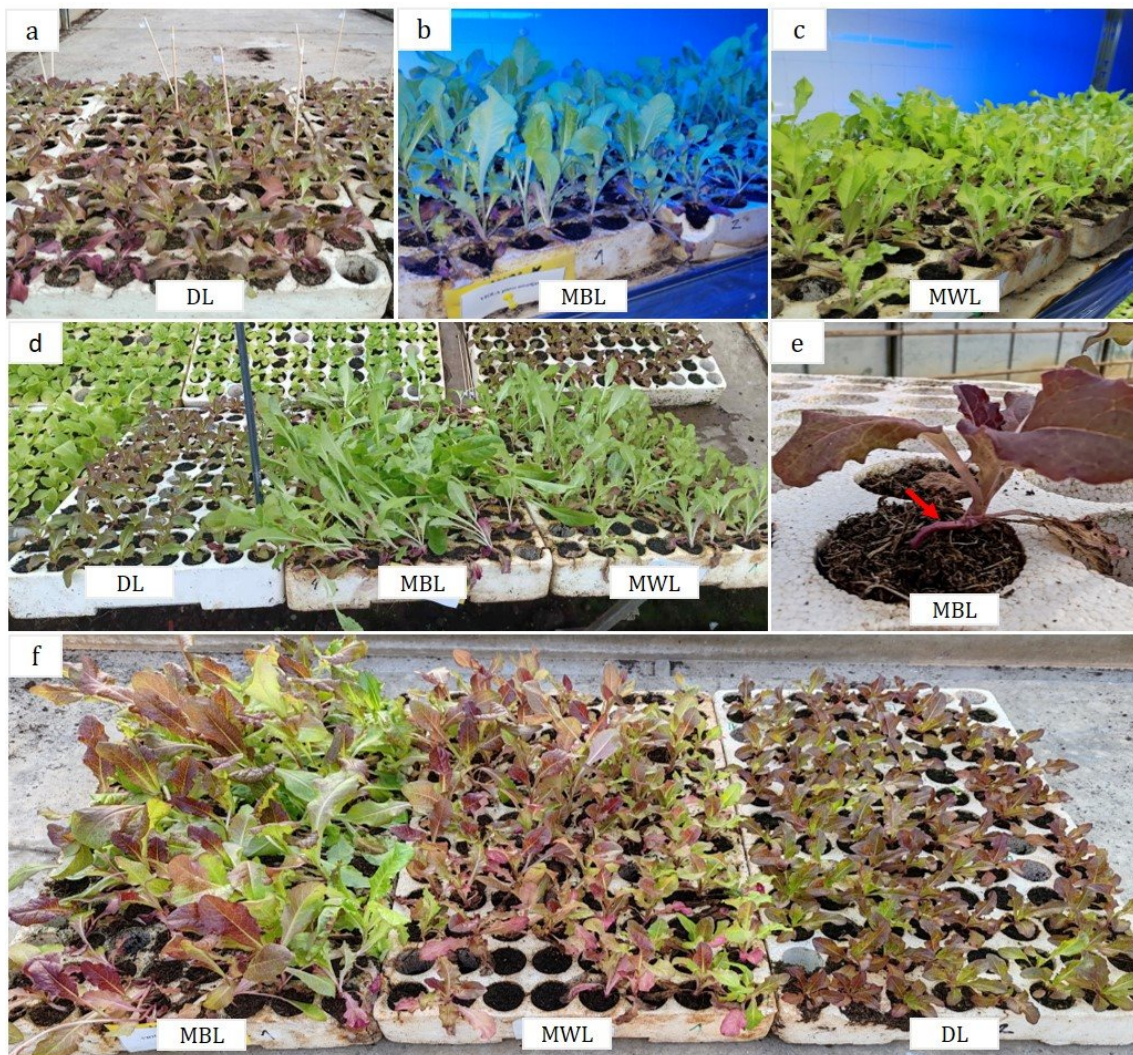


Figure 4. *Viola* lettuce seedlings development under daily light, MBL and MWL. a) seedlings grown under daily light (DL); b) seedlings grown under MBL; c) seedlings grown under MWL; d) loss of purple color in *Viola* lettuce seedling leaves; e) stem elongation (creeping stem; arrow) in plants grown under MBL; f) purple color recovery in plants grown under MBL and MWL.

CONCLUSIONS

This study revealed a statistically significant variation in observed characteristics based on the type of light and duration of plant exposure.

Viola lettuce seedlings grown in phytochambers under MWL and MBL had significantly higher biomass, number of leaves and chlorophyll content compared to seedlings grown in greenhouse conditions. However, after 10 days of cultivation in phytochambers, the LEDs negatively affected plant growth by causing stem elongation. It is necessary to be careful when choosing artificial lighting and the length of plant exposure. To produce quality lettuce seedlings during cold periods of the year (late autumn and winter), exposing plants to MWL or MBL for a short time is preferable. The exposure of curly purple-leaf lettuce variety *Viola* to MBL and MWL for four to 10 days, respectively, under a 9/15 h photoperiod accelerates seedling growth and positively affects the chlorophyll content in lettuce seedlings leaves.

The experiment will be extended until the lettuce reaches technological maturity, enabling further investigation into how different lighting during the seedling phase affects plant maturity development.

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ISOLATION AND SENSITIVITY OF *XANTHOMONAS CAMPESTRIS* PV. *CAMPESTRIS* TO COPPER COMPOUNDS IN VITRO CONDITIONS

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ABSTRACT

Bacteria *Xanthomonas campestris* pv. *campestris* (Xcc) in the agro-ecological conditions of Serbia is a significant pathogen of fam. Brassicaceae plants. Copper compounds are the only available chemical measure against phytopathogenic bacteria and most often used in production. The aim of this paper is to determine the sensitivity and tolerance change of Xcc isolates to different copper compounds (copper-hydroxide, copper-oxychloride, copper (II) sulphate). On 15 localities on the territory of Serbia, 68 samples were collected in the period 2017 – 2023, out of which 54 isolates were obtained by isolation from leaves (cabbage, cauliflower, winter oilseed rape, savoy cabbage, brussels sprout, broccoli) which were identified as *Xanthomonas campestris* pv. *campestris* based on classical and molecular methods. By testing the sensitivity, the development of isolates at the concentration of 100 ppm was determined for all investigated copper compounds. The concentration of 200 ppm enabled the development of most isolates, except for rapeseed isolates, brussels sprout isolates and some cauliflower (KL-18; KL-23) and cabbage isolates (KS-81, KS-82, KS-84, KS-88). The concentration of 300 ppm of different tested copper compounds had an inhibitory effect on the majority of tested isolates. In the case of the treatment with copper oxychloride and copper hydroxide, there was recorded the development of the isolates originating from cabbage (KS-65, KS-66, KS-67, KS-75, KS-76, KS-92, KS-93) and one isolate from brussels sprout (KP-3), while in the case of the treatment using copper (II) sulfate, two isolates originating from the cabbage of the Futog locality (KS-75, KS-76) developed. The concentration of 400 ppm of all tested forms of copper had an inhibitory effect on the development of all tested isolates. Comparing with earlier research done in the period 2013 - 2017, there was observed an increase in copper tolerance of Xcc isolates from the same localities.

Keywords: bacteria, sensitivity, copper compounds, *Xanthomonas campestris* pv. *campestris*, Brassicaceae.

INTRODUCTION

One of the reasons behind a limited production of vegetables is a significant financial loss caused by phytopathogenic bacteria (Khaliluev & Shpakovski, 2013). The bacteria *Xanthomonas campestris* pv. *campestris* (*Xcc*), the causal agent of black rot of cabbage, is an economically significant pathogen of plants, family Brassicaceae (Alvarez, 2000; Singh & Dhar, 2011). It is present wherever this species is cultivated: Africa, Asia, Australia, Oceania, Europe, America, and Caribbean, especially in mild climate conditions (Williams, 1980; Bradbury, 1986), where the average temperature is 20 - 30°C (Mariano et al., 2001).

The harmful effects of bacteriosis in agricultural production, including the production of cabbage plants, are significantly contributed by their difficult control. The control of bacteria diseases is a serious challenge due to the lack of effective bactericides, a high diversity of pathogens and a sudden increase of bacteria population. In favorable environmental conditions, a high degree of mutations leads to a quick resistance development. Also, a high degree of mutations enables bacteria to overcome the genetic resistance of plants (Civerolo, 1982; Balogh et al., 2010). Due to all above, the *Xcc* control is based primarily on preventive measures. The control of the causal agent of black rot includes using resistant genotypes, seeds without presence of pathogen, crop rotation with species from different families, the removal of harvest remains of Brassicaceae from land plots, and chemical measures of control (Trench et al., 1992; Mishra & Arora, 2012; Vicente & Holub, 2013). The number of effective chemical substances in bacterial diseases control is very limited. The most efficient bactericides are copper compounds. These compounds do not have a systemic activity; they reduce the inoculum growth on leaves and protect plant aerial surfaces from infection (Heydarpanah et al., 2019). Due to the development of resistant strains, the application of copper compounds has limited effectiveness (Adaskaveg & Hine, 1985). Research conducted in Trinidad has shown that, following multiple treatments with copper, *Xcc* becomes less and less sensitive to this compound, and eventually develops total resistance (Lugo et al., 2013). The aim of this research was to determine the sensitivity of the *Xcc* isolate to different forms of copper compounds (sulphate, oxychloride, hydroxyde), as well as to compare these results with the previous ones in order to determine the changes of sensitivity of the bacterial population.

MATERIAL AND METHODS OF WORK

Collecting samples and the isolation

The samples of brassica leaves (cabbage, cauliflower, broccoli, savoy cabbage, brussels sprouts and winter oilseed rape) with typical symptoms of bacterial disease were collected on 15 different localities (Table 1) in the period from 2017 to 2023. During the collection of the samples, the information regarding the treatments with copper compounds was recorded as well. The samples were transported to a laboratory for further isolation. Parts of the leaf were sterilized on the surface with 1% sodium hypochlorite (NaOCl) and washed three times in sterile distilled water. The isolation was done on the YDC medium (Yeast Extract Dextrose Calcium Carbonate Agar) according to the method described by Schaad et al., 2000, pp. 175 - 200. After the incubation and the colonies development, individual yellow colonies for subcultivation were chosen for the purpose of further studying. Then, individual colonies were planted on an angled YDC medium and stored on 4°C until further processing.

Testing for pathogenicity

The isolates were grown on the YDC medium at 27°C, 48 hours before inoculation. The bacteria colonies were suspended in 10 ml of sterile tap water to produce a turbid suspension 10^8 to 10^9 CFU/ml. The testing for pathogenicity was performed by spraying the suspension on the leaf surface (Popović et al., 2014). In this research, six brassica plants were used: cabbage (cv. Futoški), cauliflower (cv. Snežna grudva), savoy cabbage (cv. Gvozdena glava), broccoli (sv. Naxos), brussels sprouts (cv. Brilliant) and winter oilseed rape (cv. Slavica). The plants were in the stage of four true leaves (BBCH 14), which is the most adequate stage for inoculation according to Fargier & Manceau (2007). The plants inoculated with the referent strain of *Xanthomonas campestris* pv. *campestris* NCPPB 1144 were used as a positive control, and sterile distilled water (SDW) as a negative control. After the inoculation, the plants were kept in a phytotronic chamber in varied temperatures and light exposure during day and night, with elevated relative humidity. Changes on plants were monitored daily and the results were recorded on the 7th and the 14th day. The isolates that showed a positive reaction in the pathogenicity testing were used for further studying.

Identification

The identification of studied isolates was performed with both classical and molecular methods. The identification based on morphological characteristics included: Gram reaction (Suslow et al., 1982) and the shape of bacteria (Jarak & Đurić, 2006); biochemical-physiological characteristics: oxidative/fermentative metabolism of glucose, the creation of H_2S from peptones, the creation of indoles, the activity of oxidase and catalase, the dissolving of gelatine, the hydrolisis of starch and esculin, the reduction of nitrate, the dissolving of citrate and the proteolysis of milk (Lelliott & Stead, 1987; Arsenijević, 1997).

The molecular methods of identification were conducted according to the ISTA protocol (Annexe to Chapter 7 - 019a: Seed Health Testing Methods) by using multiplex-PCR (m-PCR). There were used pairs of primers DLH 120/DLH 125 (Berg et al., 2005) and Zup 2309/Zup 2310 (Rijlaarsdam et al., 2004). The strain of *Xcc* NCPPB 1144 was used for a positive control and the *Pseudomonas syringae* pv. *syringae* KBNS 94 and *Staphylococcus aureus* MRSA 82 were used for a negative control. Blind testing without DNA was used in every PCR amplification. Any sample in which 370 and 619 bp fragments were amplified was considered as positive.

The sensitivity of the *Xcc* isolate to copper compounds

The sensitivity of the isolate to: copper hydroxide, copper oxychloride, copper (II) sulphate and the antibiotic streptomycine sulphate was tested according to the method described in Ritchie & Dittapongpich (1991). A medium with sucrose and pepton was used (SPA; Lelliott & Stead, 1987) for the testing. In a sterilized and cooled medium (50°C), filter sterilized copper solutions were added up to the final concentration of 100, 200, 300, and 400 ppm, and streptomycine sulphate up to the concentration of 5, 10, 25, and 50 ppm. After homogenization on a magnetic mixer, the media were poured into Petri dishes with 90 mm diameter.

The bacterial cultures grown for 48 hours on the YDC medium were suspended in sterile distilled water up to the approximate concentration of 10^8 CFU/ml. The seeding of the suspension on the medium was performed with a pipette, 3 μ l of bacterial suspension in the form of drops. A medium without incorporating bactericides was sown for a negative control. The seeded media were incubated at 27°C.

After 48 hours, the presence or absence of the colonies were recorded. The trial was set up in three replication, one Petri dish represents one replication. In order to monitor the change of sensitivity of the bacterial population to copper product, the obtained results were compared to earlier research results within the same locality (Vlajić et al., 2017; Vlajić, 2023).

RESULTS AND DISCUSSION

From 2017 to 2023, 68 samples were collected on 15 localities, and, through isolation from leaves of Brassicaceae, 54 isolates were collected (Table 1). On the YDC medium, the colonies are yellow, bulged out, 2-3 mm in diameter, shiny, with slimy consistency. All the isolates caused the occurrence of symptoms on host plants. The appearing of symptoms was recorded since day 5. On day 7, the spots were getting larger and were spreading inwards. On day 14, there was the typical symptom in the shape of the letter V.

The isolates belong to the group of Gram negative bacteria, rod-shaped, asporogenous with one polar cilia. They metabolize glucose only in aerobic conditions (through oxydation). They produce indole and make H₂S from peptons, the oxidase is negative, the catalase is positive. They dissolve gelatin, hydrolyze starch, esculin. The isolates did not reduce nitrates to nitrites, they decomposed citrates and performed the proteolysis of milk. All of the performed tests gave the same results with the control referential strain Xcc NCPPB 1144.

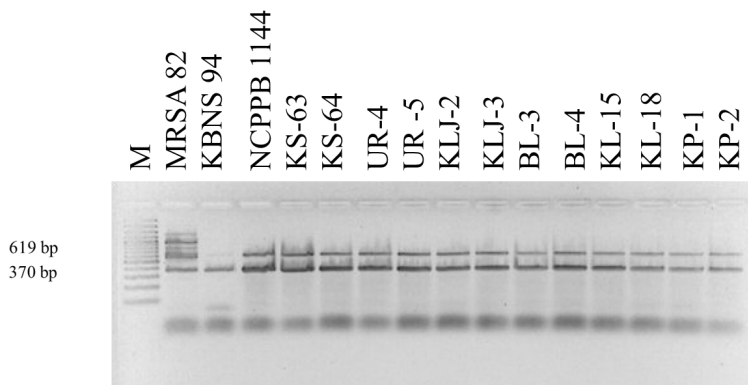
Table1. Bacterial isolates

<i>Isolate code</i>	<i>Host</i>	<i>Cultivar</i>	<i>Locality</i>	<i>Year</i>
KS-63, KS-64, KS-65, KS-66, KS-67	Cabbage	Futoški	Futog	2017
UR-4, UR-5	Winter oilseed rape	Unknown	Kovilj	2017
KL-15	Cauliflower	Snežna grudva	Kovilj	2018
KS-68, KS-69	Cabbage	Unknown	Taraš	2018
KS-70, KS-71, KS-72	Cabbage	Unknown	Pirot	2018
Klj-2, Klj-3	Collard greens	Unknown	Titel	2019
KL-16, KL-17	Cauliflower	Unknown	Despotovo	2019
KS-73, KS-74	Cabbage	Futoški	Zmajev	2020
BL-3, BL-4	Broccoli	Unknown	Jasenovo	2020
KL-18	Cauliflower	Unknown	Jasenovo	2020
KS-75, KS-76	Cabbage	Tenacity	Futog	2021
KS-77, KS-78, KS-79	Cabbage	Unknown	Leskovac	2021
KS-80, KS-81, KS-82	Cabbage	Futoški	Kovilj	2021
KL-19, KL-20	Cauliflower	Unknown	Kovilj	2021
KS-83, KS-84	Cabbage	Unknown	Vršani	2022
KS-85, KS-86, KS-87	Cabbage	Unknown	Mrčajevci	2022
KL-21, KL-22, KL-23	Cauliflower	Unknown	Mrčajevci	2022
Klj-4	Collard greens	Unknown	Zmajev	2022
UR-6, UR-7	Winter oilseed rape	Unknown	Zabalj	2023
KS-87, KS-88, KS-89	Cabbage	Unknown	Despotovo	2023
KS-90, KS-91	Cabbage	Unknown	Rusko selo	2023
KP-1, KP-2, KP-3, KP-4	Brussels sprout	Brilliant	Kovilj	2023
KS-92, KS-93	Cabbage	Futoški	Futog	2023
NCPPB 1144*	Cabbage	Unknown	UK	Unknown
<i>Code</i>	<i>Strains</i>	<i>Origin</i>		
KBNS 94**	<i>Pseudomonas syringae</i> pv. <i>syringae</i>	Serbia (curator dr R. Ilić)		
MRSA 82 **	<i>Staphylococcus aureus</i>	Serbia (curator prof. dr V. Lalošević)		

* Reference strain NCPPB 1144 was used as a positive control in all tests

** Strain KBNS94 (*Pseudomonas syringae* pv. *syringae*) and MRSA 82 (*Staphylococcus aureus*) were used as a negative control in PCR

The analysis of the results of m-PCR, done with a set of specific primers DLH 120/DLH 125 (619 bp), as well as Zup 2309/Zup 2310 (370 bp), on all isolates and the referent strain NCPPB 1144, showed that the fragments of nucleic acids of the size 619 and 370 bp (Picture 1) were amplified. Based on these results, all the isolates were identified as *Xanthomonas campestris* pv. *campestris*.



Picture 1. Identification of *Xcc* isolates originating from leaves using primers DLH 120/125 (619 bp) and Zup 2309/2310 (370 bp). M – marker (SERVA FastLoad 100bp DNK Ladder, Serva Electrophoresis GmbH, Heidelberg, Germany); MRSA 82 – *Staphylococcus aureus*; KBNS 94 – *P. s. pv. syringae*; NCPPB 1144 – referent strain *Xcc*; KS-63, KS-64, UR-4, UR-5, KLJ-2, KLJ-3, BL-3, BL-4, KL-15, KL-18, KP-1, KP-2 isolates

Through testing of the studied isolates, it was determined that all isolates develop at the concentration of 100 ppm with the tested copper compounds. The 200 ppm concentration enabled the development of most isolates in winter oilseed rape (UR-4, UR-5, UR-6, UR-7), isolates in brussels sprout (KP-1, KP-2, KP-3, KP-4), some isolates in cauliflower (KL-18, KL-23), and cabbage (KS-81, KS-82, KS-84, KS-88). The concentration of 300 ppm of the examined copper compounds had an inhibitory effect to most of the examined isolates. In the case of the treatment with copper oxychloride and copper hydroxide, there was recorded the development of the isolates originating from cabbage (KS-65, KS-66, KS-67, KS-75, KS-76, KS-92, KS-93) and one isolate from brussels sprout (KP-3), while in the case of the treatment using copper (II) sulfate, two isolates originating from the cabbage of the Futog locality (KS-75, KS-76) developed. The concentration of 400 ppm of all examined copper forms had an inhibitory effect on the development of the examined isolates (Table 2).

Table 2. Susceptibility of studied isolates to different copper concentrations

	Concentration			
	100 ppm	200 ppm	300 ppm	400 ppm
	The number of isolates developed (out of a total of 54 sown)			
<i>Bactericides</i>				
Copper (II) sulfate	54	52	2	0
Copper hydroxide	54	46	8	0
Copper oxychloride	54	50	8	0

In terms of sensitivity to streptomycin sulfate, at the concentration of 50 ppm, no development of isolates was recorded, while at the concentration of 25 ppm, the development of 4 isolates originating from cabbage (KS-65, KS-77, KS-78, KS-93) was recorded. The concentration of 10 ppm enabled the development of 37 isolates, while at the concentration of 5 ppm, the development of all isolates was recorded. (Table 3).

Table 3. Sensitivity of studied isolates to different concentrations of streptomycin sulfate

Antibiotic	Concentration			
	5 ppm	10 ppm	25 ppm	50 ppm
	The number of isolates developed (out of a total of 54 sown)			
	54	37	4	0

In their earlier research on the sensitivity of *Xcc* to different forms of copper on Futog locality, Vlajić et al. (2017) found that the concentration of 300 ppm was inhibitory for all examined isolates. Due to the occurrence of certain isolates even at 300 ppm concentration, it can be concluded that the sensitivity of the isolates to the most common copper compounds used in production was reduced. Furthermore, the results suggest that the consequence of the reduced sensitivity of *Xcc* to copper compounds is a longer period of application of the same compound, as well as growing plants in monoculture. This is in accordance with Lai et al. 2021, who concluded that frequent applications of copper-based bactericides cause the evolution and development of copper-resistant or tolerant bacterial strains. Therefore, in the places where cabbage has been cultivated traditionally (Futog, Despotovo, Mrčajevci), one of the reasons for the appearance of higher occurrences of the causal agent of black rot of cabbage, the bacteria *Xcc*, is the appearance of populations with reduced sensitivity. In addition to this fact, it is worrying that, in practice, there is a tendency to increase the application doses of copper compounds, which can lead to soil pollution. In addition, soil contamination with heavy metals, especially copper, can lead to an increase in bacterial resistance to antibiotics (Berg et al., 2010; Zhang et al., 2018). The results show that a continuous monitoring of the sensitivity of the population *Xcc* to copper compounds is needed in order to apply the measures which would enable a safer control. Also, the design of more efficient formulations of chemical compounds based on copper and new control strategies may prove significant in limiting the copper tolerance.

CONCLUSIONS

The inhibitory concentration of all examined copper compounds (sulfate, chloride, oxychloride) for the *Xcc* population present on Brassicacea plants is 400 ppm. In terms of sensitivity to streptomycin sulfate, no development of *Xcc* isolates occurs at the concentration of 50 ppm. In relation to the previous research period, there was recorded the occurrence of isolates with reduced sensitivity to the examined copper compounds and streptomycin sulfate in the same localities.

ACKNOWLEDGEMENT

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ANALYSIS OF ORGANIC PRODUCTION IN SERBIA WITH A FOCUS ON ORGANIC VEGETABLE FARMING

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ABSTRACT

The production and market for organic products are significantly increasing both globally and in Serbia. The uniqueness of organic agriculture is not only seen in the differences in applied technology but also in its development, which should be supported due to economic, ecological, and social contributions, offering opportunities for smaller agricultural farms. It serves as a link between rural development and environmental protection. This paper will analyse organic production in Serbia compared to Europe, with a focus on vegetable production. Available statistical data on the areas and distribution of organic plant production by types from 2012 to 2022 will be used. Despite suitable soil and ecological conditions, the representation of organic plant production in 2022 was approximately 0.6% of total production, while the European Union's average was 9.9%. The goal of the paper is to assess the potential of organic production, especially in vegetables, which have the smallest share, and the challenges that producers face or may face. It aims to examine how much progress has been made in solving these issues and identify areas where this specific branch of plant production can develop at a faster pace. In 2022, the total area under organic production increased by approximately 400% compared to 2012. According to the latest data, fruit crops were the most cultivated, accounting for 34% of arable land. There is a significant increasing trend in meadows and pastures, which increased 8.5 times during the analysed period. Despite a growth in vegetable production, its percentage in total organic production remains modest. Vegetable production areas in organic farming varied from 113.7 ha (2012) or 1.7% to 285.68 ha or 1.14% of the total area of 25,035.11 ha under organic production in 2022.

Keywords: Organic production in Serbia and the EU, Organic vegetable farming.

INTRODUCTION

There are numerous definitions of organic agriculture, and one offered by the FAO states that 'Organic agriculture is an integrated production system of high-quality food that is based on the best ecological practices, which is socially acceptable and economically profitable.' The term 'organic' itself is a subject of debate, as conventional plant production is also organic, so many believe it is more appropriate to use the term "Ecological" instead of "Organic". This type of production certainly has immense ecological significance as it contributes to the conservation and protection of the environment. According to Schmid et al. (2008.), organic agriculture does not use conventional pesticides, herbicides, mineral fertilizers, growth hormones, antibiotics, GMOs; instead, farmers apply organic technology that helps preserve the ecosystem and reduce pollution. Our country has favorable ecological and edaphic conditions for the development of organic agriculture. According to numerous authors (Rašković and Ivanović, 2016.; Ceranić and Paunović, 2019.), in Serbia, between 70-80% of arable land is suitable for the development of ecological agriculture. Despite the fact that the areas have significantly increased in the last 10 years under organic production, from 6340 ha in 2012. to 25035 ha in 2022., the percentage in relation to the total arable land is modest. In 2022., organic production in Serbia constituted 0.51% of the total arable land, while the EU average in the same year was 9.9%. One of the goals of the European agricultural policy is to encourage the development of organic production, which should account for 25% of the EU's arable land. In the market for organic products, the greatest demand exists for fresh fruits and vegetables. If we recall that production under fresh vegetables in 2022. was organized on a total of 285 ha (conversion period 37 ha and organic status 248 ha), it is clear that there is potential for development.

MATERIALS AND METHODS

In the research, available databases on organic production were used, both national (<http://www.minpolj.gov.rs/organska>) and international institutions (Eurostat). Comparisons were made with previous research on organic production by domestic and foreign authors. Standard statistical methods were used in data processing, that is, descriptive statistics, which covered a ten-year period for data analysis from 2012. to 2022. year.

RESULTS OF RESEARCH

In addition to the basic ecological prerequisites, such as uncontaminated soil, clean air, and quality water, the development of organic agriculture in a country also requires motivated producers to shift from conventional to organic production. From 2012. to 2022., the area under organic production increased in almost all member countries. In the EU, the total area under organic production was 15.9 million hectares, including areas that are in the conversion period. Interestingly, the largest increase, aside from Portugal at 282.8%, was also in our neighboring country, Croatia, by 282.2%. Before some areas can be certified as organic, they must go through a conversion period, that is, a transitional period from conventional to organic, lasting 2 to 3 years depending on the plant species (Organic Agriculture Law 2023., Serbia organika how to get certified). In terms of area in the EU, four countries stood out: France (2.8), Spain (2.1), Italy (2.2), and Germany (1.6) million hectares, which together make up almost half of the European area under organic production (*Figure 1.*)

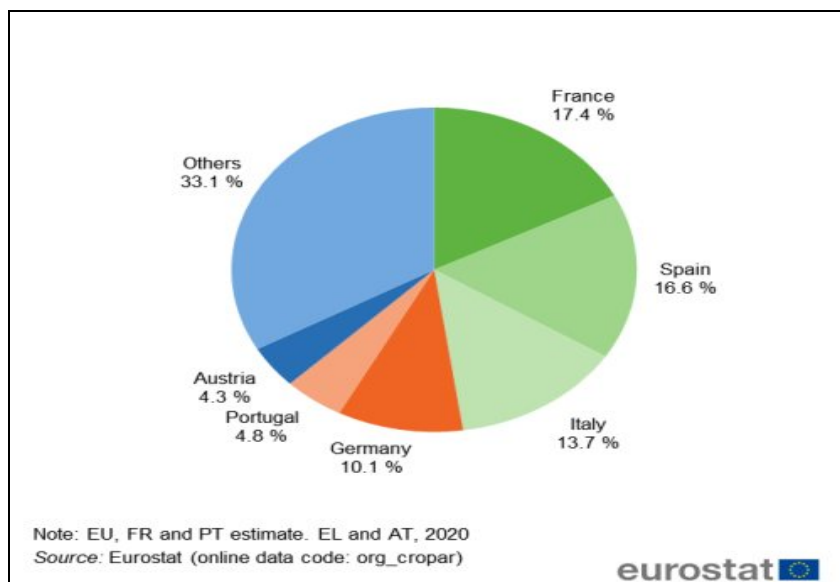


Figure 1. Share of EU total organic area in 2021.

According to Eurostat sources, the largest share of organic areas in relation to total plant production in 2021 was held by the following countries: Austria 26%, Estonia 23%, Sweden 20% graph.2. Above 10% under organic production were Portugal, Italy, Finland, Czech Republic, Lithuania, Germany, Slovenia, Spain, and Greece in 2021. Among the EU countries, less than 5% was in six countries, with the smallest share in Bulgaria (1.7%) and Malta (0.6%). The largest share of organic vegetable production in total vegetable production in 2021 was held by Sweden at 17.7%, followed by Germany at 11.2%, and then the Netherlands at 5.4% (Figure 2.)

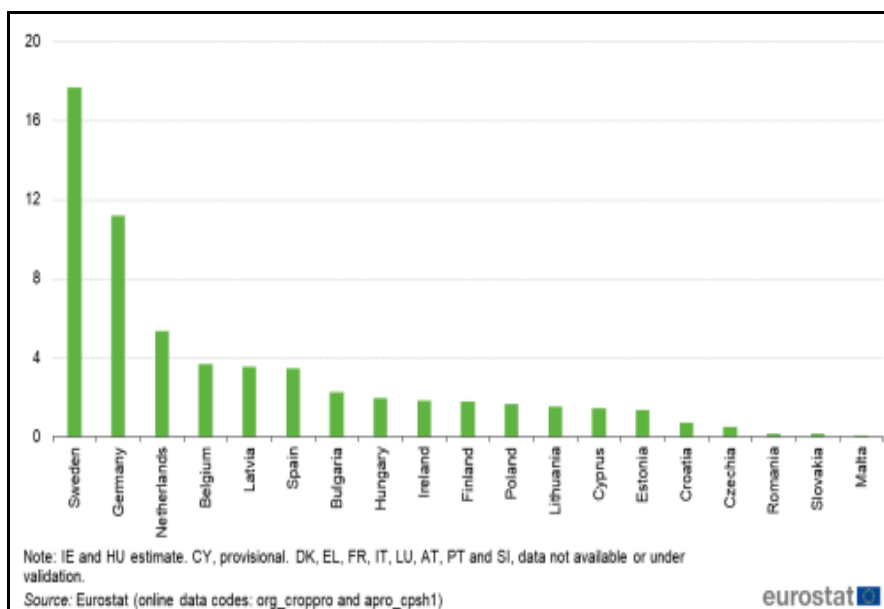


Figure 2. Share of organic fresh vegetables produce in total fresh vegetable production 2021.

As a consequence of inflation and the significant increase in food prices in general, the European Union saw a significant decrease in the export of vegetables in fresh, frozen, or dried form by as much as 20.7% in 2022. compared to 2021.

In total value, the export of organic vegetables was on par with the export of organic fruits, accounting for 4.4% (EC (2023.), EU imports of organic agri-food products, Key developments in 2022, July 2023.). In the past 10 years in Serbia, significant measures have been undertaken in the development and promotion of organic production by state institutions, the relevant ministry, the Chamber of Commerce of Serbia, and non-governmental organizations, among which Serbia Organic and GIZ are the most recognizable, along with numerous donors: USAID, FAO, EU-IPARD projects, etc. The Ministry of Agriculture is aligning domestic legislation with EU legislation related to the certification of organic products to facilitate exports, as Serbia exports about 80% of its products. Ivana Simić (2020.) notes, 'Serbia has been continuously present for more than a decade at the leading international organic products fair BioFach in Nuremberg, Germany. Since the establishment of Serbia Organika, over the next ten years, with the support of many foreign and domestic donors (GIZ, USAID, SIEPA, PKS), it has organized a joint appearance at the Serbian stand, where a large number of domestic producers and processors have exhibited. Since 2019., the Chamber of Commerce and Industry of Serbia (PKS) and the National Association of Organic Producers (NASO) and the Development Agency of Serbia (RAS) have joined the organization and financial support of appearances at the BioFach fair.

In the last three years, financial incentives for the development of organic plant production have been continuously increasing, and there are significant differences in subsidizing organic compared to conventional plant production. In 2021., incentives for organic plant production increased by 550% compared to incentives for basic plant production and amounted to 26,000 dinars/ha. The following year (2022.), subsidies per hectare under organic production increased to 31,500 dinars, but now the difference due to the increase for basic production was 250%. The latest data from 2023. is the most encouraging because the amount of incentives per hectare is even 63,000 dinars or about 525 euros, while for conventional it is 18,000 dinars or 150 euros, which is a significant shift compared to the previous period when Ivanović and Ivanović (2016.) concluded that for the development of Organic production, in addition to weak financial support, the problem is also poor institutional support. Tabaković et al. (2017.) believed that subsidies are significantly lower compared to Europe, which often makes our products non-competitive in the world market.

According to Ministry agriculture, forestry and water management there has been almost an exponential growth in organic plant production from 2012. to 2022., with production having increased manifold. However, in Serbia, the area under organic cultivation is still less than 0.6% of the total arable land, which is far below the European average and among the last countries in the EU.

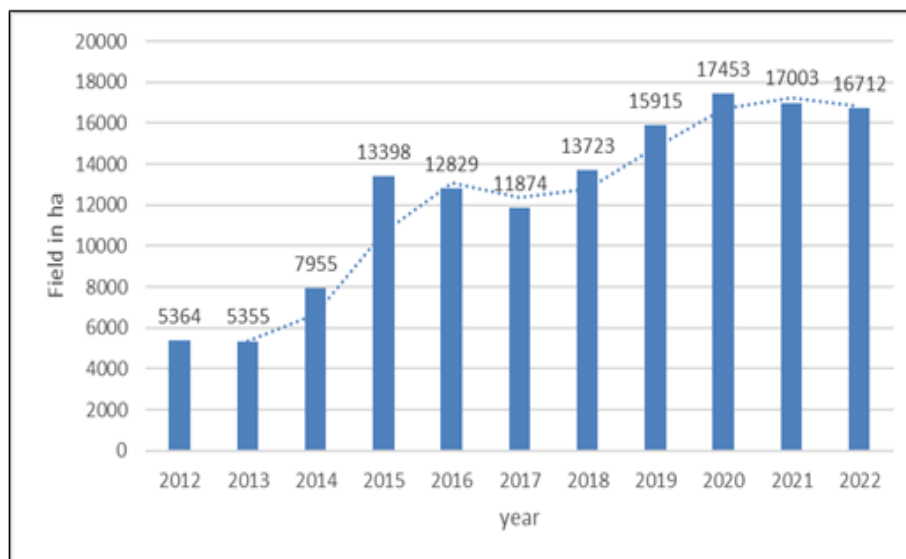


Figure 3. Field under organic production in ha in period 2012 - 2022 year in Serbia

According to earlier research for the period from 2012. to 2016., regarding the representation of organic areas in the total agricultural land in our country and neighboring countries, Serbia was behind Romania, Hungary, Bulgaria, Croatia, and North Macedonia, with organic production being less represented only in Montenegro and Albania (Vlahović et al., 2019.). According to the latest data from 2022., among the mentioned neighboring countries, the most represented organic production was in Croatia and Hungary, above 5%.

Long-term research (Kovačević et al., 2009; Rašković et al., 2012.), as well as data from the Ministry of Agriculture, Forestry and Water Management (2013-2022.), show that organic plant production has traditionally been most developed in Vojvodina (Table 1.).

Table 1. Land under organic production in Serbia in period 2012 - 2022 year

Year	Crops	Industrial crops	Vegetable	Fodder crops	Fruits	Medicinal herbs	Meadows and pastures	Total arable land	Total area under organic production
2012	2522	540	113	663	1415	128	975,91	5364,18	6340,09
2013	2273	672	106,7	595	1484	132	2872,74	5355,25	8227,99
2014	2827,6	1227,8	153,6	1204,2	2208	60	1549,36	7958,47	9547,82
2015	4251,9	2674	170,5	1440,4	2895,1	70	1899,82	13398,19	15298,19
2016	4607	2918	184,24	1348,67	3531	112	1428,92	12829,04	14357,96
2017	3661	2290,4	230	1210,9	4056	116	1548,28	11874,85	13423,13
2018	3613,6	1961,8	119,8	1336,5	5883,4	193	5530,76	13724,85	19254,58
2019	4788,8	2229,5	184,16	1797,9	5324,3	258	5349,99	15915,45	21265,44
2020	3623,2	1294	121,6	3872,6	5294,8	399	3517,44	17453,31	20970,75
2021	4458,7	2121,4	169,8	3054,1	5614,9	367,2	6523,89	17003,14	23527,04
2022	3838,5	2075,7	285,7	2262,3	5702,8	375,2	8322,91	16712,20	25035,11

We assume that the structure would be different if a subsidy system like in Bulgaria were applied, where the smallest subsidies for meadows and pastures are 120 euros, and the largest for orchards and vineyards are about 729 euros per hectare. Additional financial support is provided to younger farmers engaged in organic agriculture (Apostolov, 2017.). The reason and answer for why this is so can be understood by comparing that the most significant organic export product in Serbia is

the raspberry. Producers have contracted production, logistical support during the production cycle, and collectively offer their products through a group certificate.

Vlahović et al. (2019.) draw attention to the fact that in 2016., vegetables in organic production covered 184 hectares and constituted only 1.3% of the total organic production, and in the total vegetable production of approximately 250,000 hectares with potatoes, this percentage is negligible. The most cultivated were beans at 14%, potatoes at 11%, and zucchinis at 10%. Five years later, in 2022., vegetables are grown on 286 hectares, which makes up 1.7% of the arable land under organic production. As many as 52 types are produced, and 9 are cultivated on more than 5 hectares. Interestingly, in the structure, peas dominate with 110 hectares, potatoes with 40 hectares, beans with 32 hectares, chickpeas with 20 hectares (almost the entire area is in Banat), onions with 9.4 hectares, zucchinis with 9.1 hectares, peppers with 8.6 hectares, tomatoes with 7.1 hectares, and carrots with 6.1 hectares. Their representation in percentages is shown on the Figure 4.

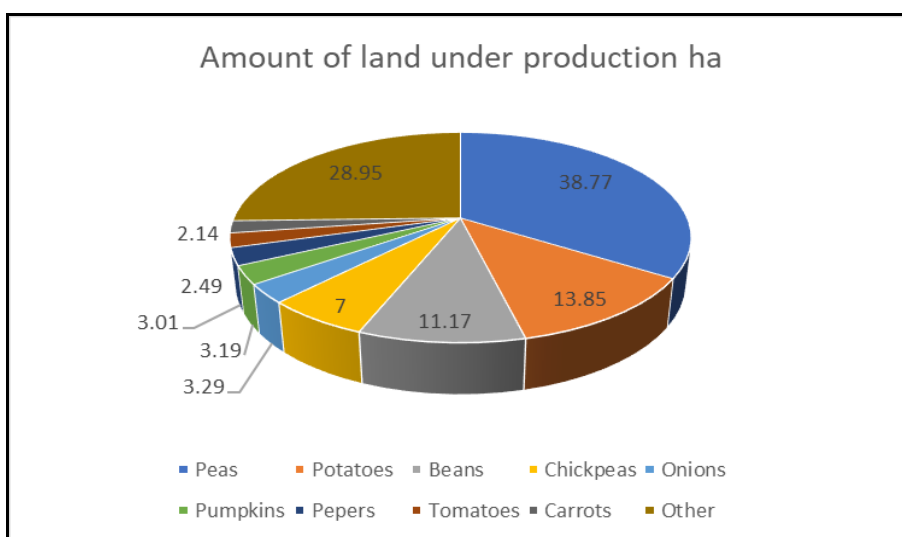


Figure 4. Amount of land under production in Serbia

Organic vegetable production could be an opportunity for small farms that are not competitive, because the production is predominantly annual, and they can grow 2 or even 3 crops during the same vegetation period. We assume that the production of organic vegetables will continue to develop, as awareness of the positive impact of fresh organic vegetables on human health grows. Many who are not market-oriented will opt for vegetable production, according to these principles, for their own needs. Of course, it cannot be expected that this will be a turning point in the development of organic vegetable farming.

In the effort to promote and develop organic vegetable production, it is stated: The constant increase in demand for organically produced vegetables should be a sufficient reason for professionals and scientists to pay more attention to this issue and to work more on educating agricultural producers. And producers, above all, should accept the economic logic to produce what brings them the highest profit.

Guided by this very logic, fruit is mostly grown on agricultural land, with fruit dominating the export of organic products at 95.87%. Fruit growers also have good logistical support through large cold storage facilities, secured and credited raw materials, advisory support, group certification, and assured placement.

According to the Customs Administration data, in 2019., Serbia exported 13,284 tons of organic products, and the export value amounted to 29.75 million euros, of which fruit and fruit products accounted for over 28.7 million euros. In 2021, the export amount was 57.4 million euros. Compared to 2020., the value of organic product exports increased by 53%, and by 93.3% over two years. The highest value, of 45 million euros, was achieved in 2021 in the export of frozen organic fruit, of which frozen berries constituted the largest part: exported raspberries had the most significant share, with an export value of 32.6 million euros or 72% of the total export. In the structure of organic (quantities) exported products, vegetable products participated with 0.09%.

Despite all the positive measures of the non-governmental and governmental sectors in improving organic agriculture and the percentage of positive indicators in the enhancement of organic plant production, the potential for the development of organic agriculture is far greater than what has been achieved. We will try to answer the question that Simić also analyzed back in 2015. Why is organic production an untapped potential of the Republic of Serbia?

As challenges, Rašković points out the following: Despite the fact that there is a great potential for the development of organic production in our country, the biggest problems faced by individual agricultural producers in the Republic of Serbia are:

- Poorly organized purchase of agricultural products, especially organic vegetables
- The offer is insufficient to enter the foreign market
- Primarily primary, not final products are offered, which results in lower profit
- There is a significant amount of labor involved which makes production more expensive; if small agricultural producers were united, they could use common machinery intended for organic production
- During the conversion period, there are higher investments, and the product cannot be sold at a higher price as organic.
- Insufficient education about the differences in technology between organic and conventional

We also agree with Baćirević and Stepanović (2019.) that for small farms, which most often deal with the production of organic food, challenges also include paying for certificates, leasing sales space, paying workers, an underdeveloped market, and poor purchasing power of citizens.

The fact that our market is insufficient to influence the development of organic vegetable farming is also shown by the research of Serbia organica, which indicates that the largest number of customers in Serbia would opt for buying fresh fruits and vegetables at 46%, confirming that the domestic market is underdeveloped due to the weak purchasing power of the population. (Vehapi 2015., Radojević, 2018.) The depopulation of Serbia in general is not encouraging, and it is particularly pronounced in rural areas and the poor age structure of agricultural household holders. According to research by Bajagić et al. 2022., among students of agricultural professions, survey results indicate that as many as 83.7% of respondents would like to engage in organic plant production. However, the main disadvantages cited are insufficient information, insufficient financial support, difficult protection, and insufficiently organized purchase of products. Most young people would opt to engage in fruit growing (58.1%). The reason for choosing organic plant production is primarily due to the production of high-quality food and environmental protection. Cvijanović and colleagues (2020.) believe that without the application of innovative solutions in production, further development and increased competitiveness of the Serbian organic sector is impossible.

All research on challenges is important because the identified problems faced or have been faced by organic producers are gradually being resolved. There is a shift, especially evident since 2019. when the Government adopted the National Rural Development Program, which includes the organic agriculture development program. Subsidies have increased from 11,400 in 2019. to 63,000 in 2023., a high percentage of participation. Producers could apply for the allocation of grants for co-financing the costs of control and certification of organic production, procurement of attached machinery, machines, and equipment, in AP Vojvodina co-financing was up to 80%. Organic fruit production in Serbia is the most developed because a large number of producers are included as cooperants in group certification, which significantly simplifies procedures, but also the decision to switch from conventional to organic production. This model, which has proven successful, should be applied to other branches of plant production, so that we have sufficient quantities of uniformly high-quality goods that we could export. To facilitate the inclusion of small farms There is a small number of producers who have directly concluded a contract with authorized control organizations, as opposed to a large number of producers who are included as cooperants in group certification. This model has proven successful in our country and in most cases, it is about production intended for export. Organic production in Serbia can be more competitive if more funds were used through and can be modernized by applying for funds through the IPARD 3-(MEASURE 1) program. The largest number of producers need professional help in preparing competition documentation, education on technology in the education system education and promotion of organic agricultural production. The answer to how to motivate Organic plant production, especially vegetable farming, is simple, we have the example of organic raspberries. at all stages of production, there is logistical support from the procurement of raw materials, joint certification, credited production, provided advisory services, and secure placement.

CONCLUSION

The development of organic agriculture, both globally and in Serbia, spans multiple decades. It is gaining increasing popularity at the global level, and the market is in constant growth. When observing the period from 2012 to 2022, the results expressed in percentages are encouraging as they have increased by approximately 400%. However, compared to the prevalence of organic production in the EU, we are among the countries with the least developed organic agriculture. In the structure of the status of organic production, meadows and pastures dominate, whose areas have also sharply increased in the last observed year. In arable lands, fruit cultures are the most represented, where raspberries absolutely dominate among plant species. The share of vegetables in organic production is below 2%. Inadequate financial support through incentives is emphasized as a dominant obstacle to the development of this production. In the future, the largest disbursements in terms of subsidizing organic production, even 3.5 times more compared to conventional, were achieved in the previous year, i.e., 2023, which was not the subject of this analysis. We will see what the benefit is in future research. The conclusion is that the reasons for the insufficient motivation of producers to switch from conventional to organic production are: specific technology and producers' lack of education about it, greater labor involvement, the need for production certification, procurement of specific raw materials (seeds for organic, specific means for storage and plant protection, adequate machinery...), appropriate ecological and edaphic conditions for establishing this type of production, poorly organized market, and weak purchasing power of consumers that would lead to more

intense demand for certified organic products. To increase the areas under organic vegetables, it is necessary to differentiate subsidies depending on the cultivated plant species and apply a system that is already being used in Bulgaria. The possibility of developing other branches of plant production exists, as an example of good practice is organic raspberry production, which is the most represented type. Organic raspberry producers have logistical support at every step of production. Is organic production an export opportunity or a mere dream in 2023? We can conclude that for a small number of types, primarily fruit, it is an export opportunity, while for vegetable farming on less than 300 hectares, it is not even a dream.

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MONITORING OF INDICATIVE SOIL INDICATORS FOR ORGANIC FARMING IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

Relevance of the study. In the context of excessive anthropogenic pressure, more and more attention should be paid to the formation of organic farming. In Ukraine, the family-individual sector of rural households is dominated by the land use of household plots and private peasant farms, in particular, household plots of rural citizens make up about 10 million households with a total area of almost 1.5 million hectares. At the same time, household plots in settlements are an important part of green infrastructure, which performs such environmental functions as reducing greenhouse gas emissions, reducing air pollution, establishing an optimal microclimate, reducing the heat island, and preserving green areas. The purpose of the study was to investigate the soils of private household plots in the settlements of Chuhuiv district of Kharkiv region for compliance with the requirements for growing organic products. Tasks solved in the study: To determine the compliance of soils with the normative indicators of land suitability according to ecological, toxicological and soil-agrochemical criteria for the normative indicators of land suitability for organic production. Results. According to the ecological and toxicological criteria of soil suitability for organic farming, the soils of the studied household plots are suitable according to the following regulatory criteria: by the location of the land in relation to international, national and regional highways, they are suitable, by the criterion of the location of the land in relation to the prevailing winds and winds in other directions - conditionally suitable. Also, the soils of the studied household plots are suitable for organic farming in terms of the content of mobile forms of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn, and no exceedances of the maximum permissible concentrations of their mobile forms were detected. When determining the suitability of soils for growing organic products according to soil and agrochemical criteria, it was found that the studied soils meet the requirements for suitability according to the following regulatory indicators: depth of the humus horizon, reaction of the soil solution, and trace element status. No phytotoxicity was detected in all soil samples and they belong to the first quality class. This is an additional evidence of the possibility of growing organic products on the soils of the studied household plots in the settlements of Chuhuiv district of Kharkiv region.

Keywords: organic farming, indicative soil indicators, ecological and toxicological indicators, soil and agrochemical indicators, green infrastructure.

INTRODUCTION

Green infrastructure facilities in cities allow solving the problems faced by the urban environment, and green infrastructure facilities can be anything: eco-ducks, green parking lots, green tracks, parks, green roofs and walls, flower beds, urban gardens and vegetable gardens, etc. (Ryabika et al., 2021). Considering vegetable gardens as an object of GI, it is possible to distinguish ecosystem services that they provide: regulation services through soil formation, pollination of plants; ecosystem maintenance services through ensuring the cycle of substances in nature; supply services through the supply of products and raw materials that can be converted into a material equivalent (Vasilyuk & Ilminska, 2020), (Ecosystem services - nature's benefit).

In the article (Russo et al., 2017) propose the term "Edible green infrastructure"(EGI), which includes the provision of food for citizens and the sustainability of the urban environment. EGI is a sustainable, planned network of edible food components and structures within an urban ecosystem that are managed and designed to provide primarily ecosystem services. Given that, according to UN projections, the urban population is growing steadily, accelerating the pace of urbanisation, which in turn is accelerating environmental degradation, increased consumption of natural resources, habitat loss and overall ecosystem change (Russo & Cirella, 2020).

The most successful way of farming in the form of vegetable gardening will be organic farming, because this method ensures the preservation of the environment, the level of biological diversity, and the conservation of natural resources (Balyuk, 2015), which will ensure the implementation of sustainable development. Given that the territorial structure of the urban landscape includes an element of the rural landscape, including private estates with vegetable gardens, this element of green infrastructure will fit well with the existing purpose of the territory.

When using the concept of Edible green infrastructure in combination with organic farming, it is necessary to ensure the provisions laid down by the founder of the concept of organic farming, Mokishi Okada, namely: to produce food that would maintain and improve human health; stabilize the biological balance in nature; be environmentally friendly; use simple available methods and means of farming (Tomashevskaya, 2013). In his work (Artis, 2011), Artis V. I. identifies the main criteria that the soil cover must meet in order to obtain organic products: 1) cultivation on ecologically clean lands; 2) cultivation without the use of synthetic microfertilizers; 3) cultivation of crops adapted to natural and climatic, soil conditions; 4) protection of crops from diseases and pests by agrotechnical, microbiological preparations and preventive measures. The aim of the study is to determine the possibility of growing organic crops within the city to support sustainable development goals and the development of edible green infrastructure.

MATERIAL AND METHODS OF WORK

To study the suitability of the soil cover for organic farming, a field experiment was set up on three representative plots under different crops in the Chuhuiv district on a private plot. Soil samples were taken by the convection method from the 0-20 cm layer according to (Derzhspozhyvstandart Ukrainy, 2004).

The study used the provisions of the Concept of Organic Farming, which is a program developed by the National Research Center "Sokolovsky Institute of Soil Science and Agrochemistry" under the auspices of the NAAS "Scientific Programs for the Development of Organic Agricultural Production and Mechanisms of its Functioning in Ukraine" (Balyuk, 2015).

According to the concept, suitable, conditionally suitable and conditionally unsuitable lands can be conditionally distinguished according to their suitability (favorability) for the production of organic products and raw materials:

- suitable - agricultural land, the agro-ecological condition of which does not impede the production of organic raw materials and high-quality agricultural products;
- conditionally suitable - agricultural lands whose soil fertility indicators do not meet the optimal ones and require measures to improve them;
- conditionally unsuitable - agricultural land on which it is not possible to grow high-quality organic raw materials without additional agro-technological solutions and financial costs (Balyuk, 2015).
- The grounds for assigning land to one of these categories according to its suitability (favorability) for the production of organic products and raw materials are the parameters of ecological, toxicological and soil-agrochemical criteria for land quality that meet the established requirements of the values (Balyuk, 2015).
- In accordance with the requirements for determining the suitability of the soil cover for organic farming, we determined the ecological and toxicological indicators of the soil, in particular
- location of the site in relation to sources of pollution, namely, in the direction of prevailing winds; location from international, national and regional highways of national importance;
- the content of pollutants in the soil, namely, the classes of soil suitability for organic farming based on the content of heavy metals (HM) and the density of soil contamination with radionuclides.

The cluster of soil and agrochemical criteria includes the following indicators:

- reaction of the soil solution;
- depth of the humus horizon;
- humus content;
- content of mobile forms of trace elements.

Therefore, to determine the suitability of the soil cover, the following studies were conducted: heavy metal content (DSTU 4770.2:2007), (DSTU 4770.3:2007), (DSTU 4770.6:2007), (DSTU 4770. 9:2007), the content of mobile trace elements, in particular: cadmium, cobalt, chromium, copper, iron, manganese, nickel, plumbum and zinc, was determined by pH using the potentiometric method (ISO10390: 1994, IDT), the number of the main ecological and trophic groups of microorganisms in colony forming units (CFU) per 1 g of soil was determined by the method (Kryvytska & Krainiukov, 2017), and the number of the main ecological and trophic groups of microorganisms in colony forming units (CFU) per 1 g of soil was determined by microbiological sowing of a soil suspension of appropriate dilution on solid nutrient medium (DSTU 7847-2015), organotrophic bacteria - on MPA (meat-peptone agar), microorganisms that assimilate nitrogen in mineral compounds and actinomycetes - on KAA (starch-ammonia agar), microscopic fungi - on Richter's medium, oligotrophic microorganisms - on GA (starvation agar).

To calculate the difference in the length of roots and seedlings in the experiment relative to the control in percent using the formula:

$$A = ((X_k - X_d)/X_k) * 100 \quad (1)$$

A - length of roots (seedlings) in the experiment relative to the control, %;

X_k - is the arithmetic mean of the length of roots (seedlings) in the control, cm;

X_d - is the arithmetic mean of the length of roots (seedlings) in the experiment, cm.

RESULTS AND DISCUSSION

The ecological and toxicological criteria for determining the suitability of soil for organic land use are: the location of land relative to sources of pollution, the content of pollutants in the soil.

One of the most important conceptual foundations of environmental and toxicological criteria for determining the suitability of land for growing organic products is the location of land relative to sources of pollution (fig. 1). This indicator is important because industrial enterprises and facilities can release pollution into any component of the environment.

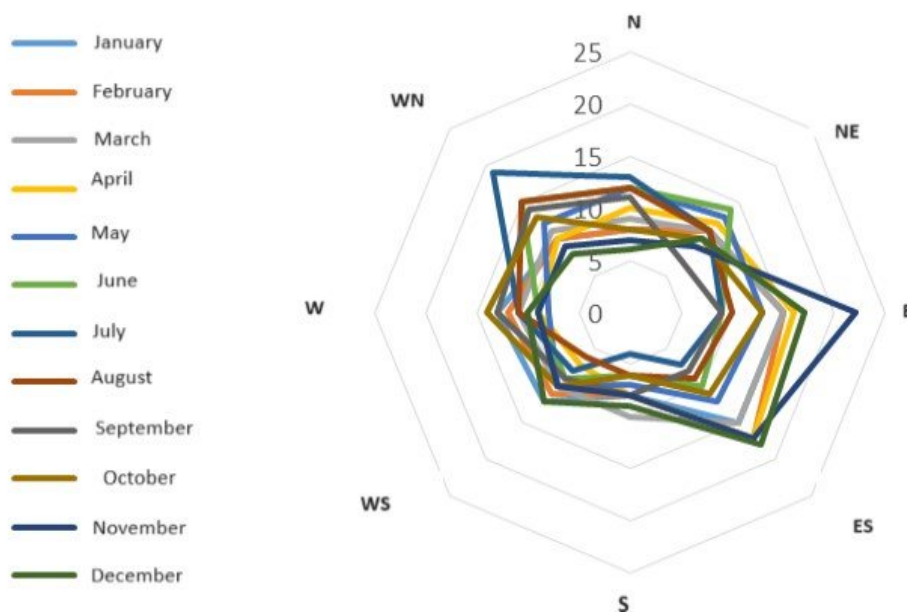


Figure 1. Wind rose of Kharkiv region

Based on the wind rose, we determine that the prevailing winds will be: east winds, northwest winds, and southeast winds. The standards of criteria for the degree of soil suitability for organic farming based on the location of land relative to sources of pollution are shown in Table 1.

Table1. Standards for the distance between land and pollution sources

Indicators	Suitable for	Conditionally suitable
Location of industrial enterprises and facilities that may pollute the environment in the direction of prevailing winds	>30 km	<30 km
Location of industrial enterprises that may pollute the environment in other areas	>15 km	<15 km
Location of land from international, national and regional highways	>300 m	<300 m

According to the results of the study, namely the comparison of the distance between industrial facilities and the test plots, the soil cover is conditionally suitable for organic farming based on the location of industrial enterprises in the direction of prevailing winds. The next step was to examine the enterprises that could be polluters in other directions, based on the results - conditionally suitable. Next, using the MapInfo software, we made a cartographic work with the roads of the Chuhuiv district in order to measure the distance of the research sites from the roads (Fig. 2.) The nearest road is the international road E40, the distance from the sampling sites is 6.6 km. The regional road P07 is 9.8 km away. Therefore, the household plot is suitable for organic farming according to this ecological and toxicological criterion.

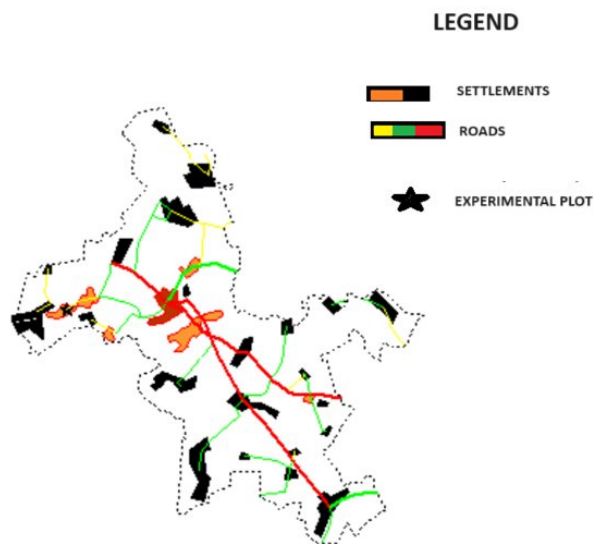


Figure 2. Roads of Chuhuiv district

An important ecological and toxicological criterion that determines the suitability of soils for organic farming is the content of mobile forms of heavy metals relative to the maximum permissible concentration (MPC). According to this criterion, soils are divided into two classes - suitable and conditionally unsuitable. To assess the suitability of soils according to this criterion, soil samples from the experimental site were analyzed. The analysis of heavy metal content was conducted for three consecutive years in two research laboratories. Table 2 shows the results of determining the suitability of soils by the content of HM relative to the MPC.

Table 2. Evaluation of soil suitability for organic farming by heavy metal city

Elements	Heavy metal content, mg/kg					MPC	Suitability
	Under cucumber culture			Under the strawberries	Under natural cover		
Cd	0.037	0.005	0.0005	0.0001	0.0013	0.7	Suitable
Co	-	0.285	-	-	-	5	Suitable
Cr	-	1.755	-	-	-	6	Suitable
Cu	0.638	1.225	0.013	0.0247	0.031	3	Suitable
Fe	0.092	4.65	-	-	-	-	Suitable
Mn	14.495	-	-	-	-	50	Suitable
Ni	1.605	-	-	-	-	4	Suitable
Pb	0.172	3.13	0.00	0.00	0.00	6	Suitable
Zn	1.761	10.835	0.00	0.4305	1.1425	23	Suitable

The detected concentrations of heavy metals do not exceed the current standards for maximum permissible values. This is a confirmation that the soil is suitable for growing organic crops.

The next step in the study of soil suitability for organic farming was to compare the indicative indicators with the suitability criteria. Indicative indicators were pH, humus content, and content of mobile forms of trace elements. According to the "Concept of Organic Agriculture", the reaction of the soil solution should be less than 8.0, under which conditions the soil cover is considered suitable for organic farming.

The soil samples collected were tested for compliance with the soil-agrochemical pH criterion, and the results showed that the soils under cucumber cultivation were suitable, and those under natural vegetation and strawberries were conditionally suitable. To determine the humus content, the National Atlas of Ukraine determined that the territory is located on typical medium-humus black soil, which corresponds to 4-6% and defines the soil as suitable for organic farming.

To determine the suitability class of soils for organic farming, their trace element status is determined, which ensures optimal plant nutrition. The content of mobile forms of Co, Cu, Zn, Mn, Ni was analyzed as trace elements that determine the suitability class. The results of the study are presented in Table 3.

Table 3 Evaluation of soil suitability for organic farming based on the content of microelements

Soil sample	Content Zn, mg/kg	Content Cu, mg/kg	Content Mn, mg/kg	Content Ni, mg/kg	Content Co, mg/kg	Suitability
Under cucumber culture	10.835	1.225	14.495	1.605	0.285	Suitable
Under the strawberries	0.4305	0.0247	-	-	-	Suitable
Under natural cover	1.1425	0.031	-	-	-	Suitable

The content of mobile forms of Co, Cu, Zn, Mn, Ni is within the normal range, which means that the soil cover is not overloaded with fertilisers and the fertilisers applied are organic, not chemical. The application of organic fertilisers not only enriches the soil, but also stimulates the synthesis of humic and fulvic acids, which have an increased metabolic capacity. Their use is a component of organic (environmentally friendly) crop production.

The next step in determining the suitability of the soil cover for organic farming was to determine phytotoxicity. This study can serve as an alternative to the ecological and toxicological criterion for determining the suitability of soil cover for organic farming - the content of pesticide residues (Balyuk, 2015). If phytotoxicity is detected in soil samples, then pesticide residue analysis is appropriate. If phytotoxicity is not detected, then this analysis can be omitted, because the definition of bioassay, because this analysis allows to detect the lowest concentrations of toxicants that can be in the soil.

The study was conducted for 96 hours, and biotesting was conducted during the experiment. The test object was black radish. The control was black radish germinated in water. The study was conducted in the laboratory of ecological and toxicological research, which is a structural unit of the Faculty of Ecology of V. N. Karazin Kharkiv National University.

After 96 hours, the length of sprouts and roots in the control and experimental samples was measured. The results of the study are presented in Table 4.

Table 4 Results of black radish germination in experimental samples

	Control	Soil sample under a cucumber crop	Sample under a strawberry crop	Sample under natural plants
Root length, mm	23.0285	23.6857	32.8571	29
Length of sprouts, mm	10.1428	9.8571	9.7428	12.97

The results of calculating the difference in the length of roots and seedlings relative to the control are presented in Table 5.

Table 5 Quality class of experimental soils by phytotoxic effect

Soil sample	Phytotoxic effect, %		Level of soil contamination	Soil quality class
	sprouts	roots		
Soil sample under a cucumber crop	2.81	-2.85	Uncontaminated	I
Sample under a strawberry crop	3.94	-42.67	Uncontaminated	I
Sample under natural plants	-27.88	-25.93	Uncontaminated	I

The study found that none of the soil samples had a phytotoxic effect, which indicates that the soils are uncontaminated and their quality class is the first. This is also evidence of the soil's suitability for organic farming, as biotesting is very sensitive to the content of various toxicants, including pesticides.

The next step was to conduct a microbiological analysis of the soil, as this analysis allows us to assess the fertility of the soil cover and determine the phytosanitary condition of the soil. During the microbiological analysis of the soil cover, four media were made to identify different types of microorganisms and their number was counted. The results of the study showed that the mineralization process under the strawberry crop is faster than under the cucumber crop, which may indicate excessive soil moisture due to excessive watering, which indicates the need to regulate watering.

CONCLUSIONS

According to the ecological and toxicological criteria of soil suitability for organic farming, the soils of the studied household plots are suitable according to the following regulatory criteria: by the location of the land in relation to international, national and regional highways, they are suitable, by the criterion of the location of the land in relation to the prevailing winds and winds in other directions - conditionally suitable. Also, the soils of the studied household plots are suitable for organic farming in terms of the content of mobile forms of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb, Zn, and no exceedances of the maximum permissible concentrations of their mobile forms were detected.

When determining the suitability of soils for growing organic products according to soil and agrochemical criteria, it was found that the studied soils meet the requirements for suitability according to the following regulatory indicators: depth of the humus horizon, reaction of the soil solution, and trace element status.

No phytotoxicity was detected in all soil samples and they belong to the first quality class. This is an additional evidence of the possibility of growing organic products on the soils of the studied household plots in the settlements of Chuhuiv district of Kharkiv region. Therefore, organic farming is a possible way to maintain the so-called "edible green infrastructure" and ensure the sustainability of the urban environment.

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Food and gastronomy

PREVENTION OF CROSS-CONTAMINATION IN THE FOOD INDUSTRY

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ABSTRACT

Food technology is one of the most important branches of the economy in most countries around the world. Not only in terms of production, processing, storage, distribution, and placement of food on the market, but also in terms of ensuring product quality, placement of health-safe products, ensuring hygienic conditions at all stages from raw materials to market placement. Cross-contamination is defined as the transfer of bacteria or other microorganisms from one substance to another. This can occur at any stage of food production. In every type of cross-contamination, bacteria are transferred from a contaminated source to uncontaminated food. Good food safety hygiene practices can significantly reduce the risk of cross-contamination. Thorough hand and surface washing, proper food storage, and timely food withdrawal. In order to prevent cross-contamination, entities must have implemented an HACCP system within their food processes. Prior to this, entities must have established a Prerequisite Program to implement the HACCP system, primarily by informing, training employees, and adhering to these measures in all processes, contributing to better working conditions. By implementing good manufacturing practices, good hygiene practices, and other legal measures, cross-contamination can be avoided. Consequently, food products in any form reach consumers as quality, health-safe, and hygienically secured.

Keywords: cross-contamination, HACCP, food safety.

INTRODUCTION

Food technology is one of the more significant branches of the economy for most countries in the world. Not only in terms of production, processing, storage, distribution, and marketing of food but also in terms of ensuring product quality, marketing of health-safe products, and ensuring hygienic conditions at all stages that raw materials go through until they are marketed. Entities in the food sector are obliged to ensure hygienic and production practices to ensure health-safe food to prevent food contamination, thus poisoning consumers and other health problems. Cross-contamination is defined as the transfer of bacteria or other microorganisms from one substance to another. This can happen at any stage of food production. In every type of cross-contamination, bacteria are transferred from a contaminated source to uncontaminated food. Good hygienic food safety practices can significantly reduce the risk of cross-contamination. Thorough hand and surface washing, proper food storage, and timely food withdrawal.

Preventing cross-contamination is one of the steps that help in the elimination of foodborne diseases. Cross-contamination of food is a common factor in the causes and symptoms of foodborne diseases. Food can be contaminated with microorganisms (bacteria and viruses) from several different sources during the food preparation and storage process. To prevent cross-contamination, entities must have implemented a HACCP system within their food processes. Previously, entities must have established a Prerequisite Program for the HACCP system to be implemented. Through the implementation of good manufacturing practices, good hygienic practices, and other legal measures, it is possible to avoid cross-contamination. Thus, food products in any form reach consumers as quality, health-safe, and hygienically secured.

NEGATIVE EFFECTS OF CROSS CONTAMINATION

Cross-contamination refers to the transfer of microorganisms from one food (food raw material, semi-finished product, product) to another, or from a contaminated surface, utensils, and personnel to food (Karahmet, Toroman, Hamidović, 2017). Cross-contamination occurs when pathogenic microorganisms (bacteria, viruses, fungi) can be transferred from raw ingredients to products that have already undergone thermal treatment and from which the present (vegetative) microflora has been removed (Radovanović, Rajković, 2009). According to Pérez-Rodríguez, Valero, Carrasco, García-Gimeno, and Zurera (2008), who examined the transmission of bacteria to food, “cross-contamination” is a general term that refers to the transfer, direct or indirect, of bacteria or viruses from a contaminated product to an uncontaminated product.

In the guidelines for validating control of cross-contamination during the washing of freshly cut leafy vegetables, Gombas, Luo, Brennan, and others (2007) concluded that cross-contamination is the result of pathogen transfer from a contaminated leaf to an uncontaminated leaf during washing in water. Cross-contamination arises due to the type of pathogen, population size, physiological status; antimicrobial type of pathogen, concentration and activity; environmental conditions (such as pH) and other operational conditions, such as temperature and turbulence. The longer a pathogen survives in water (Robinic et al., 2023) , the greater the possibility of cross-contamination.

Cross-contamination is the primary cause of pathogenic contamination of fresh produce at any point in its production-distribution chain. Production areas play a major role in forming the ecosystem of cross-contamination, making the transfer of microbes

possible in any direction, including various sources, utensils, carriers of infection, handling procedures, affecting a different series of food.

Detecting and understanding the complexity of cross-contamination pathways in food preparation areas should be a priority according to Possasi, Pérez-Rodríguez (2023).

Food is contaminated when it contains at least one unwanted/unsafe substance, which can occur during production, sale, cooking, packaging, transportation, and storage, as well as before and during harvest. Food can be chemically (Markovic et al, 2023), physically, or biologically contaminated (Food and Drug Administration, 2017). The most commonly contaminated foods are of animal origin (meat, poultry, fish, eggs, milk), while plant-based foods are less frequently contaminated and suitable for the proliferation of microorganisms, thus posing less danger to human health. Contaminants can be naturally present in food, can uncontrollably enter from the environment, or can be residues (remnants) of treatments used by humans in various stages of food production, packaging, processing, or are the result of some natural processes (Karahmet et al., 2017). Cross-contamination occurs when food passes over contaminated surfaces or when it is exposed to aerosols or condensates originating from a contaminated surface. To prevent contamination from surfaces and the environment, it is very important to maintain the hygiene of surfaces and the environment where food is produced, stored, and marketed. Since surface hygiene is important from the perspective of food safety, good hygienic practices (GHP) and verification of their application are integrated into the HACCP system (Savić Radovanović, Sindić, 2023).



Figure 1. Warning for cross contamination

(<https://everluxmaritime.com/en/catalogue/infection-prevention-and-control-safety-signs/composite/sc-161/>)

The chances of food contamination and cross-contamination increase, especially in lower socio-economic classes due to unsatisfactory environmental conditions, poor personal hygiene, poor water quality and supply, and unhygienic food storage conditions. Cross-contamination can be a cause of allergens (multiple components) presence in food, thereby causing allergic reactions in sensitive individuals. For example, through containers, the hands of employees in the production area. In terms of this group of hazards, a general approach must be established on how to handle allergens (Radovanović, Rajković, 2009). There are three main types of cross-contamination: food-to-food, people-to-food, and equipment-to-food.

MEASURES TO PREVENT CROSS CONTAMINATION

To prevent the occurrence of cross-contamination, it is of great importance for all entities in the food industry to implement and adhere to international standards, national regulations, and all operational procedures prescribed by laws. This ensures compliance with food quality criteria, safe manufacturing practices, and hygienic and sanitary conditions. Good record-keeping can also help prevent contamination and track the source of outbreaks if they occur. Having a clear system and monitoring when a facility is disinfected will help ensure that disinfection protocols are followed.

The European Union and developed countries around the world use the Codex Alimentarius, Food Law, National Regulations, GMP, GHP, HACCP, ISO, and others for managing food quality, leading and controlling production processes.

The Codex Alimentarius (Latin for “food code”) is a collection of internationally recognized standards, rules of practice, guidelines, and other recommendations related to food production and safety. Some of these texts are general, some contain very detailed requirements related to food or groups of food products, and some consider the food production process or legislative systems for food safety and consumer protection. The Codex Alimentarius Commission (CAC) (<http://www.fao.org>), an international food organization based in Rome, was formed in 1963 by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The ultimate goal of the Codex Alimentarius Commission is to protect consumer health and ensure good practice in international food trade, i.e., to prescribe rules for regulating agriculture and complete control of food from seed to final product. The CAC is responsible for developing internationally recognized standards regarding food safety (currently has 176 member countries) (Radovanović, Rajković, 2009). In the food production processes in recent years, the term “Prerequisite Programs” (PRP) is increasingly, almost exclusively, used. It can be defined as “any specific and documented activity or means that corresponds to the Codex of general requirements for hygiene in the food industry, good manufacturing practice, and current regulations (laws, regulations, and other regulations), all with the aim of creating basic requirements necessary for the production (processing and processing) of safe food in all parts of the food/nutrition chain” (Jaxsens, 2009). In other words, the term “Prerequisite Programs” (PRP) includes: good hygienic practice (Good Hygienic Practices – GHP), good manufacturing practice (Good Manufacturing Practices – GMP), and current regulations (Radovanović, Rajković, 2009). Ways to maintain food safety and hygiene are:

- Good Manufacturing Practice (GMP),
- Good Hygienic Practice (GHP),
- Standard Sanitation Operating Procedure (SSOP),
- Hazard Analysis and Critical Control Points (HACCP).

GOOD MANUFACTURING PRACTICE

Good Manufacturing Practice (GMP) is a set of requirements and procedures (measures) that define the basic principles of controlled food production, both in primary production and processing, under environmental conditions that ensure the production of hygienically correct and consumer health-safe food.

The main motive and goal of applying GMP requirements/procedures is the prevention and reduction of contamination (both level and frequency). This relates to (micro) biological, chemical, and physical types of contamination. The most important

GMP requirements and measures (procedures) that must be defined and achieved relate to (Radovanović, Rajković, 2009):

- GMP 1: cleaning, washing, and disinfection;
- GMP 2: pest control;
- GMP 3: control of water and air;
- GMP 4: temperature control;
- GMP 5: personnel – especially employees in the production area (appropriate sanitary facilities, changing rooms, dining rooms, hygienic work practices, health status, education, and motivation);
- GMP 6: structure and infrastructure (environment of the facility, materials used in the construction of the facility – especially production zones, hygienically designed equipment and materials);
- GMP 7: technical maintenance;
- GMP 8: control and management of waste materials;
- GMP 9: control of basic raw materials and other input materials;
- GMP 10: work/production procedures and behavior.

GOOD HYGIENIC PRACTICE

Good hygienic practice is not legally mandatory, but producers voluntarily apply it to obtain a higher quality product. Food hygiene consists of all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain. Hygienic measures include: cleaning and disinfection, maintenance, removal of any contamination by biological or chemical substances, foreign objects, or other substances that may endanger the safety and suitability of food. It is very important to know the sources of food contamination and process plants, as well as microbiological, chemical, and physical hazards that can threaten the health safety of food (Karahmet et al., 2017).

Table 1. Hygiene practice

Good hygiene	Lack of hygiene
Compliance with the food Law	Consumer complaints
Reduction of consumer complaints	Violation of consumer
Consumer trust	Diseases (food poisoning),
Enhanced reputation	Lack of willingness among consumers to buy again
Good manufacturing conditions for workers in processes	Bad publicity

Source: Karahmet et al., 2017.

Good hygienic practice entails controlling those microorganisms that cause foodborne illnesses. To ensure good hygienic practice is effective, it is necessary to pay attention to cross-contamination, cleaning, cooling, and thermal processing (Karahmet et al., 2017).

HYGIENE AND SANITATION OF THE PRODUCTION PROCESS

The origin of the word sanitation comes from the Latin word “sanitas,” which means health. Applied to the food industry, sanitation represents the creation and maintenance of hygienic and safe conditions. Sanitation has the role of ensuring safe food that is processed, prepared, displayed, and sold in a clean environment and by

healthy workers; to prevent contamination with microorganisms that can cause foodborne diseases and to prevent the growth of microorganisms that cause food spoilage. Effective sanitation measures include all procedures that help achieve these goals (Marriott, 1997).

Sanitation is primarily conducted to reduce the total number of microorganisms, which is possible only after reducing organic impurities, as they provide a medium for the proliferation of microorganisms. Therefore, sanitation procedures can be divided into measures called sanitary washing and measures called disinfection. In food production, there must be a standard sanitary operating procedure that details the places to be sanitized, the agents used, work methods, frequency, evaluation methods, and the like. All procedures must be performed by qualified personnel, and there must be expert supervision, especially when using dangerous chemicals. The sanitary procedure should ensure:

- Effective and reliable control and maintenance of hygienic-sanitary conditions (hygiene) in the food production facility,
- Prevention of incidental situations regarding hygienic-sanitary requirements,
- Clear definition of the levels of authority and responsibility, and
- Development of a culture within the company where production workers take an operational role in controlling hygiene in the company.

The sanitation program must be evaluated to determine its effectiveness in cleaning and sanitation. Data related to the implementation of the program not only show the effectiveness of sanitation but also provide documentation for the program being implemented. The goals and limitations of sanitation are key in determining the effectiveness of sanitation. To assess sanitation procedures, current effectiveness should be measured against previous effectiveness, and the achievement of desired goals should be used to determine progress (Karahmet et al., 2017).

Maintaining the hygiene of the production facility is the best way to prevent (avoid) the presence of pests and the accumulation of pathogenic microorganisms. Therefore, it is necessary for every company to have a developed (defined) plan for cleaning, washing, and disinfection. In modern conditions, not only the procedures of cleaning, washing, and disinfection are important, but also complete sanitation in the processes and production of food (Marriott, 1997).

Hygiene maintenance is carried out within systematic and planned activities by employees (Internal hygiene) or by competent services outside the company (External hygiene). Internal hygiene includes: controlling the condition and cleanliness of surfaces that come into contact with food, preventing cross-contamination, controlling the hygiene of the sanitary block, protecting food, packaging materials, and surfaces that come into contact with food from the influence of toxic materials, and controlling the labeling, storage, and use of chemicals. External hygiene includes: sanitary supervision over employed persons, control of water safety, and removal of pests from the company. Hygienic-sanitary measures include (Karahmet et al., 2017):

- Water safety that enters the composition of the finished product and water used for washing equipment, utensils, and tools for production,
- The condition and cleanliness of surfaces that come into contact with raw materials, semi-finished products, and finished products, including machines, equipment, work utensils, work clothes, and footwear;
- Procedures for preventing cross-contamination from unhygienic objects to products, raw materials, product packaging material, machines, equipment, work utensils, work clothes;

- Handling during washing and cleaning of the sanitary block, protection of products, raw materials, packaging materials, machines, equipment, from contamination under the influence of lubricants, fuels, cleaning substances, disinfectants, condensates, and other chemical, physical, or biological risks,
- Appropriate labeling, storage, and use of toxic substances,
- Controlling the health of employees, which can affect the microbiological contamination of products, raw materials, packaging, and
- Exclusion of pests from production facilities.

The cleaning, washing, and disinfection plan must be documented and must cover aspects such as (Radovanović, Rajković, 2009) :

- What needs to be cleaned, washed, and disinfected?
- How are the activities carried out and what equipment is used for this?
- When is it necessary to perform cleaning, washing, and disinfection?
- Who is responsible for cleaning, washing, and disinfection?
- Record or log of completed activities.

The best results are achieved when these three activities are carried out according to the following schedule (Radovanović, Rajković, 2009):

- Preparation and cleaning – visible impurities are removed with a scraper, brush, or water. As needed, equipment, utensils, and tools must be disassembled to make all parts accessible for effective hygiene maintenance. Some of the cleaning activities include: washing with hot water, cleaning with high-pressure water, using foam, suspension, then sanitation with halogen compounds, acidic sanitary agents, ozone, UV radiation, and CIP.
- Washing – surfaces are first washed with water, then with an appropriate detergent, which removes grease. Rinsing with water removes dirt and detergent, and residual water from rinsing must be removed so as not to reduce the effect of the disinfectant.
- Disinfection – for disinfection to be effective, the cleaning and washing process must be properly performed. Disinfection is the destruction, inhibition, or removal of present microorganisms, to prevent the risk of spreading diseases and spoiling food. It can be performed by mechanical, physical, and chemical methods.

The agents used in food production processes for effective washing can be chosen, but they must be odorless and of a chemical composition that does not damage the materials of surfaces that come into contact with food. Agents used for disinfection must be approved by the competent ministry (or other competent state institution) and must be registered as biocides. The use of one disinfectant over a long period can lead to resistance of certain microorganisms to that agent. Therefore, it is important to regularly and systematically change disinfectants. Also, for every agent used in the hygiene maintenance process (washing), there must be instructions for use for each product used. Detergents and disinfectants may be present in the rooms for food production and storage only during cleaning and disinfection. At any other time, these agents must be treated as a potential hazard and must be stored physically separately and secured to prevent accidental food contamination. Disinfectants can be anionic, nonionic, and cationic detergents (Radovanović, Rajković, 2009; Karahmet et al., 2017).

Cleaning equipment (brushes, scrapers, cloths, sponges, etc.) must be made of synthetic or some other material that is not a source or carrier of contamination, and must be resistant to corrosion and chemicals. The equipment must be stored in designated areas, outside of the production zone.

The equipment must be regularly cleaned and disinfected and included in the plan. Depending on the potential impact on food safety, special equipment can be used, in different colors for (Picture 2.): sanitary facilities and toilets, low cleanliness zones (zones for treating contaminated food; food from this part of the facility goes further for appropriate treatment to remove present contamination), high cleanliness zones (zones where every hazard already present in the food remains in the final product; the product is not subjected to treatment for the elimination of present hazards) (Radovanović, Rajković, 2009; Karahmet et al., 2017).



Picture No. 2. - Cleaning equipment divided by colors for different zones
(<https://www.mmccatering.co.uk/shop/colour-coded-cleaning-system/>)

SANITATION STANDARD OPERATING PROCEDURES (SSOP)

The Sanitation Standard Operating Procedures (SSOP) do not replace the practical way sanitation was conducted in production facilities; they simply document what has been successfully done. SSOP pays the most attention to the supervision of washing and disinfection procedures and the records that accompany these activities. The general requirements of SSOP, which are expected to be adopted by food industry factories in their procedures and recording methods, are (Karahmet et al., 2017):

- Use of health-safe water,
- Clean surfaces that come into contact with food,
- Prevention of cross-contamination,
- Hygiene of employed workers,
- Prevention of any kind of pollution,
- Particularly careful work with toxic components and substances,
- Health of employees,
- Timely action on non-conformities,
- Recording and keeping records,
- Existence of a HACCP plan.

HACCP

According to the definition given by the Codex Alimentarius, HACCP is a system for identifying, evaluating, and controlling hazards significant to food safety. HACCP (Hazard Analysis Critical Control Points) is a food safety system based on the analysis and control of potential biological/microbiological, chemical, and physical hazards to which raw materials are exposed, potential hazards during handling, production, distribution, and consumption of the final product. The HACCP system is adapted to all types of food products and all types of food production and handling. In the EU and World Trade Organization markets, the HACCP system became mandatory on January 1, 2006 (Council Directive 93/43/EEC). Simply put, incorporating food quality and safety standards into the general quality assurance system in companies has become a condition for doing business with partners in the international market. The legal regulations of almost all developed countries require food producers in those countries to introduce the HACCP system. The advantages of the HACCP system are (Radovanović, Rajković, 2009):

- Reduction in the occurrence of diseases caused by improper (contaminated/unsafe) food,
- Supplying consumers with health-safe food products,
- Meeting the requirements of the appropriate regulations and more efficient inspection supervision (by the competent state inspection service),
- More efficient and effective operation of the food industry (food producers) and other participants in the so-called 'food/nutrition chain',
- Increasing the competitiveness of companies in the domestic and world market,
- Eliminating technical and other barriers, especially preventing various forms of protectionism, in international trade of basic and auxiliary raw materials, as well as food products,
- Efficient introduction of new technologies and products (application of modern technological (Markovic et al., 2022) processes and equipment, as well as increasing the market offer),
- Reduction of rework, waste, and scrap,
- Reduction of production costs and overall business operations,
- Increase in profit.

The HACCP concept is based on seven basic principles recommended by the Codex Alimentarius Commission (CAC, 2003), Table 2.

Table 2. HACCP system principles

Principle	Name
Principle 1	Conducting hazard analysis
Principle 2	Determining Critical Control Points (CCP)
Principle 3	Establishing critical limits for CCPs
Principle 4	Establishing a monitoring system
Principle 5	Defining corrective actions (in case of deviation from critical limits)
Principle 6	Establishing a verification system to ensure the HACCP system is functioning correctly
Principle 7	Establishing documentation

The first step in developing a HACCP plan is to assemble a group of experts with sufficient expertise in the many food processes or products under consideration.

The HACCP team may include members from raw material handling departments, processing/production departments, quality departments, food production offices, chemical and microbiological testing laboratories, etc. (FAO, U.N. (2022a,b). Experts can be from sanitation, production, engineering, research and development, and quality control departments (Njunina, 2022). Changes that can affect product safety, which are the subject of the HACCP team meeting, include: new raw material and/or supplier, equipment change, new hygiene maintenance agents, packaging method change, product composition change (recipe), etc. (Toljagić Milodanović, 2009).

The ultimate goal of the HACCP system is to use the safest possible processes and produce the safest possible products. This means that even the correct introduction of the HACCP concept and consistent application of the HACCP system does not provide full assurance, i.e., it does not enable “absolute” food safety, since the concept of “absolute safety” is only theoretical. However, the application of the HACCP system means that the company does everything in terms of ensuring hygienic-sanitary and technical-technological working conditions and the behavior of employees so that the safety and quality of food products are at the highest or at least the required level (defined by the appropriate regulations) (Radovanović, Rajković, 2009). The HACCP system is adapted to all stages of production (excluding primary production) and handling and all types of food products. Therefore, the HACCP system can be introduced and successfully applied at all stages of production, processing and packaging, storage, transport, and distribution (<https://haccp.rs/>).

The highest management of the company, primarily the owner and/or director, must provide full and active support for the establishment, consistent application, and development of the food safety management system (e.g., HACCP system). The highest management is competent and responsible for undertaking numerous activities and implementing various specific (mandatory) requirements/tasks, primarily (Radovanović, Rajković, 2009):

- Defines and implements the goals and policy of food safety and establishes a statement on food safety policy;
- Forms a competent operational project team for the introduction, application, validation, and certification (including regular supervisory checks), as well as continuous improvements in the performance of the HACCP system – the so-called HACCP team;
- Appoints a responsible coordinator of the HACCP team – the so-called leader of the HACCP team or the representative of management for food safety;
- Defines deadlines for the introduction, validation, and certification of the HACCP system;
- Ensures resources to the HACCP team for establishing, validating, certifying, consistently applying, and systematically improving the HACCP system;
- Defines the Statement.

The statement on food safety policy is a document that, in terms of form and content, is specific to the type of production and the specific working conditions of the food (food products) manufacturing company (Radovanović, Rajković, 2009).

CONCLUSION

Cross-contamination, or cross-contamination, can be present in all food production processes, starting from the fact that the raw material can be contaminated already in the “field” and enter the industry circle and thus contaminate other food, or cross-contamination can be achieved through the hands of employees, work surfaces, due to poor hygiene and sanitary conditions.

A product placed on the market that is contaminated can lead to health consequences for consumers as well as further spread of contamination. Contamination can be prevented by applying certain hygiene and sanitary measures, respecting good manufacturing practice and the HACCP system. First of all, by informing, training employees, and their adherence to these measures in all processes, which contributes to better working conditions. In this way, the food entity satisfies the quality, safety, health correctness of legal regulations and international regulations in food production, and thus achieves consumer trust and reputation.

Given all the procedures that manufacturers need to apply and comply with, the food industry represents a complex system, which with well-implemented practices, good organization, and trained staff, can reduce all risks to a minimum, and some can be completely removed, and thus become a healthy and sustainable system that produces healthy food products.

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EFFECT OF HEAT STRESS ON FOOD CONSUMPTION, PRODUCTION AND CHEMICAL COMPOSITION OF COW'S MILK

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ABSTRACT

In order to determine the interaction of the influence of ambient temperature and relative air humidity on food consumption, milk production and chemical composition of milk in dairy cows, research was conducted during July 2023 on an agricultural farm in the vicinity of Kruševac City. The trial lasted for 26 days. The study included 20 Holstein Friesian cows, in second and third stage of lactation (150 - 300 days), housed in a facility with a tied system. During the trial, temperature and humidity of the air in the barn, feed consumption and the total production and chemical composition of the milk of the cows included in the test were measured and recorded on a daily base. Temperature and air relative humidity during the experimental period had an influence on the food consumption by the cows included in the experiment. Research results indicate that there is a moderate negative correlation between the temperature and air humidity index (THI) and the feed consumption of the monitored cows ($r = -0.469$). Based on the research results, a statistically very significant negative correlation was found between the value of the temperature and air humidity index (THI) and total milk production ($r = -0.759$) as well as milk corrected on 4% milk fat content ($r = -0.783$). High values of temperature and air humidity index had a statistically significant influence on parameters of milk chemical composition. High negative values of Pearson's correlation coefficients were found for the milk fat and protein content ($r = -0.852$; $r = -0.618$), as well as for the absolute produced amount of the specified milk ingredients ($r = -0.794$; $r = -0.821$).

Keywords: THI, Feed Consumption, Milk Yield and Chemical Composition.

INTRODUCTION

Cattle are homeothermic animals which means that their body temperature is constant and it is not dependent on ambient temperature. A condition for maintaining homeothermy is maintaining a constant thermal balance i.e. the balance between heat production and heat release from the body. The average temperature of cows measured per recti is 38,0 to 39,0 degrees of celsius. But it is considered that the biological temperature range of cows may vary from 37,5 to 39,5 C. The maintenance of body temperature is controlled by a center in the hypothalamus. In fact, the thermostatic receptors in the hypothalamus register the change in body temperature based on the amount of heat release during food digestion and nutrient metabolism. This mechanism is significant for reducing food consumption during the summer months with high outside temperature in order to reduce next production and the body's overheating. The process is called hypothalamic thermostat (Noordhuizen and Bonnefoy, 2015).

Cattle, as most other animals, are much more tolerant of low than high ambient temperature. It has been proved that dairy cows can adapt to a wide temperature range with comfort zone in the range from 0 to 20°C, but from the milk production aspect, a shorter temperature range is optimal (from 0 to 15°C). The upper critical temperature above which hyperthermia may occur is 25 to 26°C. An increase in ambient temperature has inhibitory effect on the appetite center in the hypothalamus resulting in decreased food consumption (Baile and Forbes, 1974). In lactating cows, food consumption begins to decrease at the temperature of 25 to 26°C the decrease is more intense at temperature of 30 C and it will be suspended (Rhoads et al., 2013) at 40°C. In a study conducted by Cincovic and Belic (2011) it was proved that in cows under heat stress, the dry matter utilization of the meal is reduced. This is due to calorogenic effect of food since a significant amount of energy is released by food digestion. Causing an additional heating of the body. In heat stress conditions reduced food consumption also results in reduced nutrient utilization (Rhoads et al., 2009). An increase in temperature change the basic physiological mechanism of paunch and increasing risk of metabolic disorders and health problems (Soriani et al., 2013; Nardone et al., 2010). Moallem et al. (2010) states that the rumination time plays a key role in the negative impact of heat stress on DMI, and, consequently on milk production.

Milk production in cattle is one of the most complex biotechnology since a large number of factors affect the quantity and quality of milk, the dominant of wich are climate factors (temperature, air humidity, insolation, air flow, precipitation). A long-term adverse impact of one or more climatic factors causes stress in animals wich becomes more intense the more productive they are (Bohmanova et al., 2007). In heat stress conditions, heat loss mechanisms are activated and milk production reduces (Micic et al., 2022). Outdoor or ambient temperature and air humidity in the environment in wich the animal lives are the most common indicators of heat stress. The temperature index and air humidity are calculated using the values of these parameters in anglo-saxon references it is known as temperature-humidity index (THI) (McDowell et al., 1976). Model for calculating the index is as following:

$$THI = 0.8 \times T + [(RH/100) \times (T-14.7)] + 46.4 \text{ (Mader et al., 2006) (1)}$$

According to the THI index value, heat stress can be defined as:

1. Mild, value 72 to 75;
2. Moderate, value 79 to 88;

3. Strong, value 89 to 98;
3. Very strong, value above 98 (McDowell et al., 1976).

The obtained value THI is less or equal to 70 indicates that outdoor temperature is favorable for the cows body as the obtained value of 72 to 78 indicates that outdoor temperature is stressful for the cows body. At the value that is higher than 78 there is a very strong stressful effect of outdoor temperature on the animal health, especially on the lactating cows that are in such conditions, not able to maintain body temperature within physiological limits by using their own thermoregulatory mechanism (Cincovic et al., 2011; Dikmen and Hansen, 2009). The negative effect of heat stress is manifested in the first 24-28 hours after exposure. If the values of THI are between 72 to 80 milk production is significantly decreased in the first four days after exposure (Collier et al., 2012).

MATERIAL AND METHODS OF WORK

The research was conducted during July on a cattle farm in the vicinity of Kruševac town, Serbia. During the research the cows were housed in a tie-stall barns with a slatted floor and beds 220 cm long. The brick built barn was constructed of solid brick walls on the three sides and the fourth side was opened during the summer period and closed in the winter season by a plastic sheet.

The research included 20 dairy cows of Holstein-Friesian breed. A trial period lasted 26 days during which time a total quantity of milked milk produced by all the cows included in the trial has been recorded on everyday basis. Milking was performed twice daily (at 07:00h and 18:00h). Milk chemical composition (milk fat content and milk protein) has been analysed by Lactan-600 Ultramax milk quality analyser in a laboratory of the Agricultural Faculty of Kruševac.

For the purposes of this research temperature and air humidity in cow barn where cows were housed were recorded every day in early afternoon hours (between 13 and 14 hours). To measure these parameters LCD table thermohygrometer was used and it was placed in the middle of the barn at the height of 170 cm above the floor. On the basis of these parameters the measured values of an index of temperature and air humidity were determined every day in the course of the trial period by using following model:

$$THI = 0.8 \times T + [(RH/100) \times (T - 14.7)] + 46.4 \text{ (Mader et al., 2006) (1)}$$

where:

THI – is an index of temperature and air humidity;

T – air temperature;

RH – relative air humidity.

The cows were fed two times a day, before morning and evening milking. Rations were formulated for the cows with daily dairy production of 17 kg milk with 3.9% milk fat and 3.3% milk protein by means of NRC (2021) computer model and programme. Ration and concentrate mixtures composition, and ration nutritive value are displayed in tables 1, 2 and 3.

The trial cows were in their mid-lactation. The basis of the roughage portion of the ration made alfalfa hay and whole crop maize silage. Alfalfa hay was obtained from the second cut, by mowing the plants in a full flowering phase. A whole crop maize used for silage preparation was collected when a dry matter content was 40%.

Table 1. Composition of a ration

Feeds	kg/day
Alfalfa hay	4.9
Corn silage	18
Wheat straw	1.6
Concentrate mixtures	2.9

Table 2. Composition of concentrate mixtures

Components	%
Corn grain	23.94
Wheat grain	23.94
Soybean meal, solvent	30.78
Sunflower meal, solvent	17.10
Salt	2.98
Monocalcium phosphate	0.51
Vitamin-mineral premix*	0.75

*Mixture of vitamins and trace elements, 1 kg contains: Vitamine A, (1000) UI – 3405, Vitamine D (1000) UI – 908, Vitamine E, UI – 22703, Ca – 354.2 gr, P – 0.4 gr, Mg – 0.5 gr, K – 0.5 gr, Na- 0.6 gr, S – 2 gr, Cu – 4400 mg, J – 515 mg, Fe – 272 mg, Mn – 272 mg, Zn – 13077 mg, Se – 144.93 mg.

Table 3. Nutritive value of ration

Dry Matter, kg/day	14,55
Crude protein, % DM	15,1
Rumen degradable protein – RDP, % SM	10,8
Rumen undegradable protein – RUP, % SM	4,2
NDF, %DM	41.9
ADF, % DM	28.3
Forage NDF, % DM	39.1
Non-fiber carbohydrates – NFC, % DM	35.6
Crude fat, % DM	2.5
Crude ash, % DM	4.9
Calcium, % DM	0.6
Phosphorus, % DM	0.3
Net Energy of Lactation, NE _L MJ/kg DM	6.36

For the purpose of determining the effect of temperature and air humidity on consumption of ration dry matter the evaluation of rumen fill in each trial cow was carried out. Rumen fill was estimated by observation and palpation at the left body side in the region of the transverse extension of the lumbar vertebrae, the back rib and the hip. Rumen fill scoring was on a scale from 1 to 5 (Zaaijer et al., 2005).

Data statistical analysis was performed by using the parameters of descriptive statistics (arithmetic mean, standard deviation, coefficient of variation). Statistical processing of data was performed by means of PSPP computing programme (<https://www.gnu.org/software/pspp/>, accessed 12.2.2024).

For the purpose of evaluating the statistical significance of difference of mean values a Pearson correlation coefficient was used. Statistical significance was determined at $p < 0.05$ and $p < 0.01$ levels of significance.

RESULTS AND DISCUSSION

The values of ambient conditions during trial period are shown in Table 4.

Table 4. Ambient conditions during trial period

Parameters	Values
Minimum temperature, °C	24
Maximum temperature, °C	35
Mean temperature, °C	30.42
Number of days with temperature above 25	23
Minimum air humidity, %	39
Maximum air humidity, %	70
Mean air humidity, %	53
Maximum values of THI index	84.83
Minimum values of THI index	69.38
Mean values of THI index	79.39

During trial period the temperature and air humidity ranged in the interval of 24 to 35 °C, i.e. from 39% to 70%, respectively. It points to the fact that average values of studied parameters were also relatively high particularly those referring to temperature (30.42 °C). Upper critical temperature for Holstein Friesian breed cows above which a hyperthermia may develop is 25-26°C (Berman et al., 1985) and in our trial 23 days were recorded with temperature higher than 25 °C. Taking this into consideration along with the fact that an average value of THI index (79.39) was above critical value it can be concluded that during a trial period the examined animals were exposed to heat stress.

A heat stress in cows extremely negatively impacts yield and quality of milk (Milosevic, 2002). A critical level of THI index when milk production in cow may decrease is 72 (Ravagnelo et al., 2000). Many authors determined that the greatest number of days with values of THI index above 70 were recorded during the month of July (Hosseini-Zadeh et al., 2013; Beniston, 2004; Black et al., 2004). High outside temperatures during summer months accompanied by a high air humidity are the main limiting factors for milk production (Johnson, 1987). Daily variations of temperature, relative humidity of air and THI index during trial period are shown in Figure 1.

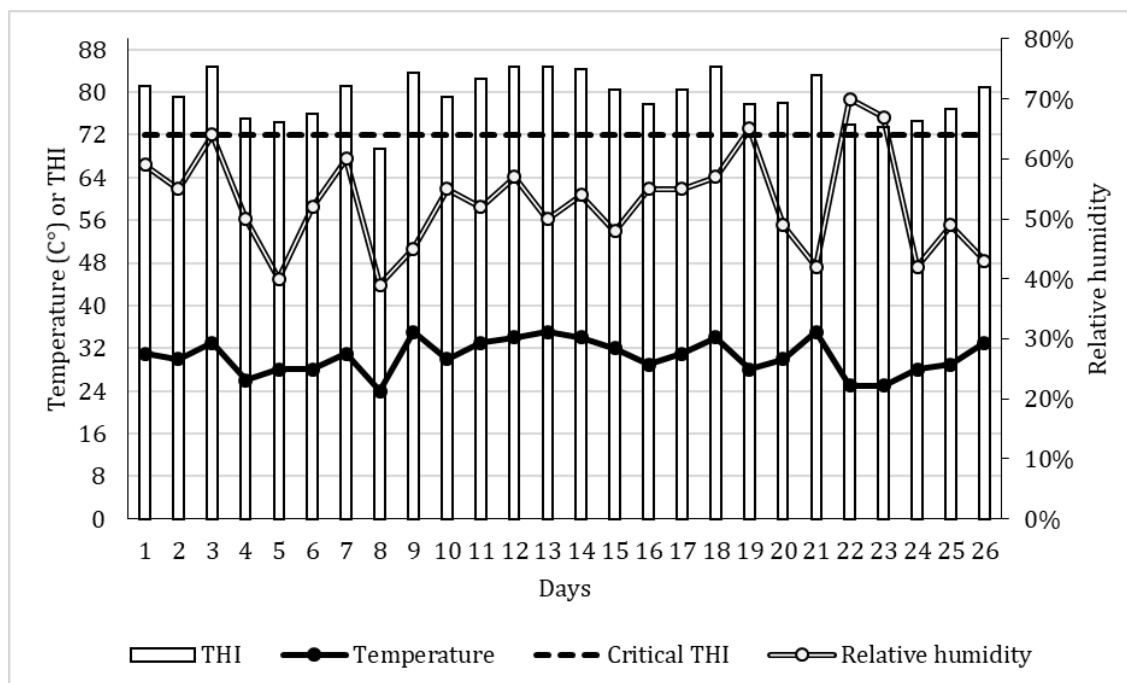


Figure 1. Average daily temperatures, relative humidity and THI variation during the trial period

On the basis of parameter values shown in Figure 2 it can be concluded that during a trial period the examined animals were exposed to the action of ambient factors within the range of unfavourable values. This research determined that 96% days during trial period were characterised by critical values of indices of temperature and air humidity (THI>72). It indicates the fact that the highest milk yield (375 kg/day) was realised in the conditions when cows were not exposed to unfavourable impacts of ambient conditions (THI<72).

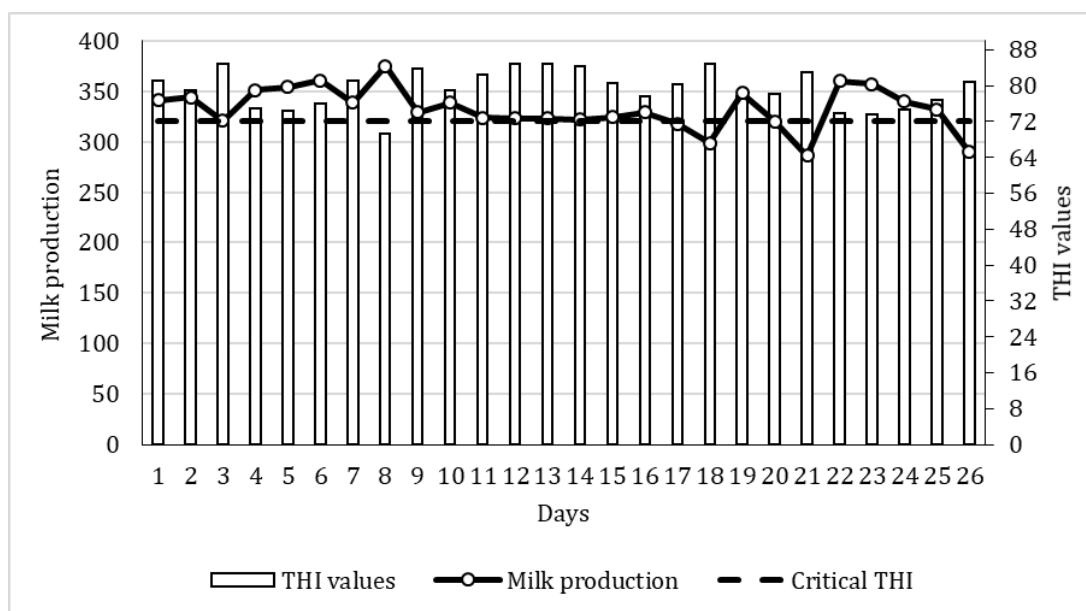


Figure 2. Total milk production and THI values during trial period

In the conditions of heat stress feed intake decreases by 20% and when ambient temperature is 40°C the quantity of feed consumed decreases by 50% (NRC, 1989) what can disturb both the energy balance and activity of mammal gland (Rhoads et al., 2009). This is particularly expressed in cows in mid-lactation period since in this phase of production cycle a quantity of milk produced depends in the highest degree on the volume of consumed feed (Spiers et al., 2004).

During a trial period the consumption of ration dry matter was accompanied by the evaluation of rumen fill in each cow included in the trial. The optimal score of rumen fill in dairy milking cows in mid-lactation period was about 3 (Zaaijer et al., 2005). In our trial the score of rumen fill ranged in the interval of 2.9 to 3.6 with an average score being 3.34 (Table 5).

Table 5. Mean values and variability of rumen fill score

Parameters	Rumen fill score
Mean value	3,34
SD	0,19
CV, %	5,68
Maximum	3,6
Minimum	2,9

The results of the analysis of the effects of ambient factors indicate a significant impact of heat stress on volume of feed consumed and consequently to the rumen fill with food (Figure 3).

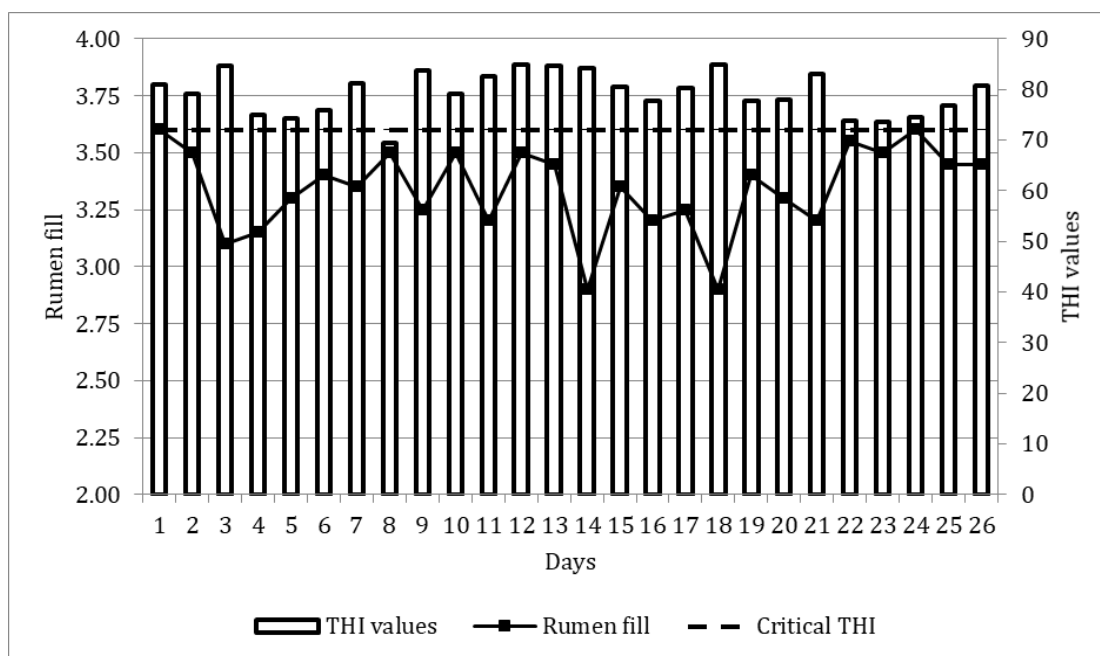


Figure 3. Impact of heat stress on volume of feed consumed

Data displayed in Figure 3 show that the lowest score of rumen fill (2.9) was perceived in the conditions of the highest value of index of temperature and air humidity. It highlights the fact that heat stress affected feed consumption decrease and, what is even more important, by lower volume of consuming ration fibers essential for maintaining normal function of rumen what resulted in decreasing the milk fat content (Bouraoui et al., 2002). In the conditions of cattle feeding by complete mixtures a

decreasing of the content of milk fat is significantly alleviated even at high THI values since by such ration the possibility of choosing more tasteful rations is significantly decreased. About 35% of losses in milk production is a consequence of a reduced intake of ration dry matter. Moallem et al. (2010) reported that a primary negative effect of high THI index was being expressed through reducing the rumination time and by slower passage of food through digestive tract what could consequently lead to decreased daily consumption of ration dry matter (DMI). Decreased intake of ration dry matter in lactating cows is connected with decreased content of protein in milk (West, 2003).

In Table 6 the average values and variability of traits of milkiness monitored during the research are displayed.

Table 6. Mean values and variability of milk yield traits during trial period

Parameter	N	$\bar{X}$	SD	CV (%)	Max	Min
Milk production, kg/day	26	17,51	1,12	6,40	19,74	15,05
4% FCM, kg/day		16,64	1,16	6,97	19,09	14,19
Milk fat content, %		3,70	0,07	1,18	3,78	3,57
Milk fat yield, kg/day		0,64	0,05	7,8	0,75	0,54
Protein content, %		3,24	0,04	1,23	3,32	3,17
Protein yield, kg/day		0,57	0,04	7,0	0,65	0,49
Milk fat - protein ratio		0,88	0,01	1,14	0,904	0,869

4% FCM – daily milk production corrected to the content of 4% milk fat

By analyzing the data in Table 6 it can be concluded that an average production of milk and 4% fat-corrected milk during trial period was 17.51 kg/day, i. e. 16.64 kg/day, respectively. Difference between minimum and maximum milk production and 4% fat-corrected milk accounted for 4.69 kg i.e. 4.9 kg, respectively. The content of milk fat ranged in the interval of 3.57 to 3.78%, and milk protein from 3.17 to 3.32%. The average yield of milk fat and protein accounted for 0.64 i.e. 0.57 kg, respectively, their average ratio being 0.88.

Bryant et al. (2007) reported that milk production, content of milk fat and milk protein can non-linearly decrease when indices of temperature and air humidity are in the interval of 65 and 75. In their research it was determined that in the interval of THI values above 80 the cows had lower yield of milk and 4% fat-corrected milk by 8.2% i.e. 9.1%, respectively, in comparison with milk yield at the interval of THI index below 80 (Table 7). Furthermore, content and quantity of fat and protein in milk follows a similar tendency of decreasing when the same intervals of the THI index values are in question. Namely, in the conditions of an intensive heat stress (THI>80) the content and yield of milk fat and milk protein were lower by 1.6%, i.e. 10%, respectively. Similar results were obtained also by other authors who determined that during summer months milk yields were lower by 8.1%, 7.3% and 5.4% in comparison with the periods of year with relatively low values of THI indices (Samolovac et al., 2012; Joksimović-Todorović et al., 2011, Gantner et al., 2011). On the other hand, mentioned authors came to a conclusion that in the conditions of heat stress the contents of milk fat and milk protein were significantly decreased particularly in the interval of 19.8% to 2.3% for milk fat and from 12.6% to 2.8% for milk protein. Kadzere et al. (2002) point to the fact that at the temperature of 35°C produced quantity of milk decreases by 33%, and at the temperature of 40°C by 50%.

The same authors concluded that the content of milk fat decreased by 39.7%, and the content of protein by 16.9%. On the other hand, Lopez-Gaitus et al. (2001) determined that milk yield decreased in the interval of 23% to 28% when THI value was between 73 and 76. Mentioned authors stated that maximum decrease of milk yield occurred when THI value reached 80.

Table 7. Effects of different values of THI on studied milk yield traits

Parameter	N	THI<80	THI>80
		$\bar{X}$	$\bar{X}$
Milk yield, kg/day	13	18.26	16.76
4% FCM, kg/day		17.44	15.85
Milk fat content, %		3.70	3.64
Milk fat yield, kg/day		0.68	0.61
Protein content, %		3.27	3.22
Protein yield, kg/day		0.60	0.54

4% FCM – daily milk production corrected to the content of 4% milk fat

The way in which ambient conditions expressed by the index of temperature and air humidity (THI) affected the volume of feed intake and milk yield traits in examined cows can be best seen through determined correlation coefficients between THI index and other parameters monitored during trial period (Table 8).

Table 8. Correlation association between THI and volume of feed intake and milk yield traits (Cohen, 1988)

Parameter/comparisons	r_p	Association
THI : Rumen fill score	-0.469*	Weak
THI : Milk yield	-0.759**	Strong
THI : 4% MKM	-0.783**	Strong
THI : Milk fat content	-0.852**	Strong
THI : Milk fat yield	-0.618**	Medium
THI : Protein content	-0.794**	Strong
THI : Milk protein yield	-0.821**	Strong

r_p - Pearson coefficient correlations

Data in Table 8 show that a negative weak correlation association ($r_p = -0.469^*$) was determined between the index of temperature and air humidity (THI) and the evaluation of the rumen fill. The results obtained are not completely in conformity with the results of the research conducted by Bouraoui et al. (2002). Mentioned authors determined a negative correlation association between examined parameters but not a statistically significant one ($r_p = -0.240^{ns}$). On the other hand, Holter et al. (1997) determined that there existed a mean negative statistically highly significant correlation association ($r_p = -0.630^{**}$; $r_p = -0.620^{**}$) between low, i.e. higher THI values (69.9; 82.9) and volume of feed intake. In the research conducted by Collier et al. (2019) it was determined that the strength of negative correlation between heat stress and quantity of feed intake decreased with an increased milk yield. The results of the research indicate that there is a strong negative correlation association between THI index and studied parameters of milk yield. The values of Pearson coefficient correlations ranged in the interval of -0.618^{**} to -0.852^{**} . The results obtained in regard to correlative association between studied parameters are consistent with the results obtained by the other authors who also studied the impact of heat stress on the milk yield traits in dairy cows (Kibar et al., 2020; Könyves et al., 2017; Brown et al., 2015; Samolovac et al., 2012; Gantner et al., 2011; Joksimović-Todorović et al., 2011; Bouraoui et al., 2002).

CONCLUSIONS

The results of the research show that milk production in summer months drastically decreases as a consequence of the impact of unfavourable ambient conditions. The increase of ambient temperature, index of temperature and air humidity (THI) above critical limits and the occurrence of heat stress are accompanied by decrease of volume of feed intake and milk production. A negative impact of heat stress affects both quantity and quality of milk. A negative mean and strong correlative association between the THI index value and volume of feed intake, milk production, milk fat and milk protein was determined.

Modifications which involve the use of suitable technical solutions such as opening of the barn, roof thermal insulation, increasing the intensity of natural ventilation and extra use of mechanical ventilation and water sprinklers in barns can increase the emission of body heat, decrease body temperature and have a positive effect on feed intake. Dairy cattle nutritive needs may change during heat stress what asks for a precisely balanced rations as specified by standards with an adequate energy:protein ratio, higher nutritive value and digestibility of feed consumed. A primary goal of abovementioned measures and procedures is to permanently eliminate or partly alleviate the consequences of heat stress in lactating cows. A final result of eliminating or mitigating the negative effects of heat stress in lactating cows will primarily depend on promptness and quality of applied measures and procedures.

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CHARACTERIZATION OF MYCOTOXIN HAZARDS WITH REFERENCE TO LEGAL REGULATIONS OF AFLATOXIN M₁ IN MILK

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ABSTRACT

Mycotoxins are among the most well-known and prevalent chemical contaminants in food. As secondary metabolites of molds, primarily produced by genera such as *Aspergillus*, *Penicillium*, and *Fusarium*, they can contaminate a wide range of agricultural and food products, as well as animal feed. In recent years, there has been an increasing global incidence of food contamination with mycotoxins. Reasons for this include climate change, as well as more frequent and advanced monitoring of their presence, supported by sensitive analytical methods. In terms of frequency of occurrence and negative impact on human and animal health, aflatoxins represent the most well-known and risky group of mycotoxins. Aflatoxin M₁ (AFM₁) is the mycotoxin most commonly detected in cow's milk, with possible reasons being the different digestive tract of ruminants, as well as higher food intake and a greater prevalence of feed (such as corn) that is more frequently contaminated with aflatoxin B₁ (AFB₁), which converts to AFM₁ after ingestion. Additionally, the season, and thus the production of AFB₁ in grains, has a significant impact on the occurrence of AFM₁ in milk. In Serbia, maximum permitted levels (MPL) for AFM₁ in milk have been changed several times between 2011. and 2014., ranging from 0.05 to 0.50 µg/kg, which is considered a significant deviation, while in Europe, the lowest MPL is currently prescribed concerning continents. This paper also provides an overview of LD₅₀ values for certain animals, from which it can be concluded that rabbits and piglets are the most sensitive species, while rodents show the least sensitivity to the effects of aflatoxins. Although many strategies have been developed to prevent or reduce the harmful effects of mycotoxins on human and animal health, a unified method that would be equally effective for all mycotoxins in different substrates has not yet been developed.

Keywords: mycotoxins, aflatoxin M₁, milk, health, contamination.

INTRODUCTION

Mycotoxins are among the most well-known and widespread chemical contaminants in food. As secondary metabolites of molds, they can contaminate a wide variety of agricultural and food products, as well as animal feed. Since the discovery of mycotoxins in 1960, many studies have been conducted focusing on their formation and ecology (Mejía-Teniente et al., 2011). Scientific literature data indicate that approximately 25% of the world's total grain production is contaminated with at least one mycotoxin. The frequent occurrence of mycotoxins, alongside their proven multiple negative effects on human and animal health, also leads to significant economic losses (Scudamore, 2008). The presence of mycotoxins in food is often overlooked due to public ignorance of their existence, lack of regulatory mechanisms, delayed food products, and the introduction of contaminated goods into the human food chain during food shortages caused by droughts, wars, political, and economic instability (Mejía-Teniente et al., 2011). All of the above contribute to the daily increase in research in the field of mycotoxicology. In recent years, the global frequency of food contamination with mycotoxins has been increasing. Climate change is cited as one reason for this, as well as the increasingly frequent and modern control of their presence, supported by sensitive analytical methods (Scudamore, 2008).

In terms of occurrence frequency and negative impact on human and animal health, aflatoxins represent the most well-known and risky group of mycotoxins. Their multiple harmful effects have been known and proven to date. Aflatoxins are synthesized by molds of the *Aspergillus* genus. The appearance of these molds and the synthesis of aflatoxins are characteristic of areas with subtropical and tropical climates. *Aspergillus* molds and aflatoxins are among the most common contaminants of maize, which is one of the most widespread grains in the world and occupies an extremely important place in human, and especially animal, nutrition. The largest mycotoxin epidemic was in Kenya in 2004 when the amount of these toxins was 220 times higher than the permitted level, resulting in the loss of many lives (Mejía-Teniente et al., 2011).

Aflatoxins (AF), ochratoxins (OT), zearalenone (ZEN), fumonisins (F), trichothecenes, T-2 toxin, and ergot alkaloids are mycotoxins of greatest agro-economic importance. Fungi are naturally present in crop microflora and animal feed, but factors influencing mycotoxin production can be divided into: physical (relative humidity, temperature, moisture, and mechanical damage), chemical (CO_2 , O_2 , substrate composition, pesticides, and fungicides), and biological (plant variety, stress, insects, spores, damage) (Bytesnikova et al., 2021). The combination of these factors creates a favorable environment for mold growth (Bytesnikova et al., 2021). Environmental conditions have the greatest influence on mold synthesis and mycotoxin production, with fungal infections most commonly occurring in the field and/or during storage (Streit et al., 2013). Nowadays, mycotoxins can occur everywhere in the environment, even in the aquatic environment (Jevtić, 2021; Abramović et al, 2017). Mycotoxins have various acute and chronic effects on humans and animals. Ruminants, however, have much greater resistance to their negative effects because their rumen is capable of mycotoxin degradation (Hussein and Brasel, 2001).

AFLATOXINS

Aflatoxins derived their name from a combination of the letter "a" from the genus *Aspergillus*, the term "fla" from the species *A. flavus*, and the word "toxicum," meaning poison. Molds from the *A. genus* synthesize aflatoxins, which represent the most significant group of mycotoxins in terms of their impact on human and animal health. Among the numerous *Aspergillus species*, *A. flavus* and *A. parasiticus* stand out as the molds that most commonly synthesize aflatoxins. Like other mycotoxins, aflatoxins can contaminate various agricultural and food products, as well as animal feed, thereby leading to multiple negative impacts on human and animal health, and their occurrence can also cause significant economic losses (Kos, 2014; Jevtić et al., 2021). The most common natural sources of contamination are cereals, oilseeds, nuts, figs, and tobacco (Bennett and Klich, 2003).

Aflatoxins mainly occur as contaminants in moderately continental, subtropical, and tropical regions. When grains, such as maize, grow in warm conditions, especially during droughts, the grain becomes more susceptible to aflatoxin formation (Richard, 2007). Aflatoxin production is controlled by numerous factors such as carbon and nitrogen sources, environmental factors like pH, light, oxidative stress, and temperature. Nitrate prevents aflatoxin production, while ammonium salts are conducive to their formation. Some amino acids such as proline, asparagine, and tryptophan significantly increase aflatoxin biosynthesis in *A. parasiticus*. pH and temperature are crucial factors for the synthesis of these toxins. The temperature required is around 30°C, and a lower pH value, i.e., more acidic, is better for growth (Mejía-Teniente et al., 2011).

According to various authors, between 13 and 20 different aflatoxins have been discovered to date, with the most well-known being aflatoxin B₁ (AFB₁), aflatoxin B₂ (AFB₂), aflatoxin G₁ (AFG₁), and aflatoxin G₂ (AFG₂). In addition to these four aflatoxins, aflatoxin M₁ (AFM₁) and aflatoxin M₂ (AFM₂) are also very significant, which are metabolites of AFB₁ and AFB₂. Aflatoxin M₁ is the hydroxylated metabolite of AFB₁ first found in animal tissues and fluids (milk and urine). M₂ is formed as a product of aflatoxin B₂. *A. flavus* predominantly synthesizes aflatoxins of the B group, while both *A. flavus* and *A. parasiticus* synthesize aflatoxins of the G group (Richard, 2007). Aflatoxins belong to difuranocoumarins, which can be divided into two groups based on their chemical structure: difurocoumarocyclopentanes (AFB₁, AFB₂, AFM₁, AFM₂) and difurocoumarolactones (AFG₁, AFG₂). AFB₂ and AFG₂ are dihydroxy derivatives of AFB₁ and AFG₁, respectively.

Aflatoxins are colorless to pale yellow crystalline substances that fluoresce intensely in the ultraviolet region. AFB₁ and AFB₂ emit a blue color, while AFG₁ and AFG₂ emit a green color, based on which they received their names. AFM₁, as a derivative of AFB₁, also emits a blue color (Mejía-Teniente et al., 2011). Aflatoxins are very poorly soluble in water (10-30 µg/ml), insoluble in nonpolar solvents, and best dissolved in polar organic solvents such as methanol, acetone, and acetonitrile. They are unstable at pH values below 3 and above 10. Aflatoxins are stable to most methods used for food and animal feed preservation (Scudamore, 2004).

AFLATOXIN M₁ IN MILK

Milk and dairy products are biologically valuable and high-quality foods that provide a range of essential nutrients necessary in human nutrition. According to the current Regulation (Regulation on the quality of raw milk and ISO/IEC 17025:2017), raw milk, upon delivery to the farm and use, must preserve its quality in the state it was obtained by milking, from well-cared-for and properly fed cows, without the addition or separation of any substance that would alter the basic composition of milk. The overall quality of raw milk is determined by its chemical composition and bacteriological correctness. These parameters vary depending on various factors: farm size, production level, feeding regime, animal husbandry practices, cow breed, lactation period, climatic conditions, procurement season, udder condition, and others (Nateghi et al., 2014; Ozcan et al., 2015). The consumption of cow's milk today is significant, with children being the largest consumers since milk is one of the primary foods during the first years of life (Bilandžić et al., 2015). Therefore, it is crucial that milk does not contain toxic compounds that could be harmful to humans, especially to children who are more susceptible to the effects of toxic compounds (Flores-Flores et al., 2015).

Aflatoxin M₁ is a metabolite of AFB₁, while AFB₂ is less commonly found in nature, and therefore its product AFM₂ is not found in milk. AFM₁ was initially discovered in the milk of humans and animals fed grains contaminated with molds. Several scientific papers have been published to date (Nabney et al., 1967; Van Egmond, 1989) in which the authors established the relationship between the intake of AFB₁ and the production of AFM₁. They concluded that shortly after the intake of AFB₁ into the body, conversion into AFM₁ occurs rapidly, followed by its excretion into milk (Nogaim, 2014). Figure 1 depicts the transfer of aflatoxins from food to milk.

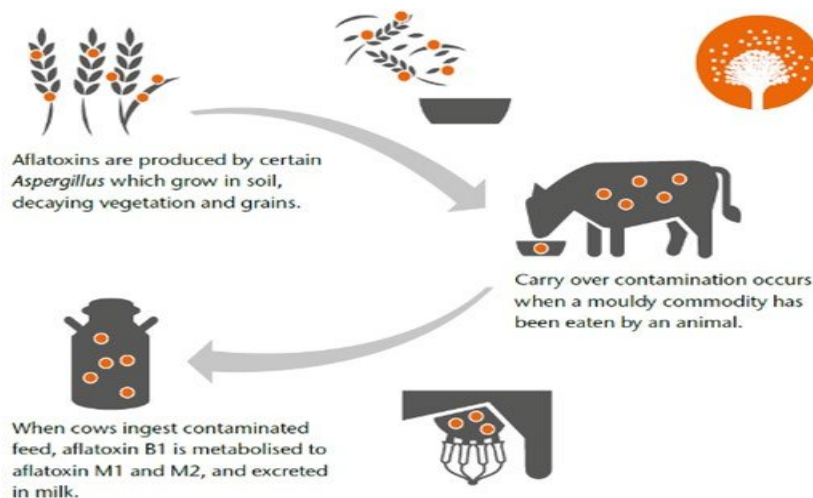


Figure 1. Transfer of aflatoxins from food to milk

(<https://www.newfoodmagazine.com/article/149227/aflatoxin-m1-in-milk/>)

Some authors argue that the presence of AFM₁ in milk depends on the species of the animal, with AFM₁ being most commonly present in cow's milk. They attribute this to the different digestive tracts of ruminants, as well as the higher quantity of ingested food and the prevalence of feed (such as corn) that is more frequently contaminated with AFB₁ (Barbiroli et al., 2007).

Additionally, the season significantly influences the occurrence of AFM₁ in milk. During the autumn and winter periods, roughage (corn, corn silage, mixtures) accounts for the largest proportion of the diet of dairy animals, which is more frequently contaminated with AFB₁ compared to the plants animals graze on during the spring and summer months (Fallah et al., 2011). Furthermore, temperature and humidity also affect the presence of aflatoxin B₁ in food. *A. flavus* and *A. parasiticus* can easily grow on food with a moisture content of 13%-18% and an environmental humidity of 50%-60% (Nogaim, 2014). Recent studies have found that AFM₁ is stable under the elevated temperatures used in the production of pasteurized and sterilized milk, powdered milk, and infant products (Kos, 2014). The concentration of AFM₁ in 85% of infant formula samples was higher than the maximum tolerance limit accepted by the European Union and the US (25 ng/kg) (Omar, 2016). Therefore, continuous monitoring of AFM₁ presence in milk is necessary, as its presence leads to the production of contaminated cheese, yogurt, cream, and other dairy products. AFM₁ can be detected in milk 12-24 hours after the initial intake of AFB₁ and reaches a high level after several days. Once the intake of AFB₁ is discontinued, the concentration in milk decreases and is undetectable after 72 hours. A linear relationship between the dose of AFB₁ ingested and AFM₁ excretion has been observed, primarily in sheep milk (Mohammadi, 2011). Also, cow feed must be stored so that it does not become contaminated. According to research conducted by the *Turkish Food Codex* and *Codex Alimentarius*, it was found that 75% of the samples were contaminated with AFM₁, and 48% exceeded the legal limit of 50 ng/kg (Nogaim, 2014).

The frequent occurrence of aflatoxin M₁ in milk has raised questions about what happens when contaminated milk is processed in the dairy industry. In the study by Van Egmond, 1983, milk that had been pasteurized and sterilized to produce yogurt and cheese was investigated. Based on the obtained results, it can be concluded that the AFM₁ content does not decrease during pasteurization and sterilization, nor was there significant reduction during yogurt production. It is important to note that the figure shows a four-fold higher concentration of AFM₁ compared to the milk from which it was made. This can certainly depend on the type of cheese being produced (Van Egmond, 1983). Brackett and Marth (1982) attempted to explain the reason for the increase in concentration. One of these reasons is proteolysis and lipolysis during aging, which allow for the retention of more or less mycotoxins in cheese.

ESTIMATION OF INTAKE AND LEGAL REGULATIONS FOR AFLATOXIN M₁ IN MILK

Consumption of cow's milk is generally extremely high because it is important in the diet of all age groups. It provides a range of essential nutrients for humans. Children are the largest consumers of milk as it is one of the main foods during the first years of life. Therefore, it is very important that milk is free from toxic compounds that can be harmful to humans, especially children who are more susceptible to the effects of toxic compounds. Various studies have shown levels of mycotoxins in milk, with AFM₁ being the most studied, so regulation of the maximum presence of mycotoxins in milk mainly applies to aflatoxin M₁.

However, aflatoxins B₁, B₂, G₁ and G₂, ochratoxins, fumonisins, zearalenone, deoxynivalenol, and their metabolites have also been found in milk samples (Evelyn Flores-Flores et al., 2015).

Given that mycotoxin occurrence is a global problem, all developed countries have competent authorities dealing with this issue. The European Commission (EC) at the level of the European Union and the Food and Drug Administration (FDA) at the level of the United States represent the two most developed institutions dealing with mycotoxin issues. In addition to these institutions, this issue is also addressed by the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), JECFA, and many other organizations. These institutions prescribe rules for controlling mycotoxins in food products and animal feed, adopt regulations on maximum permitted levels (MPLs) of mycotoxins, on the methods used in their analysis, on rules for sampling and sample preparation, as well as many other rules and regulations. At the European Union level, there is a single regulation prescribing maximum permitted levels (MPLs) for mycotoxins in food products (European Commission, EC/1881/2006). Since 2006, there have been several amendments to this Regulation. In the Republic of Serbia (RS), the control of aflatoxins in food products is based on the Regulation ("Official Gazette of RS", 28/2011) partially harmonized with the aforementioned EU Regulation in 2011. From 2011 to the present, several amendments to this Regulation in Serbia ("Official Gazette of RS", 20/2013; "Official Gazette of RS", 29/2014; "Official Gazette of RS", 37/2014) have aimed at its full alignment with European regulations. Until 2011, the Regulation from 1992 („Official Gazette of RS“, 5/92) was in force in Serbia, which differed significantly from the EU Regulation. The differences were most noticeable in terms of mycotoxins and products that needed to be controlled, as well as the MPLs of the controlled mycotoxins. Only recently, the harmonization of the Regulation in Serbia with the Regulation of the European Union can be cited as one of the reasons for the insufficiently systematic implementation of monitoring and the lack of published data on the occurrence of mycotoxins from Serbia (Kos, 2014). Table 1 provides an overview of the MPLs of AFM₁ in Serbia from 1992 to 2014, as well as the MPLs prescribed by the EC and FDA.

From table 1, it can be observed that the MPL values for AFM₁ in milk in the Republic of Serbia have been changed multiple times. Specifically, until 2011, the MPL for AFM₁ in milk was 0.50 µg/kg, after which it was changed to 0.05 µg/kg. Due to the occurrence of AFM₁ in milk in 2013, the Ministry of Agriculture, Forestry, and Water Management once again changed the MPL value to 0.50 µg/kg. This MPL value was valid from March 1, 2013, to July 1, 2014, after which it was again returned to 0.05 µg/kg. Very quickly, after 11 days, the Ministry of Agriculture, Forestry, and Water Management increased the MPL value to 0.25 µg/kg based on requests from milk producers (Kos, 2014). Table 2 shows a comparison of MPLs for total aflatoxins in food for different regions of the world. As seen, the lowest MPL values are prescribed in Europe.

Table 1. MPLs for AFM₁ according to regulations from Serbia, the European Union, and the United States

Country	Regulation	Type of Sample Controlled	MPL (µg/kg)
Serbia	„ Official Gazette SRJ“ 5/1992	Milk and dairy products	0.50
	Official Gazette RS“28/2011	Fresh milk, thermally	0.05
	„ Official Gazette RS“20/2013	processed milk for	0.50
	„ Official Gazette RS“ 37/2014	dairy production	0.05
	„ Official Gazette RS“ 72/2014	products	0.25
EU	European Commission 1881/2006		0.05
SAD	Food and Drug Administration, 2011	Milk	0.50

Table 2. MDK values for AFM₁ by continent

Region	MDK range (µg/kg)	Most common MDK (µg/kg)
Africa	10-20	10
Asia/Oceania	5-35	15
Europe	0-10	5
Latin America	2-35	20
North America	15-20	15-20

CONCLUSIONS

Various studies have shown different levels of mycotoxins in milk, with AFM₁ being the most studied, so the regulation of the maximum presence of mycotoxins in milk mainly relates to aflatoxin M₁. However, aflatoxins B₁, B₂, G₁, and G₂, ochratoxins, fumonisins, zearalenone, deoxynivalenol, and their metabolites have also been found in milk samples. Given that the occurrence of mycotoxins is a global problem, competent authorities dealing with this issue exist in all developed countries. Although many strategies have been developed to prevent or reduce the harmful effects of mycotoxins on human and animal health, a unified method that would be equally effective for all mycotoxins in different substrates has not yet been developed. Generally, there are measures aimed at preventing food contamination by molds and mycotoxins and treatments aimed at reducing the toxic effects resulting from food contamination by mycotoxins. Prevention of food contamination by mycotoxins occurs both in the field before harvest and during storage. In theory, the approach to preventing contamination in the field involves implementing "good agricultural practices," where critical points for contamination would be potentially identified to prevent mycotoxins from reaching the milk.

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Environmental protection and sustainable development

SECURING WATER SUPPLY IN MAASAI COMMUNITIES

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ABSTRACT

This study investigates possibilities to secure water supply in two Kenyan Maasai communities, one on Mount Suswa, some 100 km to the west of Nairobi, and one in Loita region, near Tanzanian border. For millennia, the Maasai life has been centred around their cattle, moving freely across Eastern Africa in search of fresh pastures and water. With their pastoralist lifestyle, the Maasai have always been directly dependent on the weather; however, the climate change has introduced additional unpredictability to the seasonal changes. Severe droughts, with no rain for several years, have had devastating consequences. The methodology has consisted of literature search primarily in Scopus scientific database and a fieldwork based on interviews and direct observation, executed in August-September 2023. The study has found that the two Maasai communities rely on a multitude of solutions, depending on the local conditions, technical know-how and affordability. The Mt Suswa Maasai use water dams as a traditional method to directly capture rainwater during rainy season, water tanks for rainwater from the roofs, and condensed steam from geothermal wells. The Loita community has a seasonal river, a large water dam, and boreholes for groundwater extraction. In both locations, there is intermittent interest and influence by several external parties, including Kenyan Government, local landowners, Christian missionaries, and foreign researchers (like the author of this paper). This implies that there is no coordination of approaches and efforts. The situation is further complicated by the fundamental change in lifestyle from pastoralist to land-ownership agricultural, imposed by the Kenyan Government, and historical distrust of the Maasai toward the Government. The paper includes discussion of the findings and the possible approaches to improve the situation. In conclusion, the Maasai find themselves in a changed world, very different from that of their fathers. While their previous lifestyle had developed to respond to the weather changes, the challenges they currently face require additional planning, technical knowledge and, possibly, external financial support.

Keywords: Maasai, water supply, climate change, draught, Kenya.

INTRODUCTION

The Maasai are an ethnic group inhabiting Kenya and northern parts of Tanzania. For millennia, the Maasai life has been centred around their cattle, which has entailed their moving freely across the land in search of fresh pastures and water. With their pastoralist lifestyle, the Maasai have always been directly dependent on the weather, with mobility as their response to adverse weather conditions. However, the climate change has introduced additional unpredictability to the seasonal changes (Brehony, 2020; Borona, 2020; Agade et al., 2022). Severe droughts, with no rain for several years, have had devastating consequences. In some locations, cattle have been decimated.

In parallel, the Maasai lifestyle has profoundly changed due to government interventions where families are given land in ownership, leading to permanent settlements. Other significant development is the widespread conversion to Christianity that has arguably taken Maasai further from their original culture and tradition. Not but not least, at some locations, geothermal wells have been discovered and have been exploited by Kenyan and foreign companies, thus resulting in displacement of Maasai from their newly established settlements (Hughes and Rogei, 2020; Hughes, 2020).

This new lifestyle, based on land ownership, compounded by climate change, has brought Maasai into a new situation where they need to rely on locally available water for them and their animals. This exploratory research is undertaken to make an inventory of the current practices that are geared toward securing water supply, as well as preferences of the Maasai. These findings serve as the basis to identify possible solutions. The research focuses on two Maasai communities, the village of Kisharu on Mount Suswa, located to the West-Northwest of Nairobi, and Ilkerin, in Loita region near Tanzanian border in the south.

MATERIAL AND METHODS OF WORK

The methodology consisted of literature search and a fieldwork using group and individual interviews and direct observation, executed on location in August-September 2023. The work took place in the village of Kisharu on Mount Suswa to the West-Northwest of Nairobi, and in Ilkerin, in Loita region near Tanzanian border.

Extensive literature search is conducted primarily in Scopus scientific database, using individual keywords and combinations of keywords, including 'Mount Suswa', 'Mount Suswa' and 'volcano', 'Maasai' and 'Kenya', 'Maasai' and 'water', 'Maasai' and 'climate change', 'Kenya' and 'geothermal'. Some of the references of the identified publications have been consulted as well. The identified literature focuses of various aspects of relevance for this research: geology of Mount Suswa, pastoralism, Maasai traditional responses to draughts, as well as local traditional 'water management' options in the broader Eastern Africa region. In addition, several books have been studied, to get some degree of acquaintance with Maasai culture and tradition.

Field research was planned for the driest period, at the end of the dry season, which is August-September. The execution of the fieldwork required involvement of guides as well as organisation of logistics, which is not a trivial matter in rural Kenya, where some of the roads are not even recognised as such by Google maps. The guides were of particular importance, as they translated between English and Maa, ensured culturally appropriate communication with the Maasai communities, and helped organise transport and accommodation. For the location on Mount Suswa, upon recommendation from a British researcher who had done extensive research with Maasai in the vicinity of Mount Suswa, a local guide was hired. Similarly, for the Loita region the guide was contacted courtesy of one of the authors of the books.

Furthermore, meetings and exchange were conducted with staff of Dutch Embassy in Kenya, and a Dutch engineer working on a water supply project in Nairobi.

Through a snow-balling effect, additional local contacts were obtained. These additional contacts include Maasai founders of two local NGOs, focusing on pastoralist tribes in Kenya, mainly Maasai, but also others. The work encompasses an array of topics ranging from water to empowerment of girls.

RESULTS AND DISCUSSION

1. Kisharu village on Mount Suswa

1.1 The village

The Outer crater of the dormant volcano Mount Suswa has been home to Maasai only since recently - they came there in the early 2000s. In the previous at least 30-40 years, there had been no human settlements on Mt Suswa at all.

The Maasai settlement in the Outer crater of Mt Suswa, the village, is called Kisharu. Its population is estimated at 3000 adults, with the total of 10000.

The village is 42 km from Suswa Town, the first 22 km of which are tarmac, and the last 20 km can hardly be called a road - it takes a strong, terrain vehicle one hour to travel.

There is a school as well as at least two churches. All Maasai in Kisharu are now Christians, Catholics. They adopted Christian faith decades ago.⁴

In general, village life is very different for Maasai men and women. Men occupy themselves with animals and financial matters, whereas women do everything else: take day-to-day care of the family and the household, bring water, collect firewood (unless they have a gas bottle), cook, clean, tend to vegetable gardens if they have them. Some of them engage in trade, selling dung to agricultural tribes such as Kikuyu in Suswa Town and MaiMahiu, the busy market town on the way from Nairobi to Suswa. Others sell chicken or beadwork jewelry, for which Maasai are famous. Traditionally, Maasai women also build their manyattas (houses) from branches, cow dung and earth.

1.2 Water supply

As could be expected, water supply is different in rainy season and dry season. Further differentiation is between water supply for human consumption and for animals. The findings are therefore presented distinguishing between these aspects.

In rainy season, the villagers take water from so-called water dams and from run-off collected from the roofs of their houses.

Water dams

As commonly done across the East Africa Region, also in Kisharu people rely on water dams as a traditional method to capture rainwater during rainy season. Householders dig up a surface to become a slope, putting the dug-up earth on the deep end, which has presumably led to the name 'water dam'. While the terminology differs across literature, in this paper the term 'water dams' is used, as this is how the Kisharu villagers refer to them.⁵

⁴ In other locations I visited (Loita and Kajiado) I was told that the Catholic Church 'allowed' the traditional Maasai rituals to be incorporated into the those of the Catholic Church, which supposedly explains the success of this church among Maasai.

⁵ The terminology is inconsistent across literature, scientific and journalistic alike. In some cases, the term 'water dam' pertains to the excavated earth and the water impoundment taken together. In others, the term 'water pans' is used to designate the water impoundment itself.

In addition, in Kisharu, there is a large water dam built by the Kenyan Government for all villagers to use.

Water dams serve the villagers and their animals well in the beginning of the dry season - this water is used for drinking and the villagers are satisfied with its quality. As the dry season progresses, however, and certainly towards its end, water becomes too contaminated and thereby unsafe to be used for drinking, or water dams dry up completely. (Both household water dam and the large one built by Government were both completely dry during our visit.)

In very dry years, when rainy season does not produce sufficient (or any!) rain to capture in the first place, women must go to wells 20 km to the tarmac road, where the Government had placed a water tank for them (and others) to use in dry periods. This is taxing for both people and animals, the latter already weakened by a lack of pasture (due to draught), and exhausted by thirst. In those dry periods Maasai have no other choice but to slaughter a (considerable) number of cattle, which is considered one of the most painful experiences in their culture.

Roof run-off

Traditional Maasai manyattas are constructed from tree branches, cow dung and earth for the walls, with plant leaves for roofing. The homesteads on Mt Suswa consist of three buildings, only one of which is a traditional manyatta, where the kitchen is situated. The other two buildings, with a living room and sleeping quarters, are constructed from others, more 'modern' materials, with metal sheet roofs.

This change in roof materials has enabled villagers to start installing gutters as rainwater conduits, from the roof to the large plastic barrels for storage.

This system is made from affordable materials and items that are not physically robust to withstand strong mountain winds, so the conduits get damaged, thereby jeopardising water supply from this source.

Similar system is observed in the Lodge, where the owner captures a lot of water from the roofs of his existing buildings and has large enough tanks to store it. As a guest in the eco-lodge, I can testify that the water supply was surprisingly ample, with a high enough pressure for a comfortable use even in the period at the end of the dry season.

Water from geothermal steam wells

For some ten years now, the villagers have been using geothermal steam wells (or, as they refer to them, steam jets) as a source of water for human consumption. They started this practice after they had observed steam coming out of the ground and started exploring it. All the wells are for the entire village to use.

Most wells are fenced to prevent access of (wild) animals, particularly elephants, and consequent damage or destruction. During the field visit at one of the wells though some sheep and goats were present, drinking from troughs placed by the villagers.

For fences, the villagers rely on their time-tested traditional solutions of intertwining cut-off branches of thorny shrubs and trees such as local acacia species, which Maasai have been using to protect their animals from wildlife as long as the memory serves. Not only is this solution highly effective, it also very sustainable as it relies on locally available, renewable materials (native plants). Also, it involves hardly any costs, as the 'gates' are made of remnants of wood and/or metal wire. All these 'design' features, which are based on traditional knowledge and experience, mean that Maasai keep their sovereignty in this matter. Finally, the fact that some of them look completely inconspicuous in the landscape of the outer crater savannah, only adds to the quality of the 'design'.

The technology of water extraction is simple: at the locations where the villagers observed steam coming out of the ground, they dug to the depth of approx. 3 m using their machetes and any other suitable tool, after which they put several plastic pipes into the ground. This is all manual labour and requires considerable physical strength (young men take pride in this). The steam then comes from the ground into the pipes, condenses into water and drips overnight into receptacles that the villagers place at the pipes' ends. They noticed that there is more steam if it rains.

At most of the wells, plastic pipes are used. The villagers buy any pipes available in the shop. It seems that these are PVC pipes. While the water from geothermal steam wells may be safe as such, PVC pipes are used to extract the hot steam from the ground, which may compromise thermal stability of PVC and release toxic substances into water.

Some pipes are even torn, with rugged edges along the tearing. Upon my inquiry, the guides explained that at some wells they heated the pipes in order to be able to bend them. At other wells, proper corner joints are used.

Potential health risks of using PVC pipes

Heating plastic is generally not a good practice, due to likelihood of release of plasticizers such as phthalates, several of which have been linked to severe endocrine disruption. Concerning specifically PVC, phthalates can constitute over half the mass of the material, which increase the availability of these hazardous substances. Furthermore, heavy metals such as lead (Pb) and cadmium (Cd) are often added to increase thermal stability, but both are highly toxic to human health, including cancer among the effects. For these reasons, Cd has been banned in such application in the EU.

The young guide, as well as the rest of the people, were completely unaware of any potential risks to them from the pipes. But he was very interested and kept asking questions and repeated by explanations back to me to make sure that he understood what I was saying. At certain moment, he offered a term of 'long-term effects' which made my explanations easier to deliver.

In one location, there were metal pipes with no rust on them, with only rusty corner joint. The villagers said they don't like to use water from here, as they don't trust its quality because of its red colour. Seven years ago, a German researcher visited and took water samples. Afterwards he informed them that the concentrations of Zn were too high and advised against using water from these pipes.

To increase the yield, around January 2022 the villagers constructed a rectangular stone-wall structure with the bottom 'open' so that the steam can come freely from the ground. Above, they placed a metal sheet cover to enable condensation. This didn't work, however, as the capture of steam was inadequate, with too high losses. So, this structure is not used anymore, and both the stone-wall structure and metal sheet cover are just sitting there.

In general, the villagers trust the quality of this water the most for human consumption and would like to have more of it, particularly, obviously, in the dry season, when the water dams start getting muddy. They have even noticed that their 'animals seem to be healthier if they drink water from the steam jets.' Also, the women said that they 'would be happiest if steam jets would provide enough water for them and the animals in the dry season, as the water is good, and the steam jets are near.' In the rainy season, they would still rely on water dams for animals because they are nearer.

For a more complete understanding of water supply in the village, it is important to illuminate the practices of fetching water. Generally, children are sent to fetch water - girls walk and carry one 20 L container at a time; boys go with donkeys, which carry a 20 L container on each side, making 40 L in total. Also, boys bring water on a motorcycle. If children are not available because they are at school, women will go. A woman will carry two containers (20 L + 10 L) hanging strapped from her head. In a meeting with women, except for one all the women were co-wives, meaning that their husbands had another wife. The women alternate with the other co-wife in fetching water and minding the children.

The issue of water is not really discussed. It is a problem that has been there in earlier generations as well; the hardship is accepted as part of life.

Current developments and prospects

Water tank at the Lodge

The field visit revealed that the owner of the Mt Suswa Bush Camp and Eco-lodge - who is a Kisii rather than a Maasai, and very keen to build trust and good relationships with the Maasai villagers - is currently constructing a reservoir for storage of rainwater, primarily intended for the villagers' animals. The water will be captured from the roofs of his large new building, which is also currently under construction. The space for the reservoir, targeting 300,000 L capacity, is already dug up. The intention is to make a ferro-cement tank. At the time of my visit, the pipes from the roofs to a preliminary chamber were under construction (from which only one large pipe will be used to transport water to the tank). I spoke with the person in charge; he is a plumber. He is responsible for both the design and the construction.

From an engineering point of view, the principle is simple enough, but it remains to be seen what level of quality of construction will be reached, as some other examples in the village show that this is often the main issue. For example, the large water dam built by the government had initially a pipe in its design, to take water to the other side of the dam, for the women to use for doing laundry. However, the pipe was leaking so much that it was closed. (In addition, there was a damage of some facilities by elephants.)

Water tank by the Government

The Government has announced that they are going to build a big reservoir in the village in 2024, where water would be brought from elsewhere, so that villagers don't need to walk 20 km with their animals in case of draught. At the time of writing of this paper (March 2024), the Government was building the access road first.

Important for this latter development is the difference of opinion in the village about the government presence and involvement. Elders are very cautious and reluctant, due to earlier experiences with government interferences with Maasai lifestyle. Youngsters however would appreciate a road but are anxious about what will happen if Mt Suswa becomes easily accessible, for example, to groups of visitors who come on motorbikes, visit the mountain and caves, and leave on the same day.

2. Olkaria

In order to understand other experiences with water supply from geothermal steam wells, the fieldwork included a visit to Olkaria, a location to the north of Mt Suswa where geothermal plants are actively exploiting steam for electricity generation.

The Maasai settlements that had previously been there are now relocated elsewhere in relative vicinity.

These developments were met by fierce opposition from the local Maasai, but at the end they had to move (Hughes and Rogei, 2020; Hughes, 2020).

At present, there are six developed stages of Olkaria geothermal plants, with several Kenyan and foreign owners. Further stages are either under construction or under exploration of their geothermal potential. (There is also a geothermal spa, which is allegedly very luxurious and popular among those who can afford its services.)

There are at least two locations where geothermal steam used to be captured for water supply. Unfortunately, they have been abandoned, as they were not functioning properly. The solution to capture the steam did not work, even though they were designed by the engineers from the geothermal plants.

There is a water tank, where women come to fetch water and do the laundry. The water tank was built after French had been there and tried to do something about the water problem, without success, due to some technical problems. The effort by the French, even though it was unsuccessful, put Kenyan Government to shame for doing nothing, so they constructed this one.

Nearby there is also a very old water tank built perhaps 100 years ago by colonial farmers, where they used to bring water from geothermal steam wells.

So, the knowledge about the potential of converting geothermal steam into water has been there for a long time. And Maasai have surely known about it, as they often had jobs as shepherds for the colonial cattle farmers. This was confirmed in a conversation with a local farmer / lodge owner of British origin.

3. Ilkerin in Loita

In Loita, water supply sources are different from those on Mt Suswa. There is a seasonal river in the village, which provides ample water during the rainy season, provided that it actually rains during the rainy season, which is not always the case. Due to the recent draught, a few years ago, their cattle were decimated, so they have considerably lesser number of cattle now, with more goats and particularly sheep. Their choice between sheep and goats is guided by the feed - goats feed on shrub and tree leaves, while sheep eat grass.

A very large reservoir (water dam) was built by Dutch missionaries in 1971, which served the villagers very well ever since, but the last year's floods destroyed the dam, so the impoundment is now very shallow. Still, during the field visit, there were women washing themselves and their laundry in little water that was there. The villagers didn't say that they were planning to repair the dam.

There are boreholes where groundwater is pumped out, using old diesel-motor pumps. Maasai villagers collect money to finance the fuel. The charge is determined based on the number of animals a household possesses. They know that solar panels would serve them better, but no action is taken to do something about it. Also, these boreholes are far, and it takes a lot of time to fetch water every day.

In Loita there have been foreigners from the Netherlands, Austria, Germany, and South Africa for a long time, first as missionaries and doctors, now as owners of tourist camps.

Some of these people have plenty of ideas and would genuinely like to help the Maasai with water provision, but money is lacking.

4. Vegetation and gardening

Related to climate and water supply, the aspects of vegetation and Maasai gardening practices are also explored.

Vegetation

While generally draught has caused devastating loss of livestock, it was remarkable that during the field visit, which was at the end of the dry season as mentioned above, the Inner Crater on Mt Suswa was green and lush, as animals are not allowed to come there. (This is because the Inner Crater is a sacred place for the local Maasai community.) The villagers reported that it rains there more than in the village. Yet, the community has not given this much thought.

Similarly, in Loita, the surrounding areas around Entesekera was all green with lush vegetation, with a permanent river. While fencing of properties is commonly recognized by the Loita women as a problem in terms of their not being able to gather sufficient amount of firewood for cooking, no consideration is given to the planting of trees to increase available wood. Relation with climate is not recognised.

Additional remarks were made about invasive plant species in Loita. An invasive plant propagates across the savannah and seems to be the only one that survives the draught. In Kajiado, the NGO representatives said that several invasive species have been observed in other Maasai areas as well. It is suspected that these plants have been brought by lorries from Tanzania.

Gardening practices

Traditional Maasai diet consisted of meat and milk. With individual land ownership and permanent settlements, Maasai women started gardening. My conversation with a group of 15 women in Loita revealed that they all have small vegetable gardens, where they are trying to grow any vegetables that can survive in dry conditions. If there is sufficient rain, they even sell the surplus produce in the nearby place, some 9 km away. Referring to the traditional Maasai diet, the women said: 'Not only meat and milk; that was long ago.' To illustrate, they said that already their mothers had gardens. At the same time, the women said that they would be interested in learning more about gardening. They are also interested in obtaining seeds of crops that are suitable for the local climate. (The vegetables on the popular local market in the Loita region were cabbage, onion, tomatoes, and carrots. There are also a lot of potatoes. The culinary herb of choice is parsley. Sunflower oil is sold in cubes.)

The fieldwork included a visit and interview with a Maasai lady, who is the owner of a permaculture garden and the founder of an NGO focused on empowerment of Maasai women and girls. A tour of her garden revealed that she had been trying various ideas, ranging from permaculture to medicinal plants and coffee. While the lady came across as very driven and ambitious, the garden itself is in a too early stage of development to give any impression of whether it is a success or not.

5. Discussion of potential solutions

Traditional practices of nomadic lifestyle arguably do not provide sufficient tools in changed circumstances that are based on individual land tenure and increased variability of the weather conditions. New approaches are needed, which include better planning, additional knowledge and possibly external financial support (Mwangi et al., 2012; Ogendi et al., 2012). Exchange of experiences regarding adaptation with other Maasai communities could potentially be very beneficial (Marty et al., 2023).

In both locations, there has intermittent interest and influence by several external parties, including Kenyan Government, local landowners, Christian missionaries, and foreign researchers (like the author of this paper). This implies that there is no coordination of approaches and efforts, which further complicates potential solutions.

With the historic distrust toward Government and foreigners, the issue of trust is essential for any external engagement and possible interventions.

CONCLUSIONS

The Maasai find themselves in a changed world, very different from that of their fathers. Their previous lifestyle had developed to respond to the weather changes, with mobility as their primary response to the diminished pastures and lack of water. Currently they individually own land and are consequently bound to the same location.

While adjusting to the lifestyle in permanent settlements, they rely on any water sources that are locally available. There is a great variety among these, ranging from traditional water dams for capture of rainwater to groundwater boreholes to geothermal steam to more recent solutions of roof run-off. Women have been the primary carrier of not only water, literally, but also of the responsibility for it.

In parallel, the Maasai have been learning about agriculture. This is also responsibility of women. The challenges they currently face require additional planning, knowledge and, possibly, external financial support. Any external interest and possible actions to address water issues need to be based on trust.

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HOUSEHOLD COMPOSTING USING ROTARY REACTOR FOR UTILIZATION OF ORGANIC HOUSEHOLD WASTE

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ABSTRACT

This study focuses on the problem of organic household waste disposal. A large amount of organic waste creates problems with waste management and has a negative impact on the environment. Household composting can be an effective solution to this problem. This paper explores the use of a home composting system located outdoors as an alternative method of managing organic household waste in a neighborhood. A home composter with a rotating drum made of galvanized steel was designed and used in the composting process. The composter consists of two chambers, each with a volume of about 170 liters, with a sufficient number of holes and valves for leachate drainage to ensure aerobic conditions. All composted materials were mixed with wood chips, which were used as a filler to improve aeration. Four experiments were conducted using different ratios of organic waste, filler, animal manure, and charcoal. The composting process in the reactor was accompanied by the measurement of various process control parameters, including temperature, pH, organic matter, electrical conductivity, and moisture content. We took into account several parameters, such as the ratio of waste to filler, co-composting with animal manure, and the addition of charcoal to the feedstock. The designed reactor proved to be effective for composting, as it can decompose organic waste with simple control and monitoring. The largest reduction in the volume of composted material (85%) was observed when the waste was treated and backfilled in a 1:0,5 ratio. Co-composting with animal manure was more favorable for the decomposition of organic matter, and the maximum reduction in the nitrogen to carbon ratio (about 62%) was observed in this treatment. There was no significant effect of charcoal on the decomposition process, but it played an important role in reducing odor.

Keywords: household composting, waste management and treatment, valorization, environmentally friendly technologies, food waste.

INTRODUCTION

Waste management is an integral part of urban infrastructure design, and it plays a key role in protecting human health and the environment.

More than 50% of municipal waste is organic waste (mostly food and vegetable), most of which is sent to landfill, while this fraction can be recycled through composting and thus contribute to solving the solid waste problem while producing a valuable product for agricultural use.

Composting is an aerobic process of biological decomposition of organic matter under controlled conditions, which is currently considered one of the best methods of municipal organic waste management (Syniashchyk et al. 2023). The process produces end products that can be used as organic fertilizers and improve soil properties. It is also an environmentally friendly and cost-effective process compared to other technologies when used under controlled and optimal conditions (Syniashchyk et al. 2024). Traditionally, centralized composting facilities are used to process the organic fraction of municipal solid waste.

However, for various reasons, centralized composting is either not possible or not the most acceptable and cost-effective in many regions. Therefore, different approaches to organic municipal waste management are currently being used, mostly through decentralized systems. These include household composting and community composting. These methods help to reduce the costs of waste collection and transportation for communities, as organic waste is sorted and processed on site.

This research focuses on the development and evaluation of a prototype home composter with a rotating drum used for composting. The main objective was to assess the effectiveness of the developed composter. Additionally, since composting processes are influenced by various factors including the carbon-to-nitrogen (C/N) ratio, moisture content, temperature, and others, different combinations of raw materials were investigated. Optimization of the filler ratio was studied by examining the composting process productivity at various ratios of filler to waste.

MATERIAL AND METHODS OF WORK

The experiment was conducted using a rotary drum composter (Fig. 1) made of galvanized steel.

This type of composter is a decentralized option for composting food waste, as it is considered compostable (Titova et al. 2023). The designed reactor consists of two chambers with a volume of about 170 liters each, blades for internal mixing, an easy-to-rotate mixing handle, and a sealed door to protect against rodents. Two valve openings adjacent to the bottom of the drum are provided for leachate discharge.



Fig.1 – Rotary Drum Composter

Aeration of the compost material was provided by natural ventilation with a sufficient number of openings on both sides of the reactor to ensure proper air circulation in the chamber and maintain aerobic conditions. In addition, mixing and aeration of the mixture was facilitated by manually turning the composted material during the experiment.

As the main raw material, we used food waste, consisting mainly of vegetables and fruits, separated at source. Manure, which was used as a co-substrate and inoculant, was obtained from a livestock farm. All composting materials were mixed with wood chips, which acted as a filler to improve aeration and structural support (Jeon et. Al, 2021; Lalremruati Angom Sarjubala Devi, 2021).

The filler used helps to reduce the high moisture content of the feedstock.

Table 1 shows the initial characteristics of the materials used, which were manually crushed to obtain particles of 1-2 cm in size and mixed with the filler and other substrates according to the experimental design, which was as follows:

Experiment 1: food waste and filler were mixed in a 1:1 ratio by weight;

Experiment 2: food waste and filler were mixed in a ratio of 1:0.5;

Experiment 3: food waste and animal manure (90% food waste and 10% animal manure) and filler were mixed in a 1:0,5 ratio;

Experiment 4: food waste and charcoal (90% food waste and 10% charcoal) and filler were mixed in a ratio of 1:0.5.

In all experiments, the added material was mixed by rotating the reactor and recoding the initial values of various control parameters to obtain a structured and homogeneous mixture for the composting process. The material was added to the reactor at the end of weeks 1 and 2, maintaining the mixing ratio of stages 1 and 2. Table 2 shows the amount of material added during the composting process, and Table 3 shows the initial properties of the compost mixture.

Table 1. Characteristics of the raw materials used in the experiment:

Parameter	Manure	Food waste
Moisture content, (%)	43	88
Organic matter, (%)	68	91
Total organic carbon, (%)	37.7	51
Total nitrogen, (%)	20	0.72
Carbon to nitrogen ratio, (C/N)	21	67
pH	9.5	5
Electrical conductivity, (ms/cm)	14.3	3
Total phosphorus, (ppm)	1050	1280
Total potassium, (ppm)	3400	1200

The composting process in the reactor was accompanied by the measurement of various process control parameters. In this context, the temperature of the mixture was measured daily and representative samples were taken weekly to determine pH, organic matter, electrical conductivity and moisture content. However, nitrogen, phosphorus, potassium and total organic carbon were measured only at the beginning and end of the process. The reactor was turned over at least twice a week for the first three weeks, and then once a week. At the end of the experiment (after about seven weeks), the contents of the reactor were removed and the final properties of the resulting compost were measured.

Table 2. Amount of material added during the composting process

Experiment	Filler, (l)	Food waste, (l)	Manure, (l)	Charcoal, (l)
Day 1				
1	51	51	-	-
2	34	68		
3	34	61.5	6.5	-
4	34	61.5	-	6.5
Day 7				
1	25	25	-	-
2	17	34	-	-
3	17	30.5	3.5	
4	17	30.5	-	3.5
Day 14				
1	25	25	-	-
2	25.5	56	-	-
3	17	31.5	3.5	
4	17	31.5	-	3.5

Table 3. Physical and chemical characteristics of composting mixtures

Parameter	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Moisture content, (%)	80	81	83	82
Organic matter, (%)	88.2	90	86	87
Total organic carbon, (%)	49	50	47.5	48
Total nitrogen, (%)	1	1.1	1.5	1
Carbon to nitrogen ratio, (C/N)	49	45	31.5	53
pH	6.8	6.0	7	6.1
Electrical conductivity, (ms/cm)	3.7	3.5	11.2	6.2
Total phosphorus, (ppm)	794	660	977	973
Total potassium, (ppm)	2200	2000	2500	1600

To determine the moisture content, the samples were sent to an oven at 105°C for 18-24 hours. Organic matter was determined by burning the samples in a muffle furnace at 550°C for 2.5 hours, and total organic carbon was using a TOC -L total organic carbon analyzer, pH was measured using pH and EC meters, after mixing the suspension of the test material and distilled water in a 1:2 ratio. The samples were shaken for 30 minutes at room temperature, after which pH and EC were measured. The potassium content was determined using a flame photometer by preparing an extract (1:10), shaking it for 30 minutes, and using the filtered sample for analysis. The phosphorus content was determined using a spectrophotometer: a sample (2.5 g) was added to 50 ml of NaHCO₃ and stirred on a shaker for 30 minutes, then filtered. To 5 ml of the filtrate was added 5 ml of vitamin C, 0.5 ml of H₂SO₄ and distilled water to a volume of 100 ml. After that, a representative amount was added to the spectrophotometer. Total nitrogen was analyzed by the Kjeldahl method.

RESULTS AND DISCUSSION

After the addition of new raw materials on days 7 and 14, we observed a significant increase in temperature. The highest temperature was recorded in experiment 2 with a low filler content (0.5), followed by experiment 1. This is due to the large amount of organic matter that supports microbial activity, in experiments 2 and 3, which received less raw materials, the temperature was lower compared to other variants that had the same ratio of waste to filler.

In all mixtures, the moisture content was slightly higher than the recommended value (40-60%), which prevented the temperature from rising, but in experiments 1, 3 and 4, the ratio of waste to filler was 1:0.5, which promoted convection and prevented heat retention, resulting in a decrease in microbial activity. An increase in temperature was also noticed after the reactor was started, but did not last long, which is normal for this type of composter as it has low heat retention properties of composted materials because the layer of decomposing material is too thin to hold a significant amount of heat and the heat dissipates quickly from the mixture.

The initial pH values were in the range of 6.7-7. A slight difference was recorded between the different treatments, as shown in Figure 1. This change in pH towards an alkaline environment is caused by the mineralization of acids, which are usually formed at the beginning of the process due to the decomposition of materials, which is a good indicator for microbial activity during the composting process (Manu et al. 2019).

In all tests, an increase in electrical conductivity was observed due to the biodegradation of organic matter. This slight increase is usually due to the release of free ions during the degradation of organic compounds. Changes in both pH and electrical conductivity correlate with other monitored parameters, indicating effective microbial activity and biodegradation of organic matter.

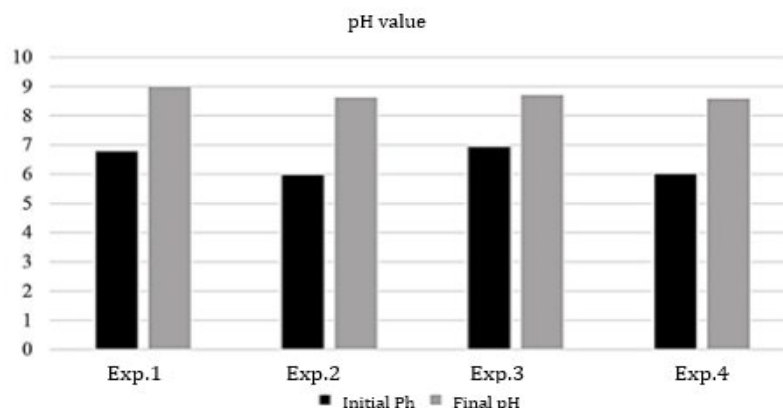


Fig.1. Initial and final pH values of composted materials

The content volume decreased in all treated variants. The increase in temperature due to microbial activity leads to an increase in moisture loss in the compost mixture. The raw materials used had a high moisture content, which led to the formation of a significant amount of leachate, which further contributed to the reduction of moisture retention characteristics. This leachate is formed due to the hydrolysis of organic matter by microorganisms. The composter influenced the change in moisture content during the experiment. The closed drum led to the retention of steam, which eventually condensed in the mixture, so the decrease in moisture holding capacity occurred slowly, mainly during the active phase, and the water was removed by evaporation. To avoid or reduce these conditions, users can leave the reactor door open for a period of time during the active phase of decomposition (especially in hot weather) to facilitate the escape of the generated steam (Bhatia et. Al. 2021).

Figure 2 shows the change in volume of the composted materials as a function of microbial activity during the process. Mixture 2 shows a significant reduction in volume of 85%, which is the lowest value. This data is important for waste management.

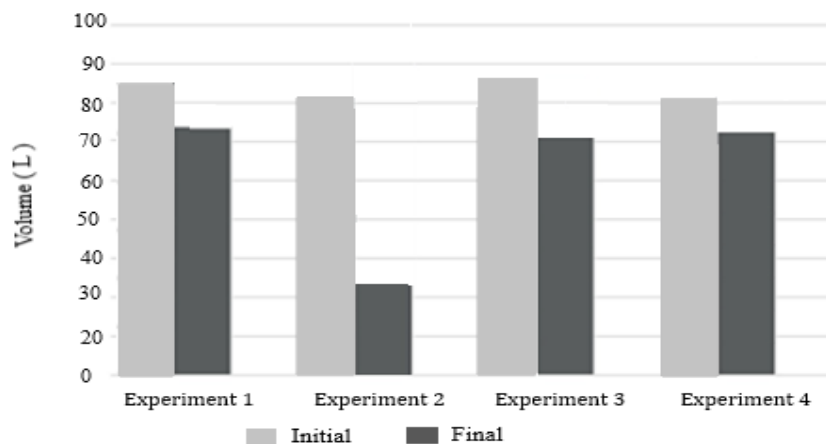


Fig.2. Percentage of volume reduction during the composting period

A decrease in volume is accompanied by a corresponding decrease in the concentration of organic carbon and nitrogen, which are key to the life of microorganisms. Organic carbon is a source of energy for microbes, which leads to CO₂ emissions into the environment, and nitrogen is used by microbial communities. The processing of raw materials can result not only in the construction of cell structures, but also in the vitalization of ammonia, especially at elevated temperatures.

During the processing of rapidly decomposing organic raw materials, we found that almost all of the materials in these raw materials were degraded, leaving only the filler. This made it difficult to obtain a sample to determine the properties of the final product.

Figure 3 shows the lowest value of 62% for experiment 3, which has a high nitrogen content in the animal manure feedstock compared to food waste. Manure contains a wide range of microbial communities that contribute to the decomposition of organic matter.

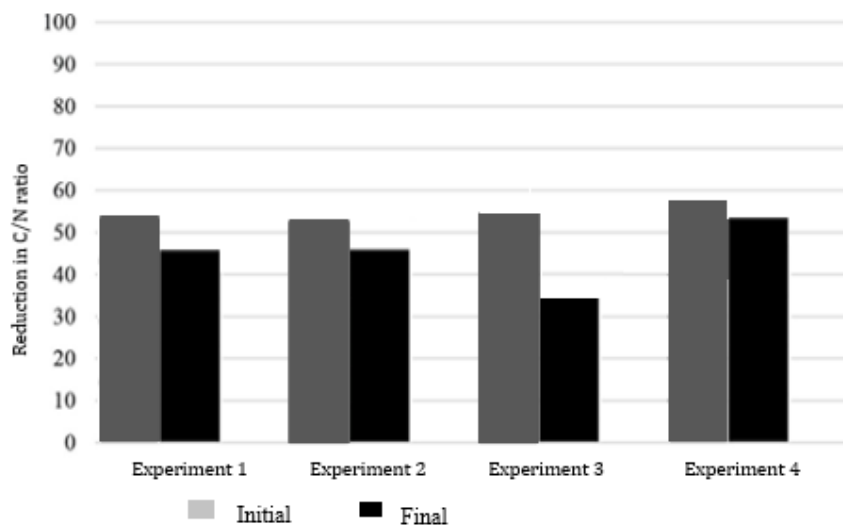


Fig.3. Percentage reduction in carbon to nitrogen ratio

The results of Experiment 2 showed that a 1:0.5 mixing ratio of waste to filler is more effective. This ratio makes it possible to treat a larger amount of waste, which ultimately provides more nutrients to support microbial activity and leads to the generation and maintenance of more heat, which promotes the development of different microbial communities, while providing the necessary aerobic conditions. In contrast, the high content of filler in other treatments can negatively affect the process, as high concentrations increase heat loss. In Experiment 4, the mixture of which contained charcoal, no significant effect on degradation was observed, but the odor was minimal compared to the others, which has a role for charcoal in reducing emissions from the composting process. Home composters are commonly used in backyards, it is recommended to add charcoal to the reactor to avoid or reduce any odors resulting from the composter.

CONCLUSIONS

Based on the results obtained, it was determined that a rotary home composter is suitable for the composting process and can be effectively used in a decentralised composting plan for household organic waste. We have found that a waste to bulk material ratio of 1:0.5 gives better results in terms of waste volume reduction, as more waste can be processed, which has a positive impact on the environment. As this study has shown, co-composting with animal manure gives better results for greater degradation of organic matter. The addition of charcoal did not show a significant effect on the degradation of organic matter, but was effective in reducing odours caused by the decomposition process.

A composting system that uses a rotating reactor requires less energy due to the optimal use of heat.

Advantages of the composting system:

- Efficient use of space: Rotary composters are usually compact and can be installed even in a small yard;
- Reduced odors and pest populations: Composters are good at retaining odors due to their design and ability to aerobically decompose organic matter. This helps to avoid unpleasant odors and reduces the risk of attracting pests.
- Environmentally friendly process: Composting is an environmentally friendly process because it reduces the amount of waste that goes to landfill and promotes recycling of this waste and recovery of valuable nutrients and organic matter.

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MACROPHYTES AS BIOREMEDIATORS AND ECOSYSTEM ENGINEERS IN WATER ENVIRONMENTS: AN OVERVIEW

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ABSTRACT

Macrophytes, represent a group of large aquatic plants. They play a crucial role in water remediation due to their ability to absorb, filter, and transform various pollutants in aquatic ecosystems and provide numerous ecological, environmental, and social benefits. The aim of this study is an overview of macrophytes role in aquatic ecosystem remediation and engineering: 1. Pollutant absorption and removal; 2. Nutrient cycling and eutrophication control; 3. Habitat provision and support for aquatic life; 4. Carbon sequestration and climate change mitigation. Macrophytes can absorb and remove pollutants such as heavy metals, nutrients (e.g., nitrogen and phosphorus), and organic contaminants from water through their roots, stems, and leaves. This process helps in reducing the overall concentration of pollutants in the water body, thereby improving water quality. Macrophytes help in nutrient cycling by taking up nutrients from the water and converting them into plant biomass controlling eutrophication and associated problems like algal blooms and oxygen depletion. Macrophytes create complex habitats for various aquatic organisms, including fish, invertebrates, and other plants. This, in turn, contributes to the overall remediation of water bodies by maintaining a balanced ecosystem. Macrophytes have extensive root systems that help stabilize sediments and prevent erosion. This not only maintains water quality by reducing the content of sediment-bound pollutants entering the water column but also contributes to the overall health of the aquatic ecosystem. Macrophytes contribute to carbon sequestration by absorbing carbon dioxide from the atmosphere during photosynthesis and storing it in their biomass. This process helps mitigate climate change and improve overall water quality. In conclusion, macrophytes play a multifaceted role in water remediation through various ecological functions, bioremediation mechanisms, and climate change mitigation. Understanding their specific roles and implementing effective management strategies can lead to healthier aquatic ecosystems and improved water quality.

Keywords: Macrophytes, bioremediation, aquatic ecosystems, water quality.

INTRODUCTION

Macrophytes, also known as macroscopic aquatic plants, grow in various aquatic environments, such as lakes, rivers, and wetlands. They play a vital role in maintaining the health and balance of these ecosystems. Aquatic macrophytes are a diverse group of plants, belonging to 33 orders and 88 families, contribute significantly to maintaining ecosystem biodiversity, with approximately 2614 species found across 412 plant genera. Their adaptability allows them to be classified into various categories (Chambers et al., 2008, Lesiv et al., 2020).

Macrophytes are classified into four main ecological groups based on their growth habitats: a) Free-floating: These plants, like water hyacinths and duckweeds, grow on the water surface and are not anchored to the substrate; b) Submerged: These plants, such as elodeids and charophytes, grow entirely underwater and are anchored to the substrate; c) Emergent: These plants, like cattails and bulrush, grow in shallow water and are partially or fully above the water surface; d) filamentous algae. Each ecological group of macrophytes plays a unique role in maintaining the health and balance of aquatic ecosystems. Understanding these groups and their functions is essential for effective ecological management and conservation efforts (Lesiv et al., 2020).

The study by Chambers et al. (2008) provides valuable insights into the global distribution and diversity of aquatic macrophytes in freshwater ecosystems, and divide them in seven groups: Chlorophyta, Cyanophyta, Xanthophyta, Rhodophyta, Bryophyta, Pteridophyta and Spermatophyta.

Bioremediators, also known as bioremediation agents, are microorganisms, plants and other living organisms that help in the process of bioremediation. Bioremediation is the use of living organisms to degrade or detoxify environmental pollutants and contaminants, such as heavy metals, organic compounds, and other hazardous substances. Bioremediators play a crucial role in restoring contaminated soil, water, and air. Macrophytes play a crucial role in water remediation due to their ability to absorb, filter, and transform various pollutants in aquatic ecosystems and provide numerous ecological, environmental, and social benefits (Demarco et al., 2023).

Macrophyte vegetation in aquatic environments is crucial for the initial accumulation and decomposition of organic matter, enabling the carbon cycle and complexification of food chains (Overbeek et al., 2018).

This ecologically diverse group of plants contributes to the structural complexity of the habitat, which further reflects on the ecology of communities of other aquatic organisms (Lucena-Moya and Duggan, 2011). Certain pioneer macrophyte species play a crucial role in shaping the hydromorphological characteristics of newly formed or degraded habitats and contribute to the process of renaturalization (O'Briain et al., 2017). The species richness and diversity of macrophytes serve as significant indicators used for long-term monitoring of river restoration success (Baart et al., 2010; Kail et al., 2015). Conversely, the number of macrophyte life forms is a reliable indicator of habitat conditions during short-term monitoring (Ecke et al., 2016).

The aim of this study is an overview of macrophytes role in aquatic ecosystem remediation and engineering: 1. Pollutant absorption and removal; 2. Nutrient cycling and eutrophication control; 3. Habitat provision and support for aquatic life; 4. Carbon sequestration and climate change mitigation.

POLLUTANT ABSORPTION AND REMOVAL

Water pollution, caused by organic and inorganic contaminants, is a pressing issue. Numerous studies focus on removing these pollutants, including pharmaceuticals and cosmetics, polycyclic aromatic hydrocarbons, artificial chemicals, microplastics, agrochemicals, pesticides, primary nutrients, and heavy metals. These investigations aim to understand and mitigate the impact of these contaminants on aquatic ecosystems (Couto et al., 2022, Geng et al., 2022, Hua et al., 2021, Alencar et al., 2020, Sudiarto et al., 2019).

Macrophytes possess the ability to act as phytoremediators, as they can accumulate trace elements in water up to 1450 times their original concentration. This capacity makes them valuable in addressing water pollution and maintaining the health of aquatic ecosystems (Rezania et al., 2016).

Macrophytes can absorb and remove pollutants such as heavy metals, nutrients (e.g., nitrogen and phosphorus), and organic contaminants from water through their roots, stems, and leaves (Couto et al., 2022, Geng et al., 2022, Hua et al., 2021). These plants can help remove heavy metals from the water through processes such as absorption, adsorption, and precipitation (Anand et al., 2019). Phytoremediation (Figure 1) refers to the process where plants efficiently eliminate, neutralize, or stabilize environmental pollutants. This eco-friendly and cost-effective approach serves as a beneficial method for detoxifying contaminated environments. Phytoremediation encompasses several techniques, such as phytoextraction, phytostabilization, phytovolatilization, and rhizofiltration, to mitigate heavy metal uptake and accumulation in plants (Pandey et al., 2022).

Phytoextraction, also known as phytoaccumulation, is a process where plants absorb toxins from sediment or water and accumulate them in their above-sediment biomass. To effectively remove pollutants, plants should either produce a large amount of biomass or have a high capacity for storing pollutants (Shi et al., 2021). Hyperaccumulator species are particularly suitable for this purpose due to their exceptional ability to accumulate contaminants. Plants that generate a lot of biomass but store pollutants for a shorter period can also be used for phytoextraction (Cristaldi et al., 2017). The efficiency of a plant species in metal phytoextraction depends on the ratio of metal concentrations in the sediment or water compared to the plant (Shi et al., 2021, Cristaldi et al., 2017).

Phytostabilization is a process that involves limiting the mobility of pollutants in the sediment by absorbing heavy metals through plant roots or precipitating them within the rhizosphere. The plants used for phytostabilization alter the sediment's chemistry, enabling heavy metal absorption and precipitation. This method is supported by various studies. Additionally, during phytostabilization, certain redox enzymes secreted by plants help transform heavy metals in the sediment or water into less hazardous forms (Ali et al., 2013, Pandey et al., 2022).

Phytovolatilization is a process where pollutants are absorbed from the sediment and water, transported through the xylem of plants, and then converted into less hazardous and volatile forms. These volatile substances are subsequently released into the atmosphere. Metals such as mercury and selenium are known for their high volatility. Phytovolatilization has been widely used to remove heavy metals from contaminated environment (Pandey et al., 2022).

Rhizofiltration is a process that involves plants absorbing and precipitating organic and inorganic contaminants through their roots, effectively removing them from contaminated wastewater, groundwater, and surface water. Key factors in

selecting plants for rhizofiltration include their ability to tolerate low oxygen conditions, withstand high metal concentrations, and possess a large surface area for absorption. Terrestrial plants are more suitable for in situ or ex situ rhizofiltration compared to aquatic plants, as they have a more intricate root system and increased surface area for absorption (Pandey et al., 2022).

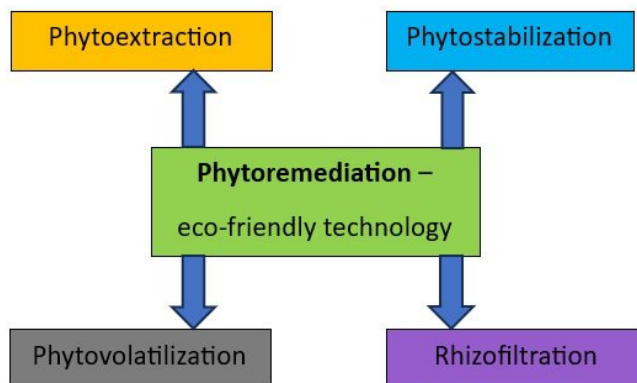


Figure 1 Phytoremediation - eco-friendly and cost-effective technology

According to numerous studies, a large number of macrophytes as bioremediators for heavy metal-contaminated waters were used. The most common species (Table 1) were: *Eichhornia crassipes*, *Pistia stratiotes*, *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Potamogeton perfoliatus*, *Lemna minor*, *Typha sp.*, *Salvinia sp.*, *Potamogeton pectinatus*, *Phragmites australis*, *Mentha aquatica*, etc. (Couto et al., 2022, Geng et al., 2022, Pandey et al., 2022, Saha et al., 2022, Vikraman Meera et al., 2022, Rezania et al., 2016).

Table1. Macrophyte species and their pollutant absorption and removal potential

Macrophyte ecological group	Macrophyte species	Cd	As	Cu	Pb	Cr	Ni	Zn	References
Free-Floating Macrophytes	<i>Eichhornia crassipes</i>	+	+		+	+	+		1, 2, 3
	<i>Salvinia sp.</i>	+	+		+	+	+		1, 2, 3
	<i>Lemna minor</i>		+	+	+	+	+		1, 2
	<i>Spirodela intermedia</i>		+		+	+	+	+	1, 2
	<i>Pistia stratiotes</i>		+		+	+	+		1, 2
Submerged Macrophytes	<i>Myriophyllum spicatum</i>	+		+	+	+	+	+	1, 2
	<i>Ceratophyllum demersum</i>	+	+	+	+	+	+	+	1, 2, 3
	<i>Potamogeton crispus</i>	+		+	+	+	+	+	1, 2, 3
	<i>Potamogeton pectinatus</i>	+		+		+	+	+	1, 2
	<i>Vallisneria spiralis</i>	+		+	+	+	+	+	1, 3
Emergent Macrophytes	<i>Scirpus sp.</i>	+		+	+	+	+	+	1, 3
	<i>Mentha aquatica</i>	+		+	+	+	+	+	1, 2
	<i>Phragmites australis</i>	+		+	+	+	+	+	1, 2
	<i>Typha latifolia</i>	+		+	+	+	+	+	1

¹ Pandey et al., 2022; ² Vikraman Meera et al., 2022; ³ Saha et al., 2022

NUTRIENT CYCLING AND EUTROPHICATION CONTROL

Eutrophication is a worldwide issue characterized by an overabundance of human-derived nutrients like nitrogen and phosphorus in water bodies (Hilbor & Beasley, 2015). This leads to several adverse effects, such as depleted dissolved oxygen levels, reduced water clarity, and an increase in toxic cyanobacterial biomass (Huisman et al., 2018). These consequences can pose threats to human health, as mentioned by Hilbor and Beasley (2015).

Phosphorus is considered the primary regulator of primary production in lakes and reservoirs and is known to be responsible for the negative effects related to eutrophication (Schindler et al., 2016). The majority of phosphorus and nitrogen supply comes from external sources such as agricultural activities (Huang et al., 2017). However, internal sources, particularly sediment-derived nutrients, can also contribute significantly (Wu et al., 2013). Research has shown that even with reduced external nutrient loads, sediment can act as an internal fertilization mechanism, releasing phosphorus into the water column (Lürling et al., 2016).

Macrophytes play a significant role in nutrient uptake through various mechanisms beyond leaf and root absorption (Riis et al., 2020). Firstly, they increase water-biota contact time by extending the residence duration within the beds, allowing for prolonged nutrient uptake. Secondly, macrophyte beds facilitate the deposition of fine particulate matter, which can stimulate recycling of organic matter and related nutrients by invertebrates and microbes (Clarke, 2002). Lastly, these plants promote nitrogen removal through denitrification, as they create favorable conditions for this process due to high organic matter content and anoxic conditions caused by the deposition of fine particulate organic matter associated with macrophyte beds (Audet et al., 2021). In the context of rooted macrophytes, these plants play a crucial role in absorbing nutrients from both water and sediment (Li et al., 2015). In situations where water nutrient concentrations surpass the requirements for macrophyte growth, these plants tend to absorb extra nutrients and store them within their tissues through a process called "luxury absorption" (Barbosa et al., 2020). Macrophytes can directly remove up to 30% of phosphorus from the water column, with this percentage reaching 25% in sediment (Li et al., 2015). Additionally, these plants help reduce wind and current impacts, minimizing the resuspension of phosphorus in sediment and making it unavailable to the water column, as mentioned by Holmroos et al. (2014).

According to Pastor et al. (2023) in areas with a predominance of submerged vegetation, the removal of macrophyte biomass led to a significant decrease in nutrient uptake. This effect on nutrient uptake and in-stream metabolism varied based on the specific characteristics of the macrophyte community.

HABITAT PROVISION AND SUPPORT FOR AQUATIC LIFE

In newly formed water bodies pioneer macrophytes can influence fine-scale physical heterogeneity and impact hydrogeomorphological processes within aquatic habitats (O'Briain et al., 2017). Moreover, the structural characteristics of macrophytes play a significant role in the composition of other aquatic communities in freshwater ecosystems (Lucena-Moya & Duggan, 2011).

It is a widely known fact that macrophytes can be a significant source of organic matter for aquatic herbivores and detritivores in certain ecosystems. Macrophytes provide sustenance in two ways: firstly, through their living components which support grazing food webs, and secondly, by offering dead organic matter that contributes to detritivorous food webs.

Macrophytes significantly contribute to habitat complexity, offering refuge from predators and increasing the potential surface area for microorganisms, invertebrates, and vertebrates to colonization (Thomaz & Cunha, 2010). This habitat provisioning service is considered one of the most crucial ecosystem services offered by macrophytes. Numerous observational and experimental studies have demonstrated positive relationships between macrophyte complexity metrics and the diversity of others aquatic biota (Thomaz, 2023). Additionally, the complexity offered by macrophytes helps trap plant propagules, enhancing the macrophyte community's own diversity (Gurnell, 2014).

Macrophytes are crucial for sustaining healthy fish populations in natural water bodies. Opuszynski and Shireman (1995) highlighted that certain aquatic plants or specific combinations of plant species can create better fish habitats compared to others. According to Thomaz et al. (2008), the complexity of macrophyte vegetation contributes to the richness and diversity of invertebrates in aquatic environments. According to Raizer and Amral (2001) emergent leaves and stems contribute significantly to the abundance and diversity of spiders in littoral zones.

Thomaz and Cunha (2010) proposed a graphical conceptual model that explains how the structural habitat complexity created by macrophytes, enhances the diversity of other aquatic communities.

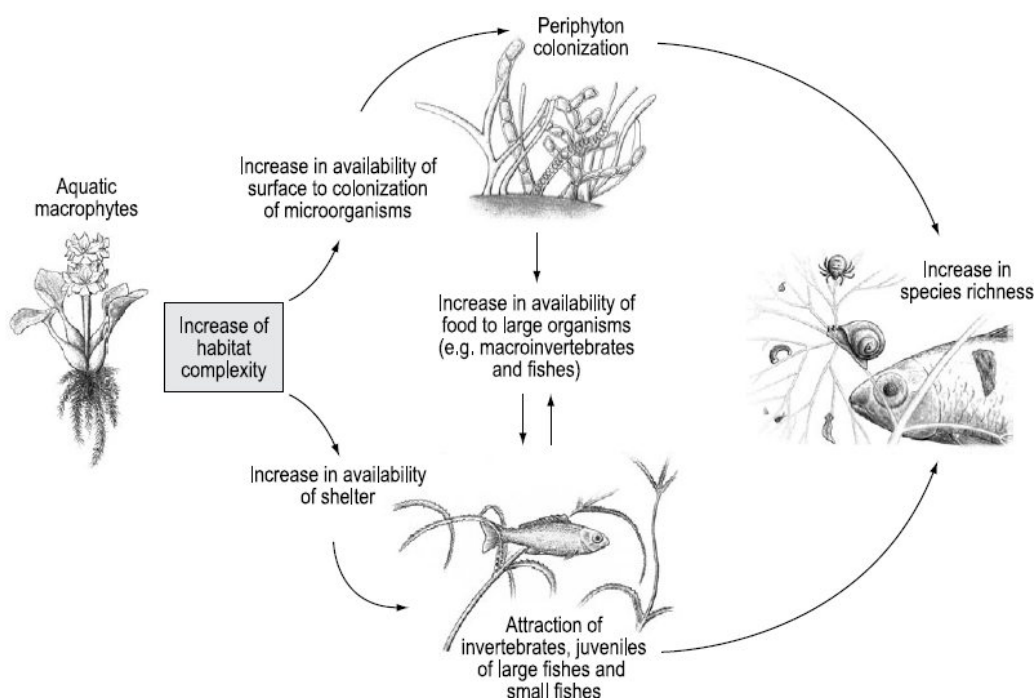


Figure 2. Structural habitat complexity created by macrophytes (Thomaz and Cunha, 2010)

CARBON SEQUESTRATION AND CLIMATE CHANGE MITIGATION

Similar to various ecosystems, freshwater ecosystems face the repercussions of climate change. A significant alteration is the heightened concentration of carbon (C) in the water (Williams et al., 2016). The majority of research in this context concentrates on ocean acidification. However, investigations in freshwater ecosystems are comparatively scarce, and the consequences are less comprehensively understood (Reitsema et al., 2018).

Macrophytes play a significant role in carbon sequestration through photosynthesis. During this process, they absorb CO₂ from the atmosphere and convert it into organic matter, such as biomass. In freshwater ecosystems, CO₂ concentrations are often higher than the atmospheric levels. However, despite this supersaturation, photosynthesis in macrophytes may still be limited due to the slower diffusion of CO₂ in water compared to air (Reitsema et al., 2018). This slower diffusion rate can hinder the efficient uptake of inorganic carbon, primarily CO₂, for photosynthesis. According to Maberly and Spence (1989), the diffusion of CO₂ in water is 10⁴ times slower than in air, which can potentially restrict the rate of photosynthesis in aquatic macrophytes. To counteract potential limitations in photosynthesis due to low CO₂ availability in aquatic environments, macrophytes have developed four diverse strategies. These include: Some submerged macrophytes can develop leaves that protrude above water, enabling them to directly absorb atmospheric CO₂, bypassing the challenge of slow CO₂ diffusion in water (Maberly and Spence, 1989); Certain macrophytes with suitable root structures and high tissue porosity can obtain and utilize CO₂ stored in sediments as an alternative carbon source (Winkel and Borum, 2009); Approximately half of all macrophytes can use bicarbonate ions (HCO₃⁻) as an alternative to CO₂ as a carbon source, helping them overcome the challenges posed by slow CO₂ diffusion in water (Madsen and Sand-Jensen, 1991); Some macrophytes have evolved to use less common photosynthesis pathways, such as C₄ or Crassulacean Acid Metabolism (CAM), instead of the prevalent C₃ pathway (Madsen and Sand-Jensen, 1991).

This not only helps in reducing the atmospheric concentration of CO₂ but also enhances the primary productivity of the ecosystem. The carbon captured by macrophytes is stored in their biomass, which includes leaves, stems, and roots (Winkel, and Borum, 2009). When these plants die and decompose, the carbon is incorporated into the sediment, further reducing the amount of CO₂ in the atmosphere (Flanagan et al., 2006). This process contributes to the overall carbon storage capacity of aquatic ecosystems. Macrophytes can help prevent the release of carbon stored in sediments by stabilizing the sediment bed through their extensive root systems. This reduces the potential for sediment disturbance, which could otherwise lead to the release of carbon back into the atmosphere (Winkel, and Borum, 2009, Flanagan et al., 2006).

CONCLUSION

Macrophytes play a crucial role in bioremediation and ecosystem engineering in aquatic environments. Their ability to absorb pollutants, provide habitats for various species, and stabilize aquatic environments makes them vital ecosystems components. Also, their capacity to absorb and store carbon dioxide from the atmosphere, along with their contribution to organic matter, helps mitigate climate change effects. Understanding macrophytes specific roles, implementing effective management strategies, promoting the growth and conservation of these aquatic plants, can enhance water quality, support biodiversity, and contribute to overall ecosystem stability.

However, there are several challenges and obstacles in utilizing macrophytes for bioremediation. Some of the main ones include: species selection (different species have varying abilities to tolerate and remove contaminants), contaminant complexity (macrophytes may be effective at removing some contaminants but not others), environmental factors (temperature, pH, salinity, and nutrient availability can significantly impact macrophytes growth and bioremediation capabilities), invasion risk (non-native macrophyte species for bioremediation purposes may lead to the introduction of invasive species, which can cause ecological harm and displace native

flora), harvesting and disposal (once macrophytes have absorbed contaminants, they must be harvested and disposed of properly), slow remediation rates (generally a slower process compared to other methods, such as chemical or physical processes), monitoring and evaluation (this can be time-consuming and resource-intensive), and also public acceptance and support.

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THE IMPACT OF ENTERIC METHANE ON THE ENVIRONMENT

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ABSTRACT

The paper gives an overview of aspects of enteric methane emission, pointing out the environmental impact. Enteric methane is formed as a by-product of feed digestion, primarily in ruminants by enteric fermentation. Ruminants emit methane created by enteric fermentation in the rumen, mostly by eructation. Nutritional interventions to mitigate enteric methane (ECH₄) have been thoroughly investigated and many innovative solutions are being tested and considered. To meet the increasing demand for meat and milk, the livestock industry has to increase its production, followed by increasing ECH₄ emissions.

The amount of ECH₄ released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Methane emitted from a ruminant animal is related to the amount of organic matter digested in the rumen, particularly the fiber fraction, and hence the amount of acetate and metabolic hydrogen produced. Dairy organizations worldwide announced greenhouse gas neutrality goals. Global climate change is affecting temperature, precipitation, and water availability, consequently affecting the decline in dry matter intake and animal productivity caused by heat stress, and global warming potential was developed to allow comparisons of the global warming impacts of different gases.

Keywords: enteric methane, ruminant nutrition, greenhouse gases, environment.

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) is a scientific body tasked with assessing the risk of climate change caused by human activity. The panel was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), figure 1. IPCC methods provide the basis for estimating GHG emissions, and have been developed with databases using statistics at the national level, but are not fully suitable for use at the local or regional level, (Ominski et al., 2007). Since measurement of the entire national cow population is not possible, it is necessary to use estimates for national inventory reporting, (Niu et al. 2021). The IPCC approach can be expanded or reformulated to be more conducive to the development of national agricultural policy while allowing for alignment between national and international data needs (Dick et al., 2008). The “Global Network” project is an international initiative for the collaboration of livestock scientists from all continents except Africa to create a global database on methane enteric production (Niu et al., 2018).

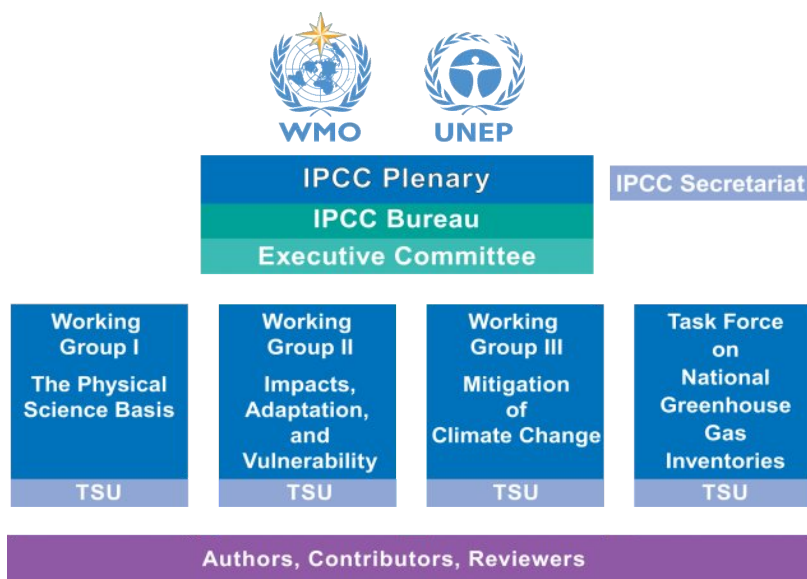


Figure 1. Structure of IPCC, www.ipcc.ch

Enteric methane (ECH_4) is produced in herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream, IPCC 2006. The amount of ECH_4 that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock (e.g., cattle, sheep) are major sources of ECH_4 with moderate amounts produced from non-ruminant livestock (e.g., pigs, horses). The ruminant gut structure fosters extensive enteric fermentation of their diet, (Ivetić, 2017). Reducing methane emissions from ruminants is a major target for sustainable and efficient livestock farming. For the animals, ECH_4 production represents a loss of feed energy and for the environment; methane exerts a potent greenhouse effect, (Muñoz-Tamayo et al., 2019).

Measurement is important to all three types of policy tools, provision of information, regulatory controls, and incentives. The concept of a global warming potential was developed to compare the ability of each greenhouse gas (GHG) to trap heat in the atmosphere relative to another gas. The Global Warming Potential (GWP) was developed to allow comparisons of the global warming impacts of different gases.

Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period, relative to the emissions of 1 ton of carbon dioxide (CO₂), EPA, IPCC, 2014. The definition of a GWP for a particular greenhouse gas is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO₂ over a specified period, (Dick et al., 2008).

By 2050, the total CH₄ emission from ruminant livestock is expected to increase significantly due to the growing demand for milk and meat for a rapidly growing world population, Gerber et al., (2013).

MEASUREMENT OF ENTERIC METHANE

A carbon dioxide equivalent or CO₂ equivalent, abbreviated as CO₂-eq is a metric measure used to compare the emissions from various greenhouse gases based on their global warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential, Eurostat (Statistical Office of the European Union, 2015). Carbon dioxide equivalents are commonly expressed as million metric tons of carbon dioxide equivalents, abbreviated as MMTCDE, Eurostat.

Per molecule in the atmosphere, CH₄ has a stronger global warming impact than carbon dioxide. Because of their very different lifetimes, the relationship between methane emissions and the concentration of methane in the atmosphere is very different to that of CO₂, (Allen et al., 2018). By the authors suggestions, instead of GWP, they suggest GWP* to accurately indicate the impact of emissions of both long-lived and short-lived pollutants on radioactive forcing and temperatures over a wide range of timescales, including under ambitious mitigation when conventional GWPs fail. Measured by GWP*, implementing the Paris Agreement would reduce the expected rate of warming in 2030 by 28%, (Myhre et al., 2013).

Methane is estimated to have a GWP of 28–36 over 100 years, United States Environmental Protection Agency - EPA. CH₄ emitted today lasts about a decade on average, which is much less than CO₂. But CH₄ also absorbs much more energy than CO₂. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. EPA reports that CH₄ GWP also accounts for some indirect effects, such as the fact that CH₄ is a precursor to ozone, and ozone is itself a GHG. The larger the GWP, the more warming the gas causes. For example, methane's 100-year GWP is 21, which means that methane will cause 21 times as much warming as an equivalent mass of carbon dioxide over 100 years.

RUMINANT NUTRITION

The type of digestive system has a significant influence on the rate of methane emission. Ruminant livestock have an expansive chamber, the rumen, at the fore-part of their digestive tract that supports intensive microbial fermentation of their diet which yields several nutritional advantages including the capacity to digest cellulose in their diet, (Ivetić, 2017).

Methane is produced by the fermentation of feed within the animal's digestive system, figure 2. Generally, the higher the feed intake, the higher the methane emission. The extent of methane production may also be affected by the composition of the diet. Feed intake is positively related to animal size, growth rate, and production, (Ivetić and Grubić, 2007). Enteric methane is expelled 99% from the mouth and nostrils, of which the majority (87%) is released by eructation, (Murray et al., 1976).

Hristov et al., (2015) reported that anaerobic fermentation of ingested plant material in the reticulo-rumen is a symbiotic process between the ruminant host and microorganisms supplying energy and protein to the host while providing optimal growth conditions and nutrients for the microorganisms. This symbiosis provides ruminants with an evolutionary advantage enabling them to efficiently use otherwise indigestible fibrous feeds (Ivetić et al., 2013), despite the loss of a small portion of the plant's gross energy as methane gas.

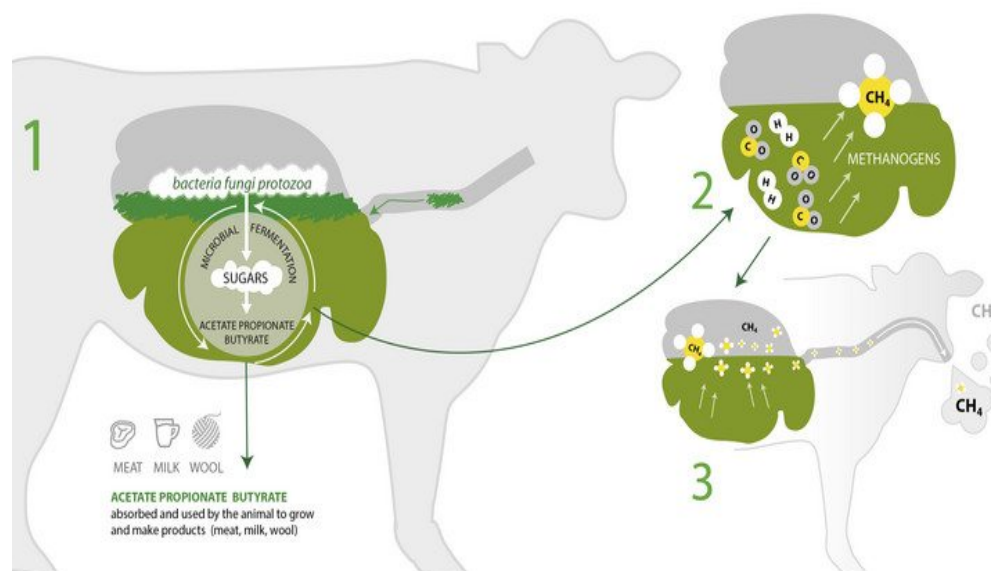


Figure 2. Ruminant nutrition, source FAO

Feed digestibility and energy intake were identified as two major factors that can affect ECH₄ emission expressed as percentage losses of dietary energy. Generally, higher energy digestibility of feed and higher energy intake level of cattle resulted in a lower percentage of digestible energy intake converted to CH₄. Increasing productivity and feed efficiency represent the greatest opportunity for mitigating CH₄ emissions per unit of livestock product. Since CH₄ represents an unproductive loss of dietary energy, one of the predominant ECH₄ emission estimation procedures is driven by first estimating daily gross energy intake (GEI) by individual animals and then multiplying the GEI by an estimate of methane conversion factor, which ranges from 2% to 11% of GEI, (Nui et al., 2021). An alternative approach is to express CH₄ conversion factors on a digestible energy basis.

ECH₄ is a byproduct of rumen fermentation produced by methanogenic archaea, (Haque et al., 2018). Cattle are some of the main contributors of anthropogenic CH₄ gas emissions to the atmosphere (Gerber et al., 2013). This particular greenhouse gas has received a great deal of attention in recent years, not only because of its involvement in global warming processes leading to climate change but also because it represents a loss of energy from the animals. Typically, methane emissions are about 2% to 12% of the gross energy intake depending on e.g., the roughage-to-concentrate ratio in the feed, carbohydrate composition, and use of supplements and additives (Johnson and Johnson, 1995).

Ruminant animals have evolved with a digestive system to digest plant materials efficiently, (Ivetić, 2018). Like most mammals, ruminants lack the cellulase enzyme required to break the beta-glucose linkages in cellulose, but they play host to diverse

populations of rumen microbes that can digest cellulose and other plant constituents, (Garnsworthy et al, 2019). When rumen bacteria, protozoa, and fungi ferment carbohydrates and proteins in plant materials, they produce volatile fatty acids, principally acetate, propionate, and butyrate. A high-fiber diet favors acetate synthesis. Synthesis of acetate and butyrate is accompanied by the release of metabolic hydrogen, which, if allowed to accumulate in rumen fluid, has negative effects on microbial growth, and feed digestibility, (Haque, 2018). Rumen archaea are microorganisms that combine metabolic hydrogen with CO₂ to produce methane and water. In ruminants' metabolism, a surplus of hydrogen is removed from the reduction reaction of NAD⁺ (nicotinamide adenine dinucleotide) by the formation of methane by methanogenic bacteria and archaea methanogens, (Palangi et al., 2022).

The amount of methane produced by a ruminant animal is related to the amount of organic matter digested in the rumen, particularly the fiber fraction, and hence the amount of acetate and metabolic hydrogen produced. The main determinants of daily methane production, therefore, are dry matter intake and diet composition, primary neutral detergent fiber content, (Niu et al., 2018)

The factors determining the amount of enteric CH₄ produced per animal include feed dry matter intake, diet composition (e.g., contents of ether extract or fatty acids and neutral detergent fiber, rumen microbial population, host physiology and host genetics, (Niu et al 2021; Shibata and Terada, 2010). The effect of methane mitigation practices should be ultimately determined in long-term experiments to address adaptation to treatment by the rumen ecosystem under industry-relevant conditions, (Hristov et al., 2015). New technologies offer the potential to manipulate the rumen microbiome through genetic selection and varying degrees of various dietary intervention strategies to reduce CH₄ emissions, (Min et al, 2022).

CONCLUSION

Stricter regulations on air pollution and greater pressure to regulate farm operations have created a constant need for an inventory of GHG emissions based on reliable and representative emission factors, as well as mitigation strategies. On the other hand, production efficiency contributes to the reduction of environmental impact per unit of product. The emission of ECH₄ represents an unproductive loss of meal energy. Methane, mainly produced by enteric fermentation and manure storage, is a gas that affects global warming 28 times greater than carbon dioxide. Feed quality, energy, and nutrient content are essential in balancing animal ration and farm production efficiency. Strategies that increase production efficiency save resources to improve the management of the external environment and represent an excellent opportunity to mitigate ECH₄ emissions per unit of product in cattle breeding.

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CLASSIFICATION OF WASTE THAT CAN BE LANDFILLED TAKING INTO ACCOUNT LOCAL CHARACTERISTICS

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ABSTRACT

An analysis of the situation in Ukraine during the transitional period of bringing the classification of waste to the standards of European legislation was carried out. We substantiated the list of types of waste that will be disposed of at the household waste landfill. The peculiarities of the industrial infrastructure of a specific settlement are investigated, taking into account factors such as the type of industrial sector, the amount of industrial waste that needs to be managed, and the availability of technologies for their recovery. Information was analyzed on the types of waste that were disposed of at the current landfill, which has been in operation since 1965. Based on the available information, a list has been compiled of the most generated waste that can be sent to the landfill for disposal in the coming years. As a result, 7 groups (categories) of waste were identified, including more than 20 types of waste. Several wastes acquired the status of dangerous, therefore, in the process of forming the list, they were not included in it. Some hazardous wastes require additional mandatory laboratory tests, which were not carried out in the current work. Instead, the presence of waste generated in the course of hostilities, namely waste from the destruction of buildings, is taken into account. In connection with the temporary absence of waste recovery technologies available in a certain region, it can be tentatively assumed that the principles of the waste management hierarchy will be followed when removing specified waste. At the same time, part of the waste included in the list can be used to compact the landfill, strengthen its slopes, as well as for the construction of roads on the working maps of the landfill.

Keywords: waste, landfill, waste disposal, war demolition waste.

INTRODUCTION

Waste management is a one of the key components for protection of public health and the environment and sustainable development of the country. Effective management begins with the classification of waste, determining its properties, volumes and consequences for the environment. According to the legislation in the field of waste management in Ukraine (Law of Ukraine 2022), waste generators have the following obligations:

- classify their waste according to the National List (Resolution 2023);
- prevent and reduce the amount of waste generation;
- process waste by themselves, or transfer it for processing to business entities in the field of waste management.

Waste treatment refers to the recovery or disposal of waste, including the preparation of waste for such operations. One of the types of waste removal is the operation of placing it on the earth's surface or in the ground, including burial, etc. - D1, D5 according to the list of waste removal operations (Law of Ukraine 2022). In the European hierarchy of waste management, landfill is in last place. It is used only in cases where the waste cannot be reused or recycled (Directive 2008/98/EC).

Therefore, the number of active landfills is being actively reduced by the efforts of the European Union. In addition, countries such as Switzerland, Sweden, Finland, Belgium, Germany, Netherlands and Denmark have practically abandoned the use of landfills for solid household waste. These countries solve the waste problem by sorting, incinerating and recycling.

In many countries, including Ukraine, landfilling remains the most common form of waste management. This is primarily due to limited resources or insufficient infrastructure for waste processing. In this case, landfills may be the only available method of waste management. Therefore, it is important that they are modern and safe. For this, it is necessary to equip landfills with engineering protective structures, organize waste storage, and ensure the recovery of valuable materials. It is also important to make a list of waste to be landfilled.

In addition to municipal waste, landfills receive waste from various industries. They are stored on separate sites or used as an insulating material for dumping household waste (DBN 2005). Unlike municipal waste, which is quite similar in its morphological composition, production waste has different origins, chemical composition and properties. For example, a region with a large number of agricultural enterprises will generate a significant amount of organic waste, pesticides, agrochemicals, etc. If the community has developed mechanical engineering, heavy industry, then the main waste will be metal, organic, chemical, as well as inorganic and abrasive waste. The variety of types of waste depends on specific technological processes and materials used at enterprises. Waste can have varying levels of toxicity and other hazardous properties, thus posing a risk to people and the environment, particularly soil and groundwater. Most of these substances do not degrade naturally, which means that they pose risk for a long period of time.

We believe that the first thing to do when operating an existing landfill, or a landfill planned for construction, is to define a safe list of waste that will be disposed of.

MATERIAL AND METHODS OF WORK

This study considers the types of waste generated in the Kremenchuk Territorial Community of Poltava Oblast that are accepted to be disposed of at a household waste landfill. This is waste from the food, engineering and construction industry (Ecological passport 2021). Certain wastes from these industries are disposed of at the municipal landfill, which has been in existence since 1965. The area of the landfill is about 28 hectares, of which 18 hectares are filled with household waste and industrial waste (Fig. 1). The height of waste storage is estimated to be 30 m. The nearest residential area is 1000 m away. Every year, up to 80 thousand tons of household waste and 20 thousand tons of non-hazardous industrial waste are sent to the landfill (Titova et al., 2021). Waste disposal technology provides for their storage on a working map with periodic compaction using a bulldozer. As the work cell is filled out, household waste is isolated with shredded construction debris. Industrial inert waste is also used as an intermediate insulating layer (Titova et al., 2022). To prevent pollution, a monitoring system has been implemented at the landfill, which includes: monitoring the state of groundwater, testing the quality of soil and atmospheric air both on the territory of the landfill and within its sanitary protection zone within a radius of 500 m.



Figure 1. Household waste landfill

In addition to household waste, some industrial waste of III and IV hazard classes, generated in the processes of production of metals, metal products, production of machines and equipment, production and distribution of energy, waste of activities of institutions of technical maintenance and repair of equipment, devices, etc., are disposed of at the landfill. This technology is permitted by current building regulations (DBN 2005).

Until 2023, waste classification in Ukraine was carried out in accordance with the state system of classification and coding of technical, economic and social information (Raczyńska 2014). Updated law (Law of Ukraine 2022), introduced a new classification of waste in accordance with the requirements of the EU framework directive (Жуковський 2016). According to this law, waste is divided into two categories: hazardous and non-hazardous waste. After the implementation of the National List of Waste, economic entities must classify waste according to the new list of waste, similar to the European "List of Waste" (Commission Decision 2000), and determine codes taking into account the hazardous properties of waste.

In this regard, there was a need to create an optimal list of waste that is allowed to be taken to city landfills. When creating a list of waste for a specific territorial community, it is necessary to assess the demand for the service of removing non-hazardous production waste and their quantitative indicators. The list of safe waste that can be landfilled is usually formed based on several criteria and standards. Usually, waste is classified by sources of generation: household, construction, agro-industrial, medical, etc. Further, classification is made according to physical state (solid, liquid, gaseous) and chemical composition (presence of organic and inorganic substances, toxicity, presence of heavy metals, etc.). The hazardous properties of waste are assessed by determining the presence of hazardous chemicals or persistent organic pollutants. This can be done on the basis of known facts about the content and components of the waste, product information, safety data sheets or laboratory tests. Based on the received information, a six-digit code is assigned, to which the symbol "*" is added in the case of hazardous waste; the first two digits of the code indicate the group to which this type of waste is assigned, the next two digits of the code indicate the subgroup to which this type of waste is assigned, and the last two digits of the code indicate the type of waste within the subgroup (Resolution 2023).

Waste data for this study was obtained from the local landfill operator. In collaboration with the landfill operator, a list of waste acceptable for disposal at the landfill in the region in question was compiled. Previously, the landfill operator requests information about waste from enterprises that are potential customers for waste disposal services. Enterprises can provide information about the composition of waste, its volume, laboratory tests, or provide a waste passport. This information is always available to the landfill operator.

If it is not possible to perform the previous operations of the five-step hierarchy of waste management, non-hazardous waste can be disposed of at a household waste landfill. Therefore, the creation of the list for the city of Kremenchuk began with the processing of available information about waste that had already been removed in previous years (since 1965).

When moving waste to a landfill, its generator provides the landfill operator with information on whether it is classified as hazardous, as well as a waste passport. In addition, radiometric and wagon control is being completed at the landfill checkpoint.

RESULTS AND DISCUSSION

According to accounting data, in addition to household waste, about 27 types of industrial waste are sent to the landfill. These include waste from the production of metals, metal products, production of machines and equipment, waste from the production and distribution of electrical energy, construction works, waste from the provision of waste treatment services, maintenance and repair activities. In connection with the hostilities on the territory of Ukraine, some large factories in Kremenchuk operate in a limited mode, so the volume of waste has significantly decreased over the previous 2 years. Instead, the amount of construction waste and demolition of buildings and structures increased.

The list of the most common wastes, which were taken to the city landfill in previous years, was considered. Names of types of waste according to According to the state classification (DK 005-96), it is included in the National list of waste (Waste classification 2023), which corresponds to the "List of Waste" (Table 1-5).

Table1 Household waste and similar waste from commercial organizations, industrial enterprises, institutions

№	Code and name of waste according to DK 005-96		Code and name of waste according to the National List	
1	7720.3.1.01	Municipal waste is mixed	20 03 01	Mixed household waste
2	7710.3.1.13	Clothes are worn or damaged	20 01 10	Clothes
3	7710.3.1.14	Shoes are worn or damaged		
4	7710.3.1.15	Remnants of textile materials	20 01 11	Textile
5	7710.3.1.17	Rubber products and materials are damaged or worn out (non-resource valuable)	20 01 99	Other waste of this subgroup (rubber waste)
6	7720.3.1.02	Sludge of septic tanks	20 03 04	Sludges of septic tanks
7	7730.3.1.04	Absorbents are damaged, worn out or contaminated	19 08 99	Anthracite loading of treatment facilities

For the typical waste of many enterprises, the exception is anthracite loading, which is used in treatment facilities, in particular, in water filtration systems for the purpose of cleaning from various impurities and ensuring high quality of purified water. Such waste is generated by city water canals and thermal energy enterprises.

Table 2. Food and tobacco production and processing waste

№	Code and name of waste according to DK 005-96		Code and name of waste according to the National List	
1	1511.2.6.02	Washing and cleaning waste	02 02 01	Sediment from washing and cleaning
2	1551.2.6.00	Storm sewer sludge in a dehydrated state	02 05 02	Sediment from wastewater treatment (cleaning) at the enterprise
3	1600.1.1.01	Tobacco raw material	02 03 04	Raw materials and products that are not suitable for consumption or processing
4	1600.1.1.04	The raw material is different		
5	1600.2.9.02	Tobacco dust		

Both industries can generate by-products, such as sludge from wastewater treatment, that require management and disposal. The production of tobacco products can include large volumes of dead tobacco that is not used in the production process.

Table 3. Iron and steel production waste

№	Code and name of waste according to DK 005-96		Code and name of waste according to the National List	
1	2711.2.9.08	Metallurgical slags	10 02 01	Waste from slag processing
2	2711.2.9.33	Cast iron smelting slags are different		
3	2711.2.9.34	Carbon steel smelting slag		
4	2711.2.9.36	Foundry slag		
5	2711.2.9.37	Steel smelting slags are different		
6	2711.2.9.31	Crucible lining waste	10 02 99	Other waste of this subgroup
7	2720.2.9.01	The scum is dry	10 02 10	Rolled scale
8	2741.2.9.02	Foundry bars and molds	10 09 08	foundry bars and orms, different from 10 09 07*
9	2741.2.9.03	Furnace slag	10 09 03	Casting process slag
10	2741.2.9.08	Dust and sludge from gas treatment facilities	10 09 99	Other waste of this subgroup
11	2741.2.9.09	Sludge of gas treatment plants		

This type of waste is generated in the metallurgical industry as a result of various processes of metal production and processing and consists of waste and impurities that are separated from the metal during its processing. Over a period of time, waste from the process of casting ferrous metal products (casting mixture waste) was used in a landfill as an insulating material (Titova 2022). The slag was used to build access roads.

Slags can also be generated in the car and machine building industries, although their volume and nature may differ from those generated in metallurgical processes. The sources of formation include: welding and metal processing, surface cleaning and preparation, heat treatment of parts components, etc.

Table 4. Waste from power plants and other incineration plants

№	Code and name of waste according to DK 005-96		Code and name of waste according to the National List	
1	4010.2.8 .01	Blacksmith slag, fuel slag	10 01 01	Bottom ash, slag and boiler dust (excluding boiler dust specified in 10 01 04*)
2	4010.2.9 .08	Solid waste that does not contain petroleum products (calcium-silica products are spent)	10 01 25	Waste from fuel storage and preparation at coal-fired power plants
3	4010.2.9 .12	Waste from technological processes of production and distribution of electricity, gas, steam and hot water, not otherwise specified (remains of mineral wool materials)	10 01 99	Other waste of this subgroup

Waste from power plants and other incineration plants is widespread not only in the studied region, but also throughout the country. We believe that before placing fuel slag on the landfill, it is advisable to conduct additional studies to identify dangerous properties.

Table 5. Construction and demolition waste

№	Code and name of waste according to DK 005-96		Code and name of waste according to the National List	
1	4510.2.9.09	Mixed waste from construction and demolition of buildings and structures	17 06 04	Insulating materials other than those listed under codes 17 06 01* and 17 06 03*
			17 01 01	Concrete
			17 01 02	Brick
			17 01 03	Facing tiles and ceramics

The sources of construction waste generation are diverse, as they are generated in various spheres of production and human life, including during any construction and reconstruction, dismantling of buildings. Waste includes waste concrete, brick, metal, wood, insulation, plastic materials, etc. A significant amount of waste is subject to processing, but at the same time, the processing of certain types of waste may be impractical and they are subject to landfilling. This is due to the lack of possibility of further waste processing within the community or region. Limited technologies, lack of special equipment for crushing waste, high cost of waste treatment costs, lack of a real stimulating market for the sale of waste components generated in the recovery process are the main factors due to which construction waste ends up in landfills.

It is important to note that some types of waste may be classified as hazardous waste under the new classification. Therefore, available information about waste, including information according to waste passports, is not sufficient for proper classification and assigning a six-digit code to the waste. In particular, these waste types include bottom ash, slag and boiler dust; cast rods and forms; insulating materials. To determine their hazardous properties it is advisable to try to obtain information about their composition from the producers and/or to conduct laboratory tests.

We believe that waste generated during military operations will require separate consideration. Recently, there has been a significant spread of demolition waste on the territory of Ukraine. To date, the issue of collecting and handling this waste has already been regulated by legislation (Resolution 2022). Part of the waste is subject to disposal at household waste landfills. Therefore, it is worth including certain types of waste from the destruction of buildings and structures in the list of waste that is disposed of at the landfill (Table 6). As can be seen from Tables 5 and 6, these types of waste are the same, but different codes are used. This is due to the fact that demolition waste can be thermally deformed, contain gunpowder residues, so their collection and accounting is carried out separately from ordinary construction waste. The landfill has a special site for temporary storage of demolition waste, which can later be buried together with household waste. Therefore, there is a clear separation between the codes of names of ordinary construction waste and demolition waste.

Table 6. Construction and demolition waste from destruction

	Departure code	Name of waste
	16 12 01	Concrete
	16 12 02	Brick, brick battle
	16 12 03	Facing tiles, roof tiles and ceramics
	16 12 44	Mixed household waste
	16 12 45	Other mixed industrial destruction waste

The waste of this subgroup needs special attention. Their management involves carrying out a complex of organizational and technical measures and works, to ensure environmentally safe collection, transportation, sorting, storage, processing, disposal. Demolition waste differs from ordinary construction waste. They are heterogeneous, often different in structure and origin. The most difficult are wastes that have undergone thermal deformation. It is almost impossible to visually establish their origin.

The associated components of waste during demolition are similar to household waste, but may contain many hazardous components. If, as a result of a visual inspection, it is not possible to determine the origin and degree of danger of the waste, it is advisable to conduct laboratory tests to determine the chemical composition. On the basis of the obtained data, a conclusion is made regarding the safety of waste and the admissibility of their placement at the landfill is determined.

As can be seen from the list of wastes obtained by us based on the available accounting data, some wastes that are common in almost every settlement are missing from it. Such waste includes: wood waste, garden and park waste, market waste, street cleaning waste, bulky waste, soil, stones, etc. Given the absence of a composting station for organic waste and a processing plant capable of shredding bulky waste in the community, the question arises, what happens to this waste? We make the assumption that all of the above wastes are included to the total amount of household waste.

Today, it is necessary to separate waste at source (of its generation), separate collection and record keeping for each type. At first glance, these methods seem impractical, because almost all waste is transported by the generator to the landfill in one vehicle, in a heap, and then it is removed on one work map. However, the more information the community has about the types of waste and their real volumes, the more precisely the problems in the field of waste management will be solved. For the development of any project: be it the installation of a textile compaction plant; installation of a wood chipper or composter, first of all, information on the volume of waste that can be processed is found out.

CONCLUSIONS

So, summarizing the obtained data, we have created a list of the most common wastes that are generated in the community and can be disposed of at the existing municipal landfill for household waste. After classifying waste in accordance with the National List, waste belongs to 7 groups, according to their source (origin):

1. Household waste
2. Waste from wastewater treatment enterprises.
3. Food production and processing waste.
4. Cast iron and steel production waste.
5. Waste from power plants and other incineration plants.
6. Construction and demolition waste.
7. Construction and demolition waste during destruction.

Manufacturing enterprises, when expanding their activities, may generate new types of waste that were not previously disposed of at the landfill. Also, changes in the technological process are possible in which waste from the hazardous waste category can move into the safe waste category and vice versa.

If the classification of waste has received the status of hazardous, it is possible to transfer it to a specialized hazardous waste landfill, which is located close to the municipal waste landfill. A specialized landfill consists of storage tanks buried in the ground in which solid and sludge waste can be placed. The landfill operator has the right to verify the reliability of the information about waste provided by enterprises, by taking waste samples from the delivered batch and transferring them to the laboratory for analysis.

When classifying waste in accordance with the new National List of Waste (Decree 2023), manufacturers will have the opportunity to expand the list of their own waste and assign it to the appropriate groups. In this case, it will be necessary to update

the list of waste that is disposed of at the landfill. Therefore, we suggest updating the relevant list once a year. Changes must be made by the landfill operator based on applications from waste producers.

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POTENTIAL APPLICATION OF PHYTOREMEDIATION TO REDUCE POLLUTION WITH POLYFLUORINATED AND PERFLUORINATED COMPOUNDS

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ABSTRACT

Poly- and perfluoroalkyl substances (PFAS) are very resistant to degradation and pose a serious environmental threat, especially the short-chain PFAS, which bioaccumulate and readily translocate in plants. They enter soils and crops by using contaminated biosolids and compost as fertilizers, irrigation with contaminated water sources, or the application of pesticides containing PFAS. Soil and water contamination with PFAS has become a significant issue with negative effects on both the environment and public health.

Removing PFAS from the environment is challenging due to their complex chemical structure and interactions with soil and water and therefore, they cannot be eliminated by traditional physical or chemical treatments. Many effective remediation technologies for PFAS removal are currently in use, including adsorption through granular activated carbon or resins, photocatalysis, electrochemical oxidation, thermolysis, and biological treatment. However, most of these techniques are energy-intensive and have considerable operating costs.

Phytoremediation uses nature to treat soils and water that have been contaminated with hazardous compounds including PFAS. This technique involves the bioaccumulation and dispersion of PFAS inside plant compartments, which is a very promising technology. Plant communities play a vital role in immobilizing and reducing PFAS bioavailability through root absorption. Phytoremediation has the potential as a low-cost, long-term green solution, and can be employed on a wide scale as an *in situ* remediation strategy. However, there is still a significant lack of knowledge regarding the selection of plant species and methods to enhance their performance.

Keywords: Phytoremediation, plants, PFAS.

INTRODUCTION

In recent years, concern about the "forever chemicals" PFAS, found in the environment and in everyday use, which affect the living world and human health there has been increasing. PFAS chemicals are available globally for various purposes such as cosmetics, food, household products, medical devices, pesticide formulations, firefighting foam, and oil production. They are detected in more than 200 applications in 64 categories and nearly 1400 types were identified for 21 industry branches. PFAS are persistent, highly toxic chemicals, very resistant to degradation, that accumulate in human and animal bodies, and in the environment (Brunn et al. 2023; Peritore et al. 2023).

Different studies have shown that releasing PFAS into the environment can pose a significant risk to public health, welfare, and the environment. The classification of perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), their salts, and structural isomers as hazardous substances is based on their chemical and physical properties, toxicity, how they behave in the body, and their prevalence in the environment. These results are being evaluated for the listing of PFASs under the Stockholm Convention on Persistent Organic Chemicals. PFOS, PFOA, perfluorohexanesulphonic acid (PFHxS), long-chain perfluorocarboxylic acids (LC-PFCA), and its salts were listed in Annex A, B, or C to the Stockholm Convention (decisions SC-4/17), and in a work program (decisions SC-4/19, SC-5/3, and SC-6/7). The ultimate goal is to eliminate the production and use of PFOS, PFOA, and their precursors globally (EPA 2023; Stockholm Convention, n.d.; Wang et al. 2017).

Various methods have been applied to reduce the content and toxicity of these chemicals. In addition to chemical treatments, the application of biological and phyto treatments can contribute to significantly reducing the concentration of these chemicals in the environment. The work aims to show the advantages and disadvantages of phytoremediation among other types of remediation, to reduce soil pollution with per and polyfluorinated compounds.

Poly- and perfluoroalkyl substances (PFAS)

PFAS are a large group of chemicals with fluorinated carbon chains. They can be divided into polymers and non-polymers (Figure 1). Two main groups of PFAS are PFOS, and PFOA chemicals. Both groups have fluoroalkyl moiety $(-CF_2)_n$ where $n \geq 6$, with long chain acids. Long fluoroalkyl moiety has a higher potential for adsorption than short-chain ones, and that feature increases the bioaccumulation and toxicity of PFAS (Leonello et al. 2021; ITRC 2022).

PFOS, is a completely fluorinated compound that contains eight carbon (C8) atoms and a sulfonate group head. PFOS has been used as a coating and protectant. PFOS is produced commercially from perfluorooctanesulfonyl fluoride (POSF) which was used as an intermediate to produce other fluorochemicals. PFOS is formulated by $C_8HF_{17}O_3S$ which has a molecular mass of 500.13 g/mol. PFOS is produced through Simons Electro- Chemical fluorination (SECF), which produces 70% linear chains and 30% branched chains isomers. They can also be created through telomerization which produces linear chains. In addition, PFOS can be formed in the environment through the degradation of POSF-based products.

PFOA, is a completely fluorinated organic acid with seven-carbon (C7) atoms and a carboxyl (C1) functional group head. PFOA has been a main constituent of aqueous film forming foams, as well as non-stick coats, and waterproofing. PFOA is formulated by $C_8HF_{15}O_2$ which has a molecular mass of 414.07 g/mol (Buck et al. 2011).

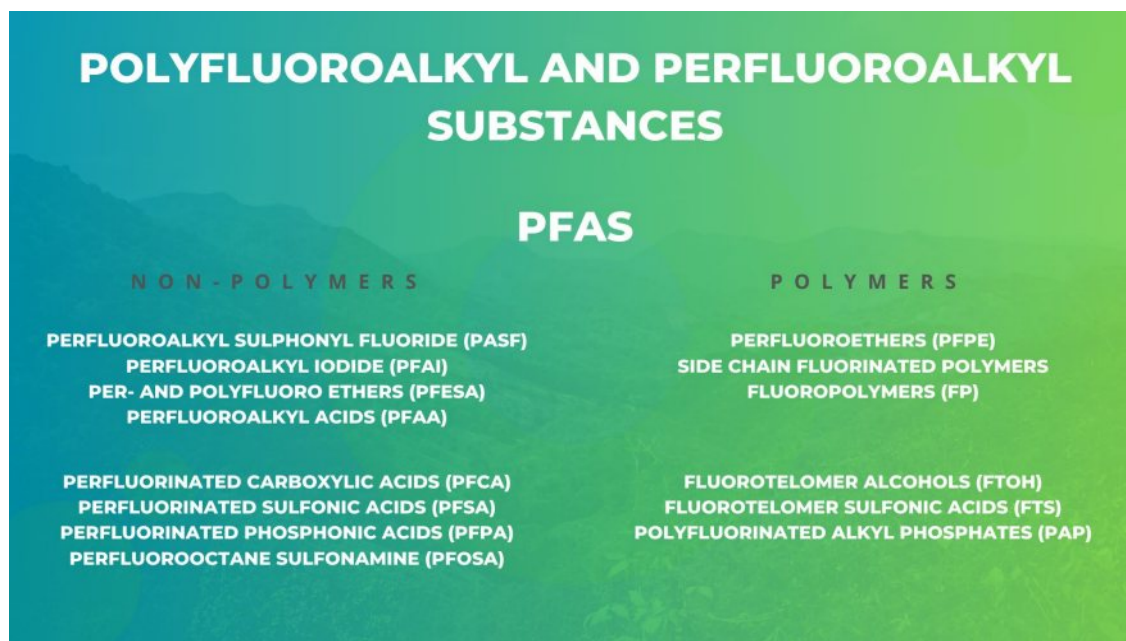


Figure 1. The main groups of polyfluoroalkyl and perfluoroalkyl substances

Sources of soil pollution

PFAS are anthropogenic (human-made) class of chemicals used in industry and consumer products since the 1940s due to their unique properties including resistance to heat, water, oil, and stains. Their properties were useful for a wide range of products and different industrial processes. Potentially affected industrial entities are: aviation operations, carpet manufacturers, car washes, chemical manufacturing, chrome electroplating, coatings, paints and varnish manufacturers, firefighting foam manufacturers, landfills, medical devices, fire departments and firefighting training centers, paper mills, pesticides and insecticides, petroleum and coal product manufacturing, petroleum refineries, photographic film manufacturers, polish, wax and cleaning product manufacturers, polymer manufacturers, printing facilities textile mills, waste management and remediation services and wastewater treatment plants (EPA 2023).

Generally, PFAS are sometimes referred to as “forever” chemicals because of their unique structure with strong carbon-fluorine backbone. The stability of these bonds confers durability while varying chain lengths and functional groups contribute to diversity properties. Strong C-F bonds cause their resistance to degradation which leads to persistency in the environment and mobility in soil, water and air. PFAS chemicals enter soils and crops through the use of contaminated biosolids and compost as fertilizers, irrigation with contaminated water sources, or the application of pesticides containing those substances. Contamination of soil and water by PFAS is a significant environmental and public health issue. . Short-chain PFAS readily bioaccumulate and translocate in plants and animals (Panieri et al. 2022; Lukić Bilela et al. 2023). They can be detected in food products like eggs, milk, meat, fish, and root vegetables. PFOA also bioaccumulates but not in the same amount as PFOS (Figure 2).

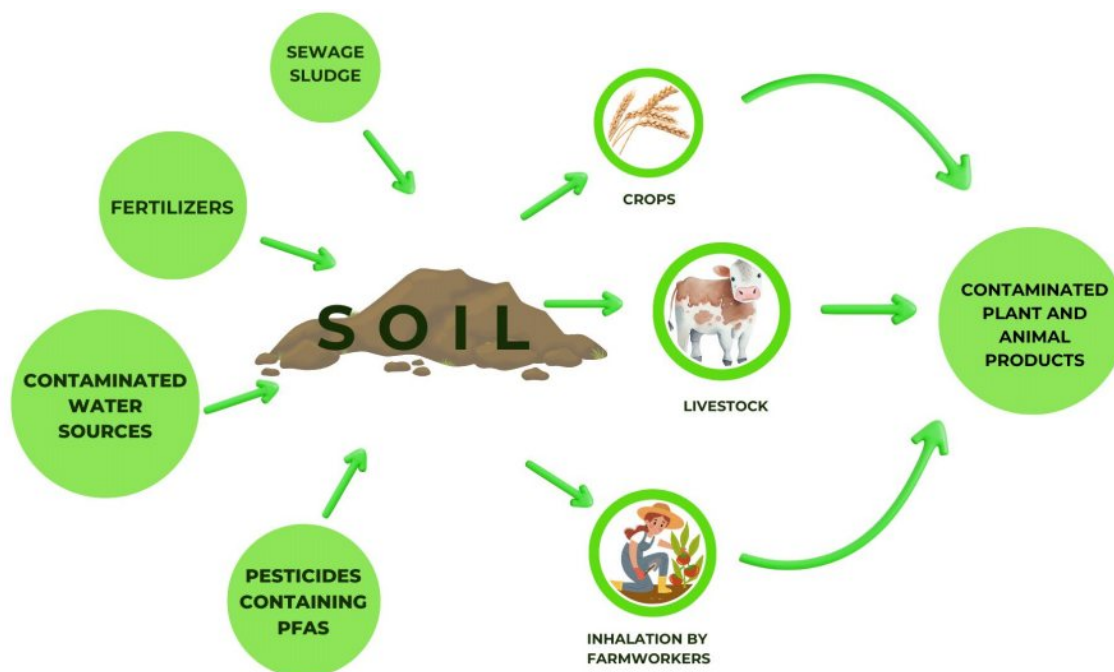


Figure 2. How PFAS move through the agricultural soil. They enter soils through the use of fertilizers, contaminated water sources, or the application of pesticides. PFAS are taken up by crops, and livestock, and can be inhaled by farm workers. This leads to the consumption of contaminated plant and animal food products.

Soil is a crucial part of the biosphere, and unfortunately, it is exposed to a high amount of man-made chemicals. The direct entry routes of these chemicals into the soil include applying treated or untreated wastewater and biosolids to agricultural lands, extensive animal production, firefighting practices, and landfill leaching. PFOS and perfluorohexane sulfonate are the dominant perfluoroalkyl acids found in the soil sampled from firefighting training grounds and airports, with concentrations of PFOS reaching up to 13,400 ng/g dw. Approximately 2749 to 3450 kg of total PFAS was present in biosolids across the USA, and 1375 to 2070 kg of PFAS ended up in agricultural land through soil applications annually. The dynamics of PFAS compounds and their fate in the soil depend on the characteristics of PFAS compounds (e.g., solubility and chain length), soil properties (e.g., organic matter and pH), and environmental factors (e.g., precipitation) (Shi, Kaur, and Gan 2023; Milinovic et al. 2015).

PFAS molecules can adhere or be absorbed by soil particles, which is governed by two mechanisms: the interaction of soil organic matter with the hydrophobic fluorinated carbon tail and electrostatic interactions of clay particles with the polar headgroup. Research indicates that sulphonate functional groups on PFAS molecules lead to stronger adsorption than other functional groups like carboxylate or phosphate. PFOS is known to be strongly adsorbed to soils through hydrophobic interaction, ion exchange, surface complexing, or hydrogen bonding, while PFOA has lesser adsorption to soil and is more soluble in water. Longer PFAS chains and higher organic content lead to increased sorption in soils.

The organic matter content in soil appears to be the dominant parameter affecting the sorption of PFAS, as the organic matter and high clay content, high organic matter, and low pH values have greater retention capacity for PFOS (Das et al. 2013; Hellsing et al. 2016; Jeon et al. 2011; Mahinroosta and Senevirathna 2020).

Techniques for remediation of PFAS-contaminated sites

Various treatments can be used to help remove PFAS from contaminated soil. Different abiotic techniques facilitate the movement of contaminants from the solid matrix into water (mobilization), reducing leaching and bioavailability by immobilizing contaminants (immobilization), and the actual destruction of these contaminants (thermal treatment, mechanochemical destruction, advanced oxidation and reduction processes) (Beškoski et al. 2024; Bolan et al. 2021).

The mobilization approach involves using methods like soil washing and soil flushing to extract PFAS from soil, making it easier to apply water remediation techniques. This method is effective for certain soil types, but not recommended for clay soils due to their high adsorption capacity.

Immobilization on sorbents like activated carbon, biochar or mineral clays, focus on reducing the mobility and bioavailability of PFAS in soil. Activated carbon, with its high surface area and porosity, is a prominent choice for immobilizing PFAS. It primarily relies on hydrophobic and electrostatic interactions to bind PFAS, making it effective for a wide range of these substances. Additionally, sorbents can be combined with stabilizers and binding agents, such as cement or fly ash, to enhance their effectiveness. The immobilization technique can be applied easily both *in situ* and *ex situ* on a large scale, which is why commercial products based on this method are used worldwide.

Thermal approach involves the treatment of PFAS-contaminated soil with high temperatures: up to 500°C - PFAS are desorbed from the soil, leading to the production of volatile fluorine compounds, while higher temperatures (900–1,200°C) eliminate up to 99% of PFAS. Thermal treatment is effective but requires substantial infrastructure and is applied outside the site, with soil disposal in landfills. Modified incineration methods like pyrolysis, gasification, and smoldering aim to make it eco-friendly and cost-effective (Sörengård, Lindh, and Ahrens 2020).

Mechanochemical destruction uses mechanical force to clean PFAS-contaminated soil without toxic solvents, high temperatures, or high pressures. It relies on processes like planetary and horizontal ball milling. Advanced oxidation and reduction techniques can break down PFAS using methods such as persulphate radicals, electron beam technology, and ultrasound. However, complete degradation is challenging due to the strong C-F bonds in PFAS and interfering organic matter in the soil. Combining ultrasound with chemical oxidants like persulphate shows promise, but more research is needed (Kang et al. 2023; Bolan et al. 2021).

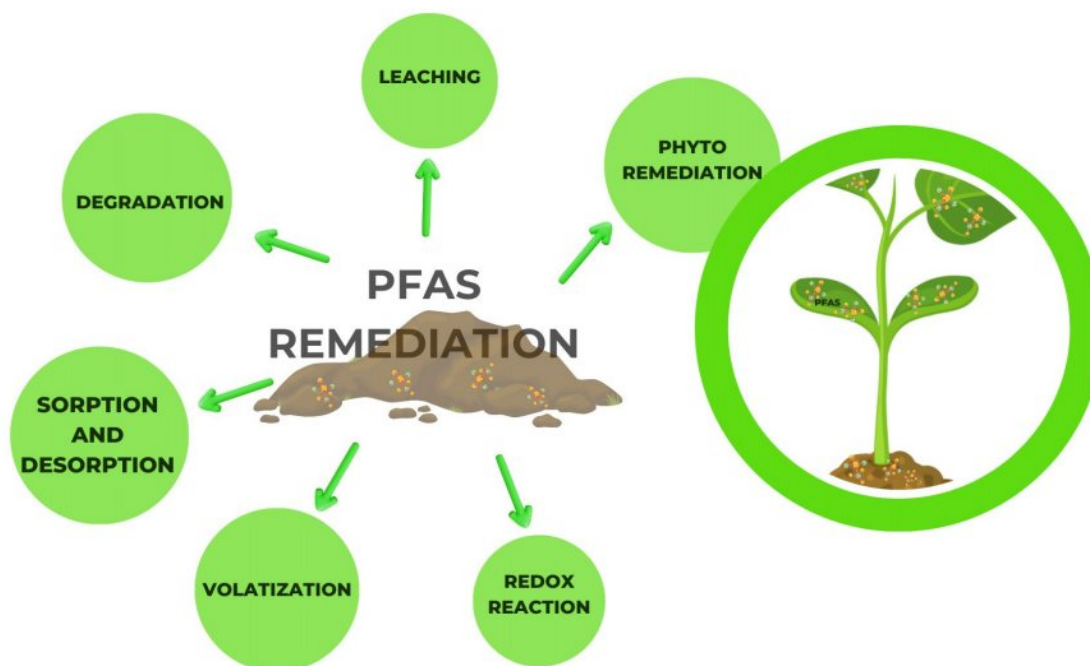


Figure 3. Remediation of PFAS contamination in soil. By phytoremediation, PFAS can be removed from soil by accumulation in plants.

Advantages of phytoremediation

Many effective remediation technologies for PFAS removal are currently in use. However, the high cost, energy-intensive physical methods resulted in an urgent need to develop *in situ* bioremediation techniques to address PFAS contamination in affected areas. One such method is phytoremediation, which utilizes the ability of plants to remove and stabilize contaminants in the soil. This technique is applicable in a wide range of atmospheric, aquatic, and geospheric environments, making it an *in situ*, ecosystem-friendly, and socially acceptable remediation technology (Beškoski et al. 2024).

The advantages of phytoremediation to conventional strategies:

- Low cost (about 10% of physicochemical methods costs);
- Stabilization and protection of soil from erosion;
- Retention of moisture in the soil, prevention of landscape damage, and maintenance of a healthy ecosystem by increasing microbial activity and diversity;
- Possible remediation of low concentrations of pollutants from various sources.

Plants use different methods to handle environmental pollutants, such as phytoextraction, phytodegradation, phytovolatilization, phytostimulation, and phytostabilization. Phytoremediation can only target pollutants that are not toxic to plants, making herbicides and toxic metals unsuitable for this process. For maximizing plant growth having a knowledge for cultivation and management, and understanding how metabolic activation affects pollutant accumulation is essential. Also, root depth is crucial for efficient phytoremediation (Pilon-Smits 2005).

Phytoremediation is a process that can involve use of different types of plants, including herbaceous, wetland, or woody plants, either individually or in combination with other remediation techniques, to remove environmental pollutants.

Even if the concentration of pollutants is low, plants can still accumulate them in their vegetative parts due to their spreading root systems. This is particularly useful for pollutants present in very low concentrations in soil and can be used as a first step for physical and chemical remediation methods which are in that case uneconomical. Diverse plants remediate different pollutants at various rates through one or multiple mechanisms (Kafle et al. 2022).

Enhancing the phytoremediation efficiency with new technologies

The applicability of phytoremediation is limited by relatively long remediation time, bioavailability of contaminants, phytotoxic threats posed by contaminants, and lacking information about its efficacy under different soil-plant conditions (Shahsavari et al. 2021; Wackett 2022). There is an urgent need to explore means to overcome these shortcomings while optimizing phytoremediation effectiveness. The limitations of phytoremediation can be overcome by using several aids including natural and chemical amendments, genetic engineering and natural microbial stimulation.

Several new technologies have been tested to further promote phytoremediation, such as the use of plant-growth-promoting microorganisms, the application of electric field (electro-kinetic phytoremediation), implementation of spatial planting patterns of diverse plant species, and the amendment of compost, biochars, titanium dioxide (TiO₂) nanoparticles, fertilizers, among others. Nanomaterials may directly remove contaminants, improve plant resistance, promote plant growth, and enhance contaminant bioavailability (Alkorta and Garbisu 2001; Bentel et al. 2019).

Understanding interactions between bacteria, fungi, and their host plants, meta-omics approach have been employed in endophytic microbes to elucidate their roles in plant defense against environmental stressors. Phytoremediation could be challenging because high concentrations of toxic contaminants can be harmful to plants. PFAS can affect plant growth and development at a molecular level. However, microorganisms that detoxify PFAS can be added to the soil and overcome this. Also, plant secondary metabolites can be used to stimulate the growth of PFAS-degrading microorganisms. This new approach is proposed as a more effective way of compensating for the shortcomings of traditional remediation methods that rely solely on plants or microorganisms.

The performance of phytoremediation depends on environmental conditions (e.g., temperature fluctuations), while microbial degradation and plant uptake is mainly confined to the plant root zone. Removal efficiency may decrease over time due to the aging or clogging of green infrastructures such as wetlands. In general, phytoremediation is relatively slow, as the remediation is limited by the metabolic and microbial activity in the plant and rhizosphere; the long periods required for phytoremediation may further limit its application (Shi, Kaur, and Gan 2023).

CONCLUSIONS

Although PFAS biotransformation has shown some promising results, a confirmed biodegradation pathway has not been established yet. To degrade PFAS, biotic and abiotic treatment strategies should be combined. Phytoremediation is a natural technique that uses solar energy to treat moderately contaminated soil or water. It is a low-cost, long-term green solution and can be applied *in situ* for remediation of different types of soil pollutants such as PFAS. Many studies showed that plants can accumulate PFAS in their vegetative parts, however identifying hyperaccumulating plant species and maximizing their growth for point-source pollution is crucial. Phytoremediation efficiency can be enhanced using PFAS detoxifying microorganisms and their stimulants, however, there is still a significant lack of knowledge regarding plant selection and performance enhancement methods.

ACKNOWLEDGMENTS

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THE IMPORTANCE OF THE PESTICIDE MARKET FOR THE DEVELOPMENT OF SUSTAINABLE AGRICULTURAL PRODUCTION IN SERBIA

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ABSTRACT

The concept of sustainable development, as a new strategy of economic and social development, is impossible without sustainable agricultural production, which has the task of preventing the degradation of natural resources, while at the same time bringing high yields and income to agricultural producers. In this way, sustainable agriculture tends to reduce negative impacts on the environment, preserve the quality of natural resources, develop the agricultural market, increase profitability due to the production of quality products, which affects socio-economic development.

The pesticide market, as a means of plant protection, i.e. a phytopharmaceutical, has a great influence on the development of sustainable agricultural production. Improper application, i.e. excessive dosage of pesticides, has a bad effect on the sustainability, then the economy of agriculture with an increase in costs, but also a violation of the quality and health of the product. In accordance with this, the Republic of Serbia has significantly regulated the use of pesticides in agriculture over the last ten years and adapted it to European legislation.

The aim of this paper is to point out the importance of the pesticide market for the development of sustainable agricultural production in Serbia. The paper consists of three parts. The first part of the paper emphasizes the importance of the development of the sustainable agricultural production market in Serbia. The second part of the paper analyzes the pesticide market in Serbia, while the third part analyzes the case of the herbicide market. At the end, the concluding considerations of the author are given.

Keywords: market, pesticides, development, sustainable agricultural production, Serbia.

INTRODUCTION

Sustainable agricultural production has the task of preventing the degradation of natural resources, while at the same time bringing high yields and income to agricultural producers. This aims to reduce negative impacts on the environment, preserve the quality of natural resources, develop the agricultural market, increase profitability due to the production of quality products, which affects socio-economic development. Sustainable agriculture increases agricultural productivity and profitability while ensuring a sustainable food supply, reducing pollution and other negative effects, as well as restoring and more efficient use of environmental resources (water, air, soil and biodiversity, etc.). The development of sustainable agricultural production, and therefore its market, is one of the goals of the sustainable development of the Republic of Serbia.

At the same time, it is necessary to point out the importance of the pesticide market for the development of sustainable agricultural production in the Republic of Serbia. Herbicides represent about 60% of the global pesticide market. Simple application, and high efficiency in suppressing weeds, made herbicides an indispensable segment of almost all crop cultivation technologies in modern agricultural production. Constant applications have led to a dramatic increase in resistant weed populations. The growth of resistant weed species and the commercialization of herbicide active substances, with new mechanisms of action, point to the fact that chemical weed control is in a challenging period.

For soil conservation, indirect weed control measures are certainly agrotechnical, such as: crop rotation, tillage, sowing of certified seeds, sowing time and sowing density, properly cared for manure, use of clean machinery in the fields. In the protection of plants, there are also biological measures that include the use of beneficial microorganisms or products of their metabolism and the use of plant extracts and essential oils that have a herbicidal effect. The biological method of protection applied alone is not enough to solve the problem of the presence of undesirable organisms in crops, but in combination with other methods (crop rotation, application of organic fertilizers, soil cultivation) it gives satisfactory results.

The aim of the paper is to indicate the importance of the pesticide market for the development of sustainable agricultural production in the Republic of Serbia. The first part is based on the development of the sustainable agricultural production market in Serbia. The second part of the paper examines the pesticide market in Serbia, while the third part examines the case of the herbicide market.

DEVELOPMENT OF THE SUSTAINABLE AGRICULTURAL PRODUCTION MARKET IN SERBIA

Sustainable agriculture implies the preservation of soil, water, plant and animal resources (Subić et al. 2017), which is technically applicable, economically profitable and socially acceptable (Ristić, 2013). The term sustainable agricultural development, appeared as a response to changes in the practice and policy of agricultural development on a global scale, which relate to the necessity for agricultural systems to survive for as long as possible while producing the required amount of food (Vujičić et al., 2006). Sustainable agriculture increases agricultural productivity and profitability, while ensuring sustainable food supply, reducing pollution and other negative effects, as well as restoring and more efficient use of ecological resources (water, air, soil and biodiversity, etc.) (Brdarić, 2022). Also, it affects the creation of an integrated system of

plant and livestock production practices, which will in the long term: meet people's needs for food, improve the quality of the environment and natural resources on which the agricultural economy depends, enable the efficient use of non-renewable and renewable resources and enable the development of natural biological cycles, maintain the economic value of production, and improve the quality of life of agricultural producers and society as a whole (Lazić, Šeremešić, 2010). FAO (2016) points to five key principles of sustainable agriculture:

- Improvement of efficiency in the use of resources,
- Preservation, protection and improvement of natural ecosystems,
- Protection and improvement of rural life and social prosperity,
- Increasing the resilience of people, communities and ecosystems,
- Promotion of rational management of natural and social systems.

The term sustainable agricultural development itself can be formulated differently (Buller, Hoggart, 2001; Vujičić et al., 2006):

- For agronomists, sustainable development is the desire for the green revolution to come to life and rise to a higher level, where sustainability is equated with sufficient food, and sustainable agriculture must use all means to achieve this goal.
- For ecologists, sustainable agriculture represents a way to ensure sufficient food and a link that contributes to the preservation of natural resources (forests, soil, biodiversity), i.e. the preservation of the environment.
- For economists, sustainability is one of the elements to increase efficiency, in the long term, by using scarce resources in such a way that there will be them for future generations.
- For sociologists, sustainability is a reflection of social values, that is, a development path that is in accordance with traditional culture and institutions.

Therefore, the key concepts and principles of sustainability in agriculture can be related to the following bases (Table 01).

Table 01: Concepts and principles of sustainability in agriculture

CONCEPTS	PRINCIPLES
High, efficient and stable production	Respecting the possibilities of the land (purposeful use)
A fusion of modern technology with traditional knowledge	Soil conservation (maintaining soil productivity, as well as curbing erosion)
Ensuring a sufficient amount of food	Using rainwater (key to soil production and conservation)
Conservation of biological diversity	Preservation of plantation areas
Preservation of traditional values and small family farms	Promoting cooperation between technical staff and the local community
Assistance to the poor and vulnerable	Adoption of practices that result in increased yields and allow soil and water conservation
High level of participation of farmers in making development decisions	

Source: Buller, Hoggart, 2001.

Conventional agricultural production has turned into an industrial form of outdoor production, the main problem of which is its energy inefficiency, due to the use of large amounts of energy, intensive processing, large amounts of synthetic fertilizers and plant protection agents, GMOs, hormones and antibiotics. This led to a series of negative impacts on the entire ecosystem and human health, and the need for drastic changes in agricultural production was imposed (Cvijanović et al., 2013a; Kumar et al., 2017). Hence the need to find new systems of food production in a sustainable way (Parfitt et al., 2010; Wezel et al., 2014).

Observing agriculture in the form of its multifunctionality, it is concluded that sustainable agriculture represents a rounded system of production, distribution and consumption of food and by-products. Within the framework of sustainable agriculture, three systems of agricultural production stand out, which are the most represented in a practical sense: good agricultural practice, integral and organic agriculture, and which are necessary for inclusion in the market.

Sustainable agriculture refers to the application of agricultural practices and technologies, which increase agricultural productivity and profitability, while ensuring a sustainable food supply, reducing pollution and other negative effects, as well as restoring and more efficiently using environmental resources (water, air, soil and biodiversity, etc.) (Santiteerakul et al., 2020). It follows that sustainable agriculture is the way of agricultural development, which is ecologically non-degrading, technologically appropriate, economically sustainable and socially acceptable (Siebrecht. 2020).

This method of production defines the goals of sustainable agriculture: the application of modified agrotechnical measures in the form of correcting mechanization, the introduction of biological means for plant nutrition in accordance with the maintenance of soil fertility, the type of crops grown and production technology, which promote the circulation of matter and the flow of energy, promoting the health care of the rural population, saving energy resources by favoring renewable sources and protecting and increasing biodiversity (Lykogianni et al., 2021; Midler, 2022).

A key component of sustainable agriculture is healthy and high-quality soil, the management of which preserves its physical, chemical and microbiological properties. Also, Cvijanović et al., (2013b) state that the constantly growing requirements for the consumption of health-safe food promote the expansion of sustainable agricultural production.

ANALYSIS OF THE PESTICIDE MARKET IN THE REPUBLIC OF SERBIA

The importance of the pesticide market, as means of plant protection, is extremely important for the development of sustainable agricultural production in the Republic of Serbia. Means for plant protection are most often divided according to purpose, i.e. type of harmful organism on which they act. Three groups are most represented in this division:

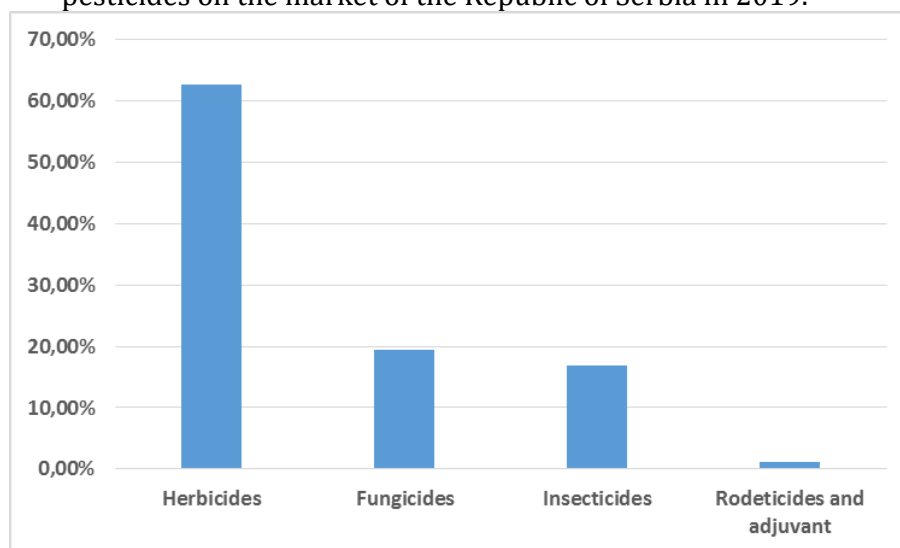
1. herbicides - pesticides intended for the control of herbaceous and woody weeds, algae, mosses, lichens and parasitic flowers.
2. fungicides - pesticides intended for controlling fungi and bacteria that cause plant diseases.
3. insecticides - pesticides intended for controlling harmful insects.

Divisions of pesticides, which are much less represented, such as acaricides (intended to control harmful mites), limacides (intended to control snails), rodenticides (intended to control harmful rodents), growth regulators (agents for regulating plant growth), wetting agents (substances that reduce surface voltage between the preparation and the plant), improve foliar wetting and distribution of the preparation, which improves the effectiveness of the active substance from the preparation and its penetration into the plant (Carolyn et al., 2013). Selling pesticides on the market within the production, wholesale and consumption of pesticides is very important, and the following division of the pesticide market is indicated:

1. pesticide production market (herbicides, fungicides and insecticides);
2. herbicide wholesale market;
3. fungicide wholesale market;
4. insecticide wholesale market

The total sale of pesticides (taking into account herbicides, fungicides, insecticides, rodenticides and wetting agents) on the market of the Republic of Serbia in 2019 is as follows: only 1.2% of pesticides (in quantity) refers to the sale of rodenticides and wetting agents, while the largest percentage is sales for herbicides 62.7%, fungicides 19.4% and insecticides 16.8%. These values of the sale of assets are kept at an approximate ratio on the territory of the Republic of Serbia from year to year and are constantly increasing. Graph 1 shows the structure of pesticide sales according to product groups on the market of the Republic of Serbia.

Chart 01. Percentage representation by product category in the total sale of pesticides on the market of the Republic of Serbia in 2019.



Source: <http://www.kzk.gov.rs/kzk/wp-content/uploads/2020/08/Agromarket-resenje-anonimizirana-elektronska-verzija.pdf>

On the Serbian market, the sale of generic pesticides (copies of original pesticides) is dominant. Domestic manufacturers and distributors of plant protection products with a significant market share in the Republic of Serbia include Galenika Fitofarmacija, Chemical Agrosava, Savakoop, Agromarket, Župa, Agroarm, etc.

Some of the largest foreign manufacturers and distributors of plant protection agents present in the territory of the Republic of Serbia are: Adama, Syngenta, BASF, Vauer, and multinational companies Belchim Crop Protection, Corteva, Agrimatco, Kite have been also present in a much smaller share of the pesticide market in the Republic of Serbia, etc.

The creation of the pesticide market in the Republic of Serbia is characterized by great competition, in which domestic and foreign producers, importers and distributors of pesticides participate with their plant protection products. The main determinant of competitiveness on the market of the Republic of Serbia is certainly the sales range of products. A significant number of domestic producers/importers/distributors of pesticides have in their portfolio (the list of products offered for sale) the products of world-famous multinational companies, which were listed earlier. In order to match the offer of multinational companies (lower prices of products-generic pesticides), domestic producers/importers/distributors are often forced to have products from well-known global pesticide manufacturers in their sales range.

The pesticide market is at a high level of transparency, given the absence of significant entry barriers in the pesticide production and wholesale market, as well as the absence of exclusive distribution rights, by individual sellers, in the observed market. In addition, pesticides from large multinational companies are often innovative (patent protected), which means that in this case, in some segments, they have no competition during the defined time period of the patent protection, when these products are exclusively offered on the market. Pesticide prices on the territory of the Republic of Serbia, compared to foreign markets, are on average lower, so it can be said that the pesticide market in the Republic of Serbia is characterized by intense competition.

Pesticides of domestic producers and pesticides of multinational companies, which are present on the market of the Republic of Serbia, are at a similar price level within the observed category of pesticides. Starting from 2017, when 16,864 tons of pesticides were sold on the territory of the Republic of Serbia, then in 2018, 17,229 tons of pesticides and in 2019, 18,564 tons of pesticides.

ANALYSIS OF THE HERBICIDE MARKET IN THE REPUBLIC OF SERBIA

Weeds contribute the most to yield loss and reduced crop product quality in an agricultural system. Weeds compete with the crop for resources such as light, water and nutrients. The use of herbicides is the most effective means of controlling weeds, because it is cheaper, more reliable and saves labor and time, compared to other weed control measures.

Herbicides are the most dominant group of pesticides on the market, in the world and in the Republic of Serbia. Herbicides are chemical or biological agents for controlling weeds. The use of these agents must be correct in order to obtain satisfactory results and to preserve the environment. Herbicides are the most dominant group of pesticides in terms of consumption by agricultural producers (about 63% of total sales of pesticides refer to sales of herbicides). The size of the herbicide wholesale market for the year 2017 is 9,469 tons, for the year 2018 it is 9,982 tons and for the year 2019 it is 11,774 tons. The wholesale market of herbicides is constantly growing, both for herbicides produced in the Republic of Serbia and for imported herbicides.

Since the emergence of herbicides in the fifties of the last century, they have been constantly commercialized every few years, so the number of new herbicides on the market has been constantly growing. There are different applications of herbicides in order to control weed species, trees and bushes of different sizes. The application of soil herbicides dominated the global herbicide market, with a percentage share of 48.8% in 2022 (Bonanno et al., 2017).

Pre-emergence herbicides can be applied through soil treatment as a direct soil treatment. By reducing weed pressure early, crops can thrive strongly during the growing season. By applying different active substances and at the correct time of application, soil herbicides can contribute more effectively in the fight against problematic weed species and slow down the development of weed resistance to herbicides (Powles et al., 1997). Herbicides for foliar application are represented by about 29.8% of the global herbicide market in 2022. In the agricultural sector, the use of herbicides optimizes crop productivity and increases overall profitability. The increasing ability of different weed genotypes to adapt to different environments and develop resistance to herbicides leads to greater application of herbicides (Frisvold and Ervin 2016). Global average herbicide consumption per hectare increased by 44.4% over the historical period, from 1.8 kg/ha in 2017 to 2.6 kg/ha in 2022.

The herbicide market size is estimated at USD 31.5 billion in 2022. The herbicide industry is projected to grow from USD 33.39 billion in 2023 to USD 53.21 billion by 2032, exhibiting a compound annual growth rate (CAGR) of 6.00% during the forecast period (2023 - 2032). Increasing desire for higher crop yields, rapid adoption of better farming techniques, new farming technologies and scarcity of fertile land are the key drivers of the market as they propel the growth of the market⁶.

CONCLUSION

The concept of sustainable development is impossible without sustainable agricultural production, which tends to reduce negative impacts on the environment, preserve the quality of natural resources, develop the agricultural market, increase profitability due to the production of quality products, which affects socio-economic development. Sustainable agriculture represents a rounded system of production, distribution and consumption of food and by-products, within which three systems of agricultural production stand out: good agricultural practice, integral and organic agriculture, which are necessary for inclusion in the market. Combining chemical and non-chemical measures, with a good knowledge of weed biology and ecology, can ensure weed control and crop yield preservation, and the herbicide industry itself needs to produce new herbicides and technology to improve agricultural production. There is an increasing desire to expand organic production and preserve the environment, which has led to the development of a special group of biopesticides. Biopesticides are obtained from natural materials such as microorganisms (fungi, bacteria, viruses...), plant (plant extracts) and animal life (nematodes...) and some minerals. The main characteristics of biopesticides are less toxicity, they are effective against the targeted harmful organism, they are fast are broken down and have no residual action, and the resistance of the target harmful organisms to them has not been established for now.

⁶ More about it at <https://www.marketresearchfuture.com/reports/herbicides-market-4853>

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THE OWLS OF SERBIA: DISTRIBUTIONS, GLOBAL THREATS, AND CONSERVATION STATUS AT EUROPEAN AND NATIONAL LEVELS

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ABSTRACT

Owls play an important role in the environment by controlling small animal populations. Because mammals are their primary prey, this can be especially beneficial to humans by reducing the amount of food lost to rodents. Ten species of owls nest in Serbia: common barn owl (*Tyto alba*), Eurasian pygmy owl (*Glaucidium passerinum*), little owl (*Athene noctua*), boreal owl (*Aegolius funereus*), Eurasian scops owl (*Otus scops*), northern long-eared owl (*Asio otus*), short-eared owl (*Asio flammeus*), tawny owl (*Strix aluco*), Ural owl (*Strix uralensis*), and Eurasian eagle-owl (*Bubo bubo*). This paper provides an overview of the Serbian owls' distribution, threats, endangerment, and conservation status at the national and European levels. The IUCN Red List database and data from the European Birds of Conservation Concern publication were used to analyze the population status, conservation status, and threats at the European level. When it comes to the analysis of the conservation status at the national level, the Rulebook on the Proclamation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Mushrooms of the Republic of Serbia was used. The distribution of owls on the territory of Serbia was analyzed based on existing scientific publications and available websites. All Serbian owls are categorized as "Least Concern" at the European level. In Serbia, one species is decreasing, one is stable, two are increasing, one is fluctuating, and the population status of others is unknown (no data). All of them are listed as strictly protected species on the national level. The threats that affect the largest number of Serbian owls at the European level are "Agricultural & forestry effluents". Understanding the distributions, global threats, and conservation status of owls in Serbia is crucial for implementing effective conservation strategies both at the European and national levels.

Keywords: owls, Serbia, Europe, threats, conservation.

INTRODUCTION

Owls belong to the Strigiformes order of birds, which has over 200 species, most of which are solitary and nocturnal hunters (Abd Rabou, 2020). These birds are distinguished by their upright posture, large, broad heads, binocular vision, binaural hearing, sharp talons, and silent flying feathers. The diurnal northern hawk owl and the gregarious burrowing owl are two exceptions (Soni, 2022). The two families of owls are the barn-owl family (Tytonidae) and the true (or typical) owl family (Strigidae). Although the precise placement is debatable, recent phylogenetic studies place owls within the clade Telluraves, which is most closely related to the Accipitriformes and the Coraciiformes (Gilbert et al., 2018; Houde et al., 2019).

Owls have large forward-facing eyes and ear holes, a flat face, and usually, a conspicuous circle of feathers around each eye, called a facial disc, which can be adjusted to sharply focus sounds from varying distances onto the owls' asymmetrically placed ear cavities (Sieradzki, 2022). While most birds of prey have eyes on the sides of their heads, owls' forward-facing eyes are stereoscopic, allowing them to perceive depth better than most other birds, especially when hunting in low light (Martin, 2014). Due to their farsightedness, owls are unable to see objects that are closer than a few centimeters from their eyes (Murphy & Howland, 1983). Owls use their filoplumes, or hair-like feathers on their feet and beaks, to act as "feelers" to sense the prey they have caught (Soni, 2022). They have a perfect far vision, especially in low light (Sieradzki, 2022).

As birds of prey, owls depend on killing other animals to survive. Invertebrates (insects, spiders, earthworms, snails, and crabs), fish, amphibians, reptiles, birds, and small mammals comprise their diet (Sieradzki, 2022). The species of owl mostly determines the primary diet. For example, whereas barn owls primarily eat mice, shrews, and voles (Charter et al., 2009), scops, and screech owls eat insects (Motta-Junior, 2002; Latková et al., 2012). Bigger owls, like the eagle owl, will eat hares, juvenile foxes, and birds as big as gamebirds and ducks (Sándor & Ionescu, 2009). Certain species, like African fishing owls and Asian fish-owls, have specialized in fishing (Slaght & Surmach, 2008). While some owl species have specific preferences regarding food types, most owls are opportunistic and will eat any available prey (Allen et al., 2019).

Since most owls hunt during the night, they are nocturnal animals (Wood et al., 2021). Many owl species are crepuscular, meaning they are active in the twilight hours of dawn and dusk (Lisney et al., 2012). The northern pygmy owl (*Glaucidium gnoma*) is one such species (Frye & Jageman, 2012). A few owls are also active during the day; the short-eared owl (*Asio flammeus*) and the burrowing owl (*Speotyto cunicularia*) are two such species (Calladine et al., 2010; Scobie et al., 2014). Stealth and surprise are key components of the owls' hunting strategy. Owls can become stealthy thanks to at least two adaptations. First, in some situations, their feathers' dull color can make them nearly invisible. Second, owls' flight is almost silent due to the serrated edges on their remiges' leading edges, which dampen wingbeats. An owl can kill its prey with its powerful talons and sharp beak, then swallow it whole (assuming it's not too big). Owls generally have a hunting territory away from their daytime roost (Duncan, 2003).

Except for Antarctica and some isolated islands, owls are found throughout the entire world. They are regarded as cosmopolitan animals as a result. Despite their wide range, owls are primarily found in tropical regions. Within their range of distribution, less than 10% of species exhibit migratory behaviors, although some alter their habitat for seasonal reasons (Duncan, 2003).

Owls play an important role in the environment by controlling small animal populations. Because mammals are their primary prey, this can be especially beneficial to humans by reducing the amount of food lost to rodents. Owl conservation will not only improve rodent control, averting massive crop losses, but it will also stop the use of chemicals without purpose, protecting ecological diversity.

Ten species of owls nest in Serbia: common barn owl – *Tyto alba* (Scopoli, 1769), Eurasian pygmy owl – *Glaucidium passerinum* (Linnaeus, 1758), little owl – *Athene noctua* (Scopoli, 1769), boreal owl – *Aegolius funereus* (Linnaeus, 1758), Eurasian scops owl – *Otus scops* (Linnaeus, 1758), northern long-eared owl – *Asio otus* (Linnaeus, 1758), short-eared owl – *Asio flammeus* (Pontoppidan, 1763), tawny owl – *Strix aluco* (Linnaeus, 1758), Ural owl – *Strix uralensis* (Pallas, 1771), and Eurasian eagle-owl – *Bubo bubo* (Linnaeus, 1758) (Rašajski, 2017).

This paper provides an overview of the Serbian owls' distribution, threats, endangerment, and conservation status at the national and European levels.

MATERIALS AND METHODS OF WORK

The IUCN Red List database (2024) and data from the *European Birds of Conservation Concern* publication (BirdLife International, 2017) were used to analyze the population status, conservation status, and threats at the European level. The IUCN Red List database and data from the *European Birds of Conservation Concern* publication were used to analyze the population status, conservation status, and threats at the European level. When it comes to the analysis of the conservation status at the national level, the *Rulebook on the Proclamation and Protection of Strictly Protected and Protected Wild Species of Plants, Animals, and Mushrooms of the Republic of Serbia* (Republic of Serbia, 2016) was used. The distribution of owls on the territory of Serbia was analyzed based on existing scientific publications and available websites.

RESULTS

Distributions in Serbia. The distribution pattern of owls in Serbia varies among species (Table 1). Some are mostly found in Vojvodina (*T. alba*, *A. noctua*, *A. flammeus*), while others occur more frequently south of the Sava and Danube rivers (*G. passerinum*, *O. scops*, *A. funereus*). Some species, such as the long-eared owl (*A. otus*), have a wide distribution, while some are limited to only a few localities where they nest (*G. passerinum*, *A. funereus*, *S. uralensis*).

Table 1. Information on the representation and distribution of owls in Serbia (according to Rašajski, 2017)

Species	Distribution in Serbia
<i>Tyto alba</i>	common in populated areas, especially in Vojvodina
<i>Glaucidium passerinum</i>	very rare, it breeds in only three locations in southwestern Serbia
<i>Athene noctua</i>	very common, especially in Vojvodina
<i>Aegolius funereus</i>	very rare, can only be found in southwestern Serbia
<i>Otus scops</i>	frequent, especially south of the Sava and Danube
<i>Asio otus</i>	the most common of all; most of the breeding population is in Vojvodina
<i>Asio flammeus</i>	very rare, most common in Bačka and Banat
<i>Strix aluco</i>	frequent nester of old forests and plains
<i>Strix uralensis</i>	rare nesting bird in several localities in Banat, southwestern and eastern Serbia
<i>Bubo bubo</i>	few in Central Serbia, very rare in Vojvodina

Population statuses and trends. According to BirdLife International (2017), of all the species of owls that live in Serbia, the little owl (*A. noctua*) has the largest

population in Europe (618.000-1.170.000 breeding pairs, while the Eurasian eagle-owl (*B. bubo*) has the smallest one (18.500-30.300 breeding pairs) (Fig. 1a). For Serbia, there are only estimates of the population sizes for those species that belong to one of the SPEC categories (Fig. 1b). Among them, the population of the short-eared owl (*S. aluco*) is the least numerous (0-45 breeding pairs), while the Eurasian scops owl (*O. scops*) has the largest population in Serbia (26.000-41.000 breeding pairs).

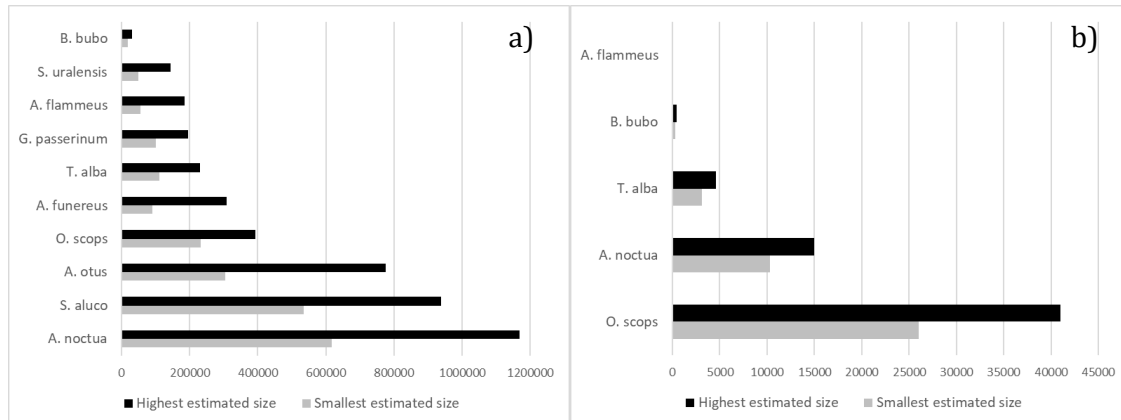


Figure 1. Population sizes of owl species in Europe (a) and Serbia (b), expressed through the number of breeding pairs (according to BirdLife International, 2017)

According to the IUCN Red List (2024), owls that occur in Serbia have different population trends in Europe. The only species whose population is estimated to be in decline is the common barn owl (*T. alba*), while the Eurasian pygmy owl (*G. passerinum*), boreal owl (*A. funereus*), Eurasian scops owl (*O. scops*), short-eared owl (*A. flammeus*), tawny owl (*S. aluco*), have stable populations in Europe. The Ural owl (*S. uralensis*) and Eurasian eagle-owl (*B. bubo*) have increasing populations. For other species, population trends in Europe are not known. According to *European Birds of Conservation Concern* (Table *European Population Sizes and Trends*), three species have fluctuating populations (*T. alba*, *A. funereus*, *A. flammeus*), two are stable (*G. passerinum*, *A. noctua*), and two have increasing populations in Europe (*S. uralensis*, *B. bubo*), while for the rest these data are unknown or uncertain. In Serbia, one species is decreasing (*T. alba*), one is stable (*A. noctua*), two are increasing (*O. scops*, *B. bubo*), one is fluctuating (*A. flammeus*), and the population status of others is unknown (no data) (BirdLife International, 2017) (Table 2).

Table 2. Assessment of population trends of owl species in Europe and Serbia (according to IUCN Red List, 2024 and BirdLife International, 2017)

Species	Population trend according to:		
	IUCN Red List at the European level	European Birds of Conservation Concern – breeding in Europe	European Birds of Conservation Concern – in Serbia
<i>Tyto alba</i>	decreasing	fluctuating	decrease
<i>Glaucidium passerinum</i>	stable	stable	no data
<i>Athene noctua</i>	unknown	stable	stable
<i>Aegolius funereus</i>	stable	fluctuating	no data
<i>Otus scops</i>	stable	uncertain	increase
<i>Asio otus</i>	unknown	unknown	no data
<i>Asio flammeus</i>	stable	fluctuating	fluctuating
<i>Strix aluco</i>	stable	uncertain	no data
<i>Strix uralensis</i>	increasing	increasing	no data
<i>Bubo bubo</i>	increasing	increasing	increase

Endangerment and conservation status. All Serbian owls are categorized as “Least Concern” at the European level according to the IUCN Red List. Out of the ten species, five are included in Annex I of the Council Directive 2009/147/EC – *EU Birds Directive* (*G. passerinum*, *A. funereus*, *A. flammeus*, *S. uralensis*, *B. bubo*) (European Union, 2009), and all ten are included in Annex II of the *Berne Convention on the Conservation of European Wildlife and Natural Habitats* (Council of Europe, 1979). According to BirdLife International (2017), one species is classified as SPEC 2, four species are classified as SPEC 3, and the remaining species are designated as non-SEC. All Serbian owls are listed as strictly protected species on the national level (Republic of Serbia, 2016).

Threats. According to the IUCN Red List, the threats that affect the largest number of Serbian owls at the European level are “Agricultural & forestry effluents”. Other threats affecting a larger number of Serbian owls are “Roads & railroads”, “Annual & perennial non-timber crops”, “Hunting & trapping terrestrial animals” etc. The species affected by the largest number of threats is the short-eared owl (*A. flammeus*) (Table 3).

Table 3. Threats affecting Serbian owls in Europe (according to IUCN Red List)

Threat	<i>A. flammeus</i>	<i>B. bubo</i>	<i>A. otus</i>	<i>A. noctua</i>	<i>G. passerinum</i>	<i>O. scops</i>	<i>S. aluco</i>	<i>T. alba</i>	<i>A. funereus</i>	<i>S. uralensis</i>
Agricultural & forestry effluents	+	+	+	+		+	+	+	+	
Roads & railroads	+	+		+		+	+	+		
Annual & perennial non-timber crops	+		+	+		+		+		
Hunting & trapping terrestrial animals	+	+	+			+	+			
Problematic native species/diseases			+		+		+			+
Housing & urban areas	+					+		+		
Problematic species/diseases of unknown origin					+	+			+	
Wood & pulp plantations									+	+
Utility & service lines		+					+			
Commercial & industrial areas				+						
Tourism & recreation areas	+									
Livestock farming & ranching	+									
Renewable energy	+									
Logging & wood harvesting					+					
Recreational activities		+								
Dams & water management/use	+									
Invasive non-native/alien species/diseases	+									
Viral/prion-induced diseases		+								
Air-borne pollutants					+					
Temperature extremes				+						
Storms & flooding					+					

DISCUSSION

The distribution patterns of owls in Serbia exhibit a degree of variability across species, reflecting the diverse ecological landscapes and habitats present within the country. This reveals distinct regional preferences among different owl species, highlighting the importance of understanding local ecological factors in shaping their distributions. The diverse distribution patterns observed among owl species in Serbia underscore the importance of comprehensive conservation planning at both European and national levels. By identifying regional hotspots of owl diversity and understanding the ecological requirements of each species, conservation initiatives can be optimized to mitigate threats and preserve these iconic birds of prey for future generations.

The species that have the smallest range in Serbia or that nest in the smallest number of localities are *G. passerinum*, *A. funereus*, *A. flammeus*, and *S. uralensis* (Rašajski, 2017), so for this reason these species should be given special conservation attention.

The population sizes and distributions of owl species in Serbia play a crucial role in understanding their conservation status both at the national and European levels. BirdLife International's data highlight significant disparities in population sizes among owl species, with the little owl (*A. noctua*) boasting the largest population in Europe. With an estimated 618,000 to 1,170,000 breeding pairs, the little owl's abundance underscores its importance as a widespread and relatively common species within the European owl community. Conversely, the Eurasian eagle-owl (*B. bubo*) exhibits the smallest population size in Europe, with only 18,500 to 30,300 breeding pairs, but it should be borne in mind that the population of this species is increasing in Europe (IUCN Red List, 2024; BirdLife International, 2017). At the national level, there are varying population estimates for owl species in Serbia, but only for those falling under specific conservation categories according to BirdLife International (2017). Among these species, the short-eared owl (*A. flammeus*) emerges as the least numerous, with an estimated population ranging from 0 to 45 breeding pairs. This low population size raises concerns about the species' vulnerability to local and global threats, highlighting the urgent need for conservation measures aimed at enhancing their breeding success and habitat protection. In contrast, the Eurasian scops owl (*O. scops*) exhibits the largest population in Serbia, with estimates ranging from 26,000 to 41,000 breeding pairs. This relatively high population size suggests a favorable conservation status for the species within Serbian territories, but also the existence of suitable habitats and ecological conditions.

Comparing the data from the IUCN Red List website (2024) and BirdLife International (2017), certain differences can be observed when it comes to the population trends of owls in Europe, but both sources state that *S. uralensis* and *B. bubo* have increasing populations, while *G. passerinum* has a stable population. The only species that one source (the IUCN Red List) states has a declining population is *T. alba*, while BirdLife International (2017) states that it has a fluctuating population. BirdLife International (2017) states that the population of this species in Serbia is in decline.

According to the IUCN Red List, agricultural and forestry effluents emerge as the most pervasive threat affecting many owl species in Serbia at the European level. The runoff of pollutants from agricultural and forestry activities poses serious risks to owl habitats, water quality, and prey availability, thereby compromising their overall reproductive success and survival. Addressing the root causes of agricultural and forestry effluents through sustainable land management practices and pollution mitigation measures is imperative to mitigate their adverse impacts on owl populations.

Roads and railroads constitute another prominent threat to Serbian owls, exacerbating habitat fragmentation, collision mortality, and disturbance. The expansion of transportation infrastructure often leads to habitat loss and isolation, limiting the dispersal and movement of owl populations and increasing their susceptibility to other threats. Additionally, the conversion of natural habitats for annual and perennial non-timber crops poses a significant threat to owl populations in Serbia. The conversion of forests, grasslands, and wetlands into agricultural landscapes disrupt nesting sites, foraging grounds, and prey availability for owls, leading to declines in population abundance and reproductive success.

Moreover, hunting and trapping of terrestrial animals represent a direct threat to owl populations in Serbia, particularly through incidental capture, disturbance, and persecution. Overexploitation of prey species and illegal hunting practices can disrupt food webs and prey-predator dynamics, posing long-term threats to owl populations.

Based on the endangerment and conservation status at the European and national level, no differences can be observed between the Serbian owls, i.e., none of them can be singled out as more endangered than the others, considering that they are all classified in the category of "Least Concern" (IUCN Red List, 2024), that is, in the category of strictly endangered species at the national level (Republic of Serbia, 2016). Only five of the ten species are included in Annex I of the *Birds Directive* (European Union, 2009). However, it must be borne in mind that, even though some of the species are not included in the annexes of the Directive, all of them are covered by the general protection regime provided by Article 1 of the Directive to all species of birds naturally occurring in the wild state in the European territory of the member states to which the treaty applies. All species are included in Annex II of the *Berne Convention*, i.e. according to this convention, all species of Strigiformes are strictly protected species (Council of Europe, 1979).

According to BirdLife International (2017), *O. scops* is categorized as SPEC 2, i.e. as a "species whose global population is concentrated in Europe, and which is classified as Regionally Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened, Declining, Depleted or Rare at European level". *T. alba*, *A. noctua*, *A. flammeus*, and *B. bubo* are classified as SPEC 3, i.e. as a "species whose global population is not concentrated in Europe, but which is classified as Regionally Extinct, Critically Endangered, Endangered, Vulnerable, Near Threatened, Declining, Depleted or Rare at European level". The term "species whose global population is not concentrated in Europe, and whose European population status is currently considered to be Secure" refers to other species that are classified as Non-SPEC. These data also do not indicate which species in Serbia is in the greatest endangerment.

If several parameters discussed in this paper (distribution, number of nesting sites, population status and trend, number of threats affecting the species) are taken into account, the short-eared owl (*A. flammeus*) can be designated as the most endangered owl in Serbia. This species in Serbia is a rare and irregular resident bird that breeds in several localities in Vojvodina, in habitats such as swamps, wet meadows with tall grass, and salt marshes (Rašajski. 2017). These wetlands are also highly threatened, which can be a key issue when it comes to the conservation of this species. In addition, this species is affected by a large number of threats at the European level, the most of all Serbian owls. It is particularly worrisome that all the threats mentioned when it comes to Serbia are most pronounced in Vojvodina. Although the population of this species in Serbia is not declining, but fluctuating, it can still be worrying, given the very low number of breeding pairs in Serbia. However, the distribution of this species in Eurasia is such that the northern parts of Serbia represent the peripheral parts of its range, so its low population and small distribution in this country are expected.

A species that can also be distinguished from the others is the barn owl (*T. alba*), considering that it is the only species that, according to BirdLife International (2017), is the only one with a declining population in Serbia. However, this owl is still a numerous nester in Serbia, which is adapted to live in populated areas, suburban settlements, farms, etc. It also nests in a large number of locations, not only in Vojvodina but also south of the Sava and Danube rivers (Rašajski, 2017).

Other species that should also be singled out are *G. passerinum*, *A. funereus*, and *S. uralensis*, due to the small number of localities where they nest, as well as *B. bubo*, due to the relatively low population, although it, as in the case of *T. alba*, is at a good level compared to the European populations.

CONCLUSIONS

The analysis of owl populations in Serbia, encompassing their distributions, population sizes, threats, and conservation status at European and national levels, provides valuable insights into the challenges and opportunities for owl conservation in the region. Our study highlights the need for targeted conservation efforts to mitigate threats and preserve the diverse owl species inhabiting Serbian landscapes. The distribution patterns of owls in Serbia reveal distinct regional preferences among different species, emphasizing the importance of understanding local ecological factors in shaping their distributions. Conservation planning must consider these variations to effectively protect owl populations across different habitats and landscapes. Population size estimates and trends underscore the conservation significance of owl species in Serbia, with some species exhibiting stable populations while others face declining or fluctuating trends. Special attention should be given to species with small ranges or nesting sites, such as the short-eared owl (*A. flammeus*), which faces numerous threats and relies on threatened wetland habitats in Vojvodina.

In conclusion, the conservation of owl populations in Serbia requires a holistic approach that integrates scientific research, policy interventions, and community engagement to address the complex interplay of ecological, socio-economic, and conservation challenges. By prioritizing conservation efforts and implementing targeted measures, we can ensure the preservation of these charismatic birds of prey and their habitats for future generations to appreciate and enjoy.

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Economics and Management

INTEGRATING SUSTAINABLE SUPPLY CHAIN PRACTICES FOR SOCIAL HOUSING DEVELOPMENT: A QUALITATIVE STUDY OF JOHANNESBURG, TEMBISA

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ABSTRACT

Investigation conducted in Tembisa, focusing on the relationship between sustainable supply chain management (SSCM), social housing projects, and environmental conservation. With urbanization rapidly expanding and the demand for affordable housing escalating, Tembisa stands at a critical point where supply chain management practices are of utmost importance. Through in-depth interviews with industry professionals in social housing and supply chain management namely contractors, and housing officials, with focus group discussions with community members, this study aims to uncover strategies that integrate sustainability practices in social housing projects.

The research reveals the relationships between sustainable supply chain practices and social housing development. It identifies the adoption of materials that are friendly to the environment. Furthermore, the study emphasizes the significance of collaborative efforts involving diverse stakeholders which are, private enterprises, and local communities within Tembisa, in driving sustainable supply chain practices in social housing projects.

Key findings emphasize the need for comprehensive approaches that consider economic, social, and environmental factors in the formulation and implementation of supply chain practices in social housing projects. The research highlights the importance of policy frameworks that incentivize sustainability practices stakeholder engagement namely Housing officials, and community-driven approaches that empower residents and cultivate a sense of ownership. The insights gained from this study offer actionable recommendations for stakeholders involved in supply chain practices and social housing projects encouraging change in thinking towards inclusive, equitable, and environmentally conscious supply chain practices. By addressing the challenges of social housing and environmental protection.

Keywords: Sustainable supply chain management, Social housing, Environmental preservation, Qualitative data, Tembisa.

INTRODUCTION

According to Mpingana et al. (2022) urbanization has been a global trend for decades, and with it comes an increased demand for affordable housing, particularly in developing countries. South Africa, like many other countries, faces challenges of urban expansion and housing shortages, with areas like Tembisa, a township situated in the northeastern part of Johannesburg, demonstrating these challenges. Tembisa is a predominantly black township, which emerged during the apartheid era because of forced removals and racial segregation policies, and it has since grown into one of South Africa's largest townships, home to a 551,119 thousand population (Morole et al., 2023).

Significance of Study

The significance of this study lies in its potential to address pressing issues related to urbanization, affordable housing, and environmental sustainability in contexts shaped by historical injustices and ongoing socioeconomic disparities. Tembisa, as a rapidly growing urban township in Johannesburg with a population of 551,119 thousand has surged over the years, driven by factors such as rural-to-urban migration, population growth, and the legacy of apartheid policies that limited housing options for black South Africans (Botha, 2021).

Despite its vibrant community and entrepreneurial spirit, Tembisa faces a socio-economic challenge, which is inadequate housing (Parnell & Pieterse, 2016). The demand for affordable housing far outweighs the available supply, leading to overcrowding, informal settlements, and a strain on existing infrastructure (Makapela & Tanga, 2022; Seipobi, 2021). In this context, the integration of sustainable supply chain practices holds immense potential to address the housing needs of the population.

Study Objectives

The primary objectives of this study are:

1. *To identify the key factors influencing the adoption of sustainable supply chain practices in the context of social housing development in Tembisa: This objective examines the specific challenges and opportunities faced by stakeholders involved in social housing projects in Tembisa.*
2. *To assess the impact of sustainable supply chain on environmental conservation and social housing within Tembisa's housing projects: This involves evaluating the outcomes of sustainable supply chain initiatives in terms of their environmental, social, and economic dimensions.*

With these objectives, the study aims to contribute to the advancement of sustainable development in social housing in Tembisa.

LITERATURE REVIEW

Urban expansion has led to burgeoning housing demands, particularly in townships like Tembisa. With social and environmental challenges, this literature review aims to delve deeply into the complex relationship between sustainable supply chain practices, social housing development, and environmental preservation, elucidating the various factors at play and offering practical and actionable insights for policymakers and practitioners.

Vela (2021) explains that Sustainable supply chain practices represent a critical strategic imperative in tackling the urgent housing demands of rapidly expanding urban populations while simultaneously addressing environmental concerns. At the core of this principle then lies the incorporation of environmentally friendly materials.

Mashaba (2020) states that In Tembisa, the integration of sustainable supply chain practices is of heightened significance. The township's historical underinvestment and systemic socio-economic factors make it necessary to shift more to an inclusive and sustainable development model (Mahlaba, 2021). By leveraging sustainable supply chain practices, Tembisa can not only address its social housing challenges but also foster economic resilience within the township (Ndevu & Gumbo, 2022).

Furthermore Ballard et al. (2021) address the social factor of sustainability highlighting the importance of ethical labor standards within supply chain management. Fair wages, safe working conditions, and opportunities for skills development not only enhance employee well-being but also contribute to broader social equity objectives. By prioritizing the welfare of workers involved in social housing construction projects, Tembisa can foster a more inclusive and equitable development, by empowering marginalized employees and fostering social cohesion (Du Plessis, 2023).

According to Cheruiyot (2024) the full potential of sustainable supply chain practices necessitates collaborative partnerships among diverse stakeholders. play a critical role in shaping regulatory frameworks and policy frameworks that promote sustainability within supply chain management. Amoah et al. (2021). Further expound that instituting green procurement policies, providing financial incentives for sustainable construction practices, and enforcing environmental regulations, can create an enabling environment for sustainable development practices to thrive.

Private sectors such as developers, contractors, and suppliers, wield considerable influence over supply chain management and are instrumental in driving sustainable practices. By integrating sustainability into procurement processes, adopting green building standards, and investing in renewable energy solutions, private sector institutions can catalyze broader transformations within the construction industry (Amoah et al., 2020). Moreover, by engaging in multi-stakeholder initiatives and partnerships, private sector actors can leverage collective expertise and resources to address complex sustainability challenges collaboratively (Scheba et al., 2021).

Mahlangu (2022) notes that civil society organizations and local communities serve as critical factors for change, advocating for inclusive and sustainable development results. Through community-driven projects and participatory planning processes, civil society organizations can amplify the voices of marginalized communities and hold stakeholders accountable for their social and environmental responsibilities. By fostering partnerships between the private sector and the public sector.

In conclusion, this literature review has provided an exploration of the intricate interplay between sustainable supply chain practices, social housing development, and environmental preservation. By elucidating the link between sustainable supply chains and social housing initiatives, as well as highlighting the imperative of collaborative partnerships in driving sustainability.

MATERIAL AND METHODS OF WORK

In this study, a qualitative research approach was employed to explore the integration of sustainable supply chain practices for social housing development in Tembisa, South Africa. The research design was crafted to align with the objectives outlined in the introduction, focusing on uncovering strategies for integrating sustainability principles and examining the relationships among sustainable practices and housing development.

The data collection process involved two primary methods in-depth interviews and

focus group discussions. Industry professionals (contractors and housing officials) engaged in social housing development, supply chain management, and environmental conservation were interviewed to gain insights into existing practices, challenges, and opportunities for integrating sustainability. Additionally, focus group discussions were conducted with community members residing in Tembisa to capture diverse perspectives on social, economic, and environmental aspects of social housing.

Purposive sampling was utilized to select industry professionals with expertise in sustainable supply chain management and social housing, ensuring representation from various stakeholder groups. Meanwhile, convenience sampling was employed to select community members from different neighborhoods within Tembisa, facilitating a broad spectrum of perspectives on housing and environmental concerns.

Upon completion of data collection, thematic analysis was performed on transcribed interviews and focus group discussions. This involved identifying recurring patterns, themes, and relationships related to sustainable supply chain practices, social housing, and environmental preservation. Additionally, thematic analysis was conducted to compare perspectives among different stakeholder groups, facilitating a comprehensive understanding of the research. Ethical considerations were critical throughout the research process. Informed consent was obtained from all participants, ensuring their voluntary participation and confidentiality of shared information. Anonymity and confidentiality measures were implemented to safeguard participants' identities and privacy during data analysis and reporting.

RESULTS AND DISCUSSION

In-depth interviews and focus group discussions were conducted to integrate the sustainable supply chain practices for social housing development in Tembisa. The study aimed to uncover strategies for integration and explore the relationships among sustainable practices, social housing development, and environmental conservation.

Responses from contractors on the Integration of Sustainable Supply Chain Practices for Social Housing Development:

Table 1

Question	Respondent 1	Respondent 2	Respondent 3
What measures have your organization taken to incorporate sustainability principles into social housing development projects?	"We use a strategy of implementing a comprehensive sustainability policy that includes using eco-friendly building materials, optimizing energy efficiency, and promoting waste reduction."	"We source sustainable materials and implement green building certifications to ensure adherence to sustainability standards."	"We use eco-friendly materials and prioritize community engagement and social inclusion in our housing projects to foster sustainable development."
How do you ensure that sustainable supply chain practices are integrated into your procurement processes?	"We have developed supplier sustainability criteria and conduct regular audits to evaluate suppliers' environmental and ethical practices."	"Our procurement team collaborates closely with sustainability experts to identify suppliers that align with our organization's sustainability goals."	"Through supplier training programs, we educate our suppliers on sustainable practices and encourage them to adopt environmentally friendly approaches."
Can you provide examples of specific eco-friendly materials or technologies your organization has used in recent housing projects?	"Our organization has incorporated solar panels, rainwater harvesting systems, and low-flow water fixtures to reduce energy and water consumption in housing developments."	"We have utilized recycled steel, reclaimed wood, and energy-efficient insulation materials to minimize environmental impact."	"We prioritize the use of locally sourced materials such as sustainably sourced bricks and flooring, for the benefit of the environment."

Responses from Housing officials on the Relationships Among Sustainable Practices, Housing Development, and Environmental Conservation:

Table 2

Question	Respondent 1	Respondent 2	Respondent 3
How do you perceive the link between sustainable supply chain practices and environmental conservation in the context of social housing development?	"By prioritizing sustainability in housing development, it can assist to mitigate environmental degradation, and conserve natural resources, ultimately promoting environmental sustainability."	"The integration of sustainable supply chain practices fosters a symbiotic relationship between social housing development and environmental conservation, creating win-win solutions that benefit both communities and the environment."	"Sustainable supply chain practices, such as using eco-friendly materials directly contribute to environmental conservation efforts by reducing resource consumption and minimizing pollution"
Can you share examples of how sustainable housing development initiatives have positively impacted the local environment in Tembisa?	"Through the implementation of green infrastructure such as permeable pavements and rain gardens, sustainable housing projects have reduced stormwater runoff, improving local environmental conditions."	"By incorporating energy-efficient building designs and renewable energy technologies, sustainable housing developments in Tembisa have reduced greenhouse gas emissions and contributed to mitigating climate change."	"Sustainable housing initiatives have led to improved air and water quality, and enhanced biodiversity in Tembisa, creating healthier and more livable communities for residents"
How do you involve residents and communities in environmental conservation efforts related to housing development projects?	"By fostering partnerships with local community organizations, schools, and youth groups, we empower residents to take ownership of environmental conservation efforts and actively participate in tree planting, recycling, and clean-up activities"	"Through collaborative decision-making processes and community-led projects, we ensure that residents have a voice in shaping environmental policies and practices related to housing development projects, resulting in a sense of ownership over their environment"	"We engage residents through community outreach programs, environmental education initiatives, and participatory planning processes to raise awareness about environmental issues and involve them in conservation efforts related to housing development projects"

Focus groups with local community members respondents:

Table 3

Question	Respondent 1	Respondent 2	Respondent 3
. In your opinion, what are the most pressing environmental challenges facing social housing developments in Tembisa, and how can they be addressed?	"The biggest problem is having too much trash laying around We can fix this by sending by requesting the local municipality to send service delivery trucks to collect trash."	"The issue is not having enough water; I think this can be addressed by the local municipality by inspecting the water infrastructure."	"The problem is. electricity cuts. We can fix this by reducing the impact of electricity cuts to assist with the problem".
What role do you think sustainable housing development plays in mitigating the effects of climate change and promoting resilience in vulnerable communities?	"Making homes that are kind to nature helps us when the weather gets bad because of climate change. It would be good to make homes that can handle the weather, even when it's bad."	"Sustainable housing can also save us money on electricity and water bills, which is important Plus, if our houses are stronger and safer, we can worry less about getting displaced when bad things happen."	"I think sustainable housing helps with climate change by using things like solar power and recycled materials, which reduces pollution and saves energy. And for vulnerable communities, it means we're less likely to lose our homes in disasters like floods or storms."
What partnerships and collaborations are essential for advancing environmental conservation goals in social housing development projects?	"Partnerships with local environmental groups could be helpful. They could advise on things like using eco-friendly materials".	"Companies have programs to support communities and the environment. reaching out to see if they're interested in partnering with sustainable housing projects. "	"Partnerships with environmental groups, universities, and even big companies could help make housing projects eco-friendlier and more sustainable."

Thematic analysis

Theme 1: Integration of Sustainable Practices in Social Housing Development

One prominent theme that emerged from the data is the integration of sustainable practices in social housing development. Respondents highlighted various measures taken by organizations to incorporate sustainability principles into their projects. For example, Respondent 1 mentioned implementing a comprehensive sustainability policy that includes using eco-friendly building materials, optimizing energy efficiency, and promoting waste reduction. This demonstrates a commitment to environmentally conscious practices in social housing development.

Moreover, examples of specific materials that are friendly to the environment and technologies used in recent projects were provided, such as solar panels, rainwater harvesting systems, and low-flow water fixtures to reduce energy and water consumption. Respondent 2 mentioned utilizing recycled steel, reclaimed wood, and energy-efficient insulation materials to minimize environmental impact. These examples showcase the tangible ways in which sustainable practices are being integrated into social housing projects.

Theme 2: Link Between Sustainable Practices and Environmental Conservation

Another key theme that arose is the link between sustainable practices and environmental conservation in the context of social housing development. Respondents emphasized the importance of prioritizing sustainability to mitigate environmental issues and conserve natural resources. For instance, respondent 3 highlighted that sustainable supply chain practices directly contribute to environmental conservation efforts by reducing resource consumption and minimizing pollution.

Furthermore, examples of how sustainable housing development projects have positively impacted the local environment in Tembisa were shared. These include the reduction of stormwater runoff through green infrastructure, the decrease in greenhouse gas emissions through energy-efficient designs, and the improvement of air quality. These examples illustrate the tangible benefits of integrating sustainable practices into housing development for environmental preservation.

Theme 3: Community Engagement in Environmental Conservation Efforts

A significant theme that emerged is the involvement of residents and communities in environmental preservation efforts related to housing development projects. Respondents emphasized the importance of engaging residents through partnerships, education initiatives, and participatory planning processes. Respondent 1 mentioned empowering residents to take ownership of conservation efforts through activities like tree planting, recycling, and clean-up activities.

Additionally, collaborative decision-making processes were highlighted to ensure that residents have a voice in shaping environmental policies and practices related to housing development projects. This theme underscores the importance of community engagement in promoting sustainable practices and environmental preservation in social housing development.

Overall, the themes of integration of sustainable practices, the link between sustainable practices and environmental conservation, and community engagement in environmental conservation efforts are central to understanding the dynamics of sustainable supply chain practices for social housing development in Tembisa. These themes highlight the different approaches required to achieve sustainable and environmentally conscious housing development in Tembisa.

Discussion

The findings of this study offer significant insights into the integration of sustainable supply chain practices within the context of social housing development in Tembisa and explore the relationships among these practices, housing initiatives, and environmental conservation efforts. Through the qualitative data presented the study aimed to accomplish two primary objectives: firstly, to understand the strategies necessary for the seamless integration of sustainable supply chain practices into social housing projects, and secondly, to unravel the link between these sustainable practices, housing development, and environmental preservation.

Objective 1: Uncover Strategies for Integration

In pursuit of the first objective, the study's exploration into the strategies that were essential for integrating sustainable supply chain practices revealed various approaches undertaken by industry professionals namely contractors and housing officials. These strategies encompassed the utilization of eco-friendly materials, optimization of energy efficiency measures, and the reduction of waste. Moreover, the study analyzed the critical role of partnerships and collaborations with local communities and stakeholders to ensure the longevity and efficiency of sustainability within social housing projects. However, the study also highlighted the challenges preventing the full-scale implementation of these strategies.

Objective 2: Understand the Relationships Among Sustainable Practices, Housing Development, and Environmental Conservation

The second objective aimed to elaborate on the relationships among sustainable practices, social housing development, and environmental conservation. The insights gained from focus group discussions provided a detailed understanding of the perceived

linkage between sustainable supply chain practices and environmental preservation. Participants acknowledged the importance of utilizing environmentally friendly materials and implementing measures in energy-saving in social housing development to uphold environmental conservation.

CONCLUSIONS

In conclusion, this study has provided valuable insights into the integration of sustainable supply chain practices in social housing development within the context of Tembisa, South Africa. Through qualitative inquiry, the study aimed to uncover strategies for integration and understand the relationships among sustainable practices, housing development, and environmental conservation.

The findings highlighted several key strategies for integrating sustainable practices, including the utilization of eco-friendly materials, optimization of energy efficiency, and fostering partnerships with local communities and stakeholders. However, challenges such as higher upfront costs and limited accessibility of eco-friendly materials underscored the need for innovative solutions and collaborative efforts to overcome barriers to implementation.

Moreover, the study elucidated the perceived link between sustainable practices and environmental conservation, with participants acknowledging the importance of eco-friendly materials and energy-saving measures in housing development projects. Additionally, the positive impact of sustainable housing initiatives on local environmental conditions was recognized, including improvements in air quality and reductions in waste generation.

Critical analysis revealed areas necessitating further exploration, including the broader social and economic dimensions of sustainability and the complexities of stakeholder engagement within sustainable housing projects. Future research endeavors should aim to address these gaps and foster inclusive, equitable, and environmentally conscious approaches to social housing development.

Overall, this study contributes to advancing sustainable development agendas in South Africa by providing actionable recommendations for policymakers, practitioners, and stakeholders involved in social housing projects. By addressing the challenges of housing development and environmental protection, this research advocates for a shift towards inclusive, equitable, and environmentally conscious supply chain practices in Tembisa and beyond.

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DEVELOPMENT OF PROJECT IDEA AS A FUNCTION OF ECOLOGICAL INNOVATIONS

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ABSTRACT

Inventions represent big requests and challenges in front of every organisation and individual that are operating in constantly shifting ecological surroundings. If the ecological organisation does not innovate and create, it cannot progress, and eventually lacks business success. So, in order to innovate and create, there has to be invention as an ecological idea and novelty that hasn't come on the market. Unless there is no realisation in industry and environmental protection of an invention as a solution to a certain problem, invention will remain just an eco-idea. It is often the case that good ecological ideas doesn't get on the market place, because the innovator himself cannot represent adequately his idea and acquire financial means so he could implement the innovation and start the manufacturing. Sometimes the best technological ideas are not on the market because they are not cost effective, regardless of the fact that they are technologically better than the existing ones. Project ecological ideas can be represented by promotional activities, by engaging human resources and financial means in the direction of transforming eco-ideas in ecological innovations and the final product, for completing the goal of protection of the environment. The purpose of the work is to represented the way to transform conceptual solutions to ecological innovation, not depending on the means of financing ecological projects and the fact on what ecological innovation should specifically do. The methodology of the work represents a theoretical overview of the collected data, obtained on the basis of previous research.

Keywords: Ecology, Innovation, Project.

INTRODUCTION

Entrepreneurship cannot even be imagined without innovation, because it represents the basis for the realization of profitable production or service business activities. Entrepreneurship - an innovative process of creating and developing business ventures or activities and creating business success in a changing environment. Entrepreneurship is an original business that is created by finding market potentials and solving sales problems in a better way than has been applied so far. All attention must be directed towards consumers and their demands. The success of an entrepreneurial project lies in a good assessment of market opportunities. Companies that develop an entrepreneurial business concept should accept changes and leave the status quo position that stagnates the company and lags behind the competition, should encourage innovative business ideas that are compatible with the company's potential and accept the level of risk.

Because an important fact stands: the consequence of productive entrepreneurship is economic growth and for entrepreneurship to be productive, it must be innovative!

Innovation represents a specific tool of entrepreneurs, a means by which they use change as an opportunity to perform various production or service activities.

According to numerous authors, like Sener et al. (2017) and Mohamed et al. (2022), the definition of innovation is different. Innovation (lat. *Inovatio* - means introducing something new) is the process of introducing an invention and its application. It is the process of materializing an invention through a new product, technological procedure or means of production. Also, a popular definition is that innovation is the successful exploitation of new ideas. It can also be defined as the process of converting new ideas into commercial success on the market. According to Stocka et al. (2017) innovation is a process in which new ideas are transformed through economic activity into a sustainable result with certain values.

The simplest recognized model of innovation is the straight-line model (Figure 1), although the process itself is much more complex. Various researches and creativity lead to an invention (invention), which also represents an idea. In order for an idea to be brought to innovation, it must go through various developments and designs to be acceptable and marketable.



Figure 1. The straight-line model of innovation development (Source: OTA, 2021.)

Innovations can be divided into: administrative, organizational, financial, technological, marketing, social innovations... Based on the criteria of technological changes, innovations can be divided into: introduction of new products or new qualities of old products, introduction of new production processes, conquest and expansion new markets, development of new sources of supply of inputs, changes in industrial organization.

Innovations come in different shapes and forms. When it comes to innovation management, its importance is reflected in two things. The ability to pick up signals that herald change and the willingness to make certain changes and leave the old ones behind. That is, the most important task is knowledge management - development and building of skills in a certain area, adaptation and adoption of new and different knowledge, leaving outdated as unnecessary.

The difference between improving and perfecting existing product designs and introducing a new concept that departs significantly from the old practice is one of the key subjects of studying the management of new technologies and innovations (Figure 2).

The connection between key concepts and components	Changed	Incremental innovation	Modular innovations
	Unchanged	Architectural innovations	Radical innovations
		Strengthened	Rejected
		Key concepts	

Figure 2. Framework for defining innovations (Source: Henderson, Clark, 2020)

Incremental innovations introduce relatively small changes to existing products, take advantage of existing designs, and often reinforce the dominance of existing firms. Although they are not the result of radically new technological knowledge and scientific breakthroughs, they have significant economic consequences over time.

Radical innovations are based on a completely different set of technological and scientific principles and often open up the possibility of developing new markets and applications altogether. Radical innovations often create problems and difficulties for already existing companies, but they can also become the basis for the successful entry of new companies or for the redefinition of business activity.

Radical and incremental innovations have very different impacts on the competitive profile of business activity and require different organizational capabilities. Organizational capabilities are difficult to create, and their adaptation is expensive. Incremental innovations enhance the capabilities of existing organizations, while radical innovations require new capabilities that allow answering new questions, developing new technological scientific knowledge and skills, and developing and applying new approaches to problem solving.

The difference between radical and incremental innovations has a significant impact on a firm's competitive profile, but is not sufficient to fully explain innovation activity. There are many examples of technological innovations that resulted in small changes in existing technologies, but had a significant, even dramatic, impact on competitiveness.

Architectural innovations are innovations that change the way product components are connected together, while keeping the core product design concept and core knowledge contained in the components intact. This renders the firm's architectural knowledge useless, but not the product's component knowledge.

There are two more types of innovation according to the previously mentioned criteria. Innovations that change key product design concepts while leaving the relationships between key concepts and components unchanged are modular innovations.

Such is, for example, replacing analog with digital phones where, to the extent possible, analog with digital components are replaced with changes to the key concept, without changing the product architecture.

Eco-innovation represents a prerequisite to developing ecological organizations and industry as a whole in environmental protection. It is more important for the companies how much they will earn on ecological innovations, than the environmental protection itself, because the innovations have to be economical and cost-effective. The innovation process leads to increasing competitive advantage and recognizability, as well as economic growth. Without constant innovations growth is impossible, because the business subjects that do not innovate cannot adapt to constant changes on the market, and keep operating in the same manner, while other business entities meet market needs in a new and more advanced way.

Every ecological innovation has phases which do not require significant funds and that is mainly in phases in which there is exploration of possibilities and there is only engagement of people and time resources. After that phase some ecological innovations don't need additional funds especially in service industries where they improve the way services are delivered or where there are improvements in work organisation. Nevertheless the majority of ecological organisations require significant financial funds and quite a long time span for transforming invention into innovation. That is why the project approach is a necessity for transforming inventions into innovation, and the innovative organisation return the invested funds into research and development and make profit.

If we take for example a room fan for air. It was a large, electric device, mounted on the ceiling (or mobile), with an engine that was hidden from view and with insulation from noise, in which *incremental innovations* were related to improving the design of the propeller or the power of the engine. Switching to central air conditioning is a *radical innovation*. New components such as compressors, chillers and corresponding control mechanisms require new technological know-how and new mutual relationships. For manufacturers of large ceiling-mounted room fans, the introduction of portable fans is an *architectural innovation*.

EMERGENCE OF ECOLOGICAL INNOVATIONS IN BUSINESS

Ecological innovations in modern business conditions represent a significant aspect of the business of every business company and the economy as a whole. Innovation is a special weapon for achieving competitive advantage and the way in which changes are used as opportunities for new jobs. The variety of definitions of eco-innovation manifests itself in heterogeneous terms and concepts. Environmental innovation, eco-innovation, green innovation, and sustainable innovation or sustainability-oriented innovation are just some of the terms used by researchers (Pichlak et al. 2021). Eco-innovation is not just about ideas. The conventional approach to business often implies that the business idea and concept have already been identified, and that the main job is to develop a business plan in order to implement it. However, the big problem is the identification, evaluation and processing of the idea, as well as its development into a business concept. This has a huge impact on the application of creativity and the transfer of ideas into ecological innovations. The initial idea may require a significant creative leap, but a bigger part of the process involves hundreds of research operations and problem-solving operations, each of which requires a creative approach. While the beginning requires the skills and inspiration of a given individual, later the contribution of many people over a period of time is important (Ernst & Young, 2006).

Creative results don't just come as a result of what is currently in the person himself; it is influenced by time, other people, places, surroundings, specific knowledge and strategies that people can use as individuals or in groups. Hence, no one is, in the absolute sense, primarily more or less creative. Creativity should not be seen as something that is fixed and static, it rises and falls in accordance with combinations of numerous factors.

Idea as such is not and cannot be innovation. Idea for a new solution, for improvement of existing products or services, is not an innovation until it reaches the market, and doesn't become accepted by the consumers and gains some market advantage. Invention precedes innovation. Invention is a new solution or improvement of something that is existing on the market, but that is not accepted by the market. In order for invention to be accepted there are numerous preconditions and actions that need to be taken.

Coming up to ideas and solutions

The level of education of innovators does not separate them from other scientists and engineers. Potential educated innovators have a significant tendency to achieve higher levels of productivity compared to their lower level of education counterparts. Numerous models of the creative process can be helpful to those who need to engage in innovation. A validated and practical process for testing how to come up with an idea involves three main phases (Morris, H., 2005):

- Understanding the opportunity - involves systematic effort to define, construct or formulate problems,
- Gathering ideas - involves gathering options and answers for open representations about the problem. Gathering ideas consists of a phase of gathering and focusing on the problem,
- Action planning - is appropriate when a person or group recognizes a number of interesting or promising options that are not necessary and successful, appreciated or useful. This phase includes two components: solution development and acceptance.

Although techniques to support creative strategic decisions and problem solving can be learned and taught, they are best suited for solving real life problems. For a problem to be interesting it must be real. The problem becomes real only when it involves emotions or attachment, intellectual and cognitive abilities, personal frameworks and resources. Those who carry the problem must also have some influence, authority, and responsibility for making decisions to implement the solution. It also means that the problem bearer is motivated and willing to give in to the challenge of systematic solving and must be interested in carrying out the process to the very results. Finally, investigation and solutions must involve imagination.

From idea to success – intellectual property, the key to business success

Intellectual property is a term used to describe various types of innovation, mental activity, and creative or artistic endeavor. Intellectual property can be in intangible form, such as knowledge and know-how developed from research and experience, or it is in tangible form that includes inventions and patents. Patents are widely known as intellectual property, but also as many other things, such as secret sales, copyrights, trademarks, service marks, which also represent intellectual property.

Intellectual property, whether owned or possessed, is something that has control over use. As for the value of control, the type of intellectual property must be understood through its breadth. In order to have real value, intellectual property must have commercial value and must involve an adequate exclusive right to give the business a competitive advantage (Berman, B., 2002).

A common method of intellectual property protection developed for new products and services is through the use of patents. The patent system has been set up by governments to encourage innovation by protecting investors' interests. The patent system helps to secure the exclusive rights of inventors, for a time, in exchange for disclosing the invention to the public. In case of not acquiring a patent system, a large number of technologies would be kept secret and hidden from the public. The patent system also helps spreading information about new technologies, which helps to promote innovation.

When starting a business, a large number of people think that a good idea is the basis for good business. These "genius" ideas generally remain just ideas that, if realized, allow for earnings in modest figures, without any knowledge or experience of the field in which that "genius" idea is to be realized. In order to be a successful innovator you need (Slater, R., 2003):

- Knowledge - what are the needs of the market, what technologies are needed to realize the idea, some activities, etc.,
- The innovator himself - his experience, passion, perseverance, perseverance, work, etc.,
- Idea - dream, goal, untapped market opportunities.

Nobody can know for certain what market conditions in means of technology and market requirements can be expected in the future. For that reason there are various experiments (that include many failures) and fast learning through numerous players and new ventures (Bessant, J., Tidd, J., 2007).

PROJECTS IN FUNCTION OF ECO-INNOVATIONS

Defining project activities is a complex job (Pyzdek, T., 2003). It consists of a number of executions that need to be decomposed into individual activities. Several important things are crucial in the project (Verzuh, E., 2003):

- project team - when the project starts and ends, the project team is formed and disappears with the project. The more unique the projects, the more difficult it is to establish an appropriate team, with an adequate combination of skills;
- budgeting - it is difficult to find a source of funding for a project, especially for something that is new, untested and unproven on the market;
- authority - the unique nature of the project means that the line of vertical authority is more significant than the norms on the project;
- assessment - when a new project is established, deadlines and budget are set, and the return on investment is expected. Projects consist of a number of variables, so it is difficult to assess the certainty of their success;
- communication - projects that require cooperative, concentrated efforts, cross-functional project teams must organize good communication channels for each project.

Project management (managing projects) is a skill and science of routing and coordinating given resources in the life-span of a project while using modern techniques and methods in order to accomplish planned objectives in terms of scope, costs, deadlines, quality and satisfaction of participants in the process of project realization. (Kuriş et al., 2000).

Innovator and eco-projects

Innovators are usually persons that possess high technical abilities, that are narrow specialized for the field in which they are doing business. Often a good ecological idea never becomes innovation because the innovator himself cannot find a way to acquire funds to start the execution of the idea, and doesn't have the way to make the new solution come on the market.

It is best if the innovator himself, more precisely the person who has a good ecological-technical solution to a problem, comes into contact with people who are familiar with economic trends and ways of putting the eco-idea on the market. Just putting an eco-idea on the market requires making a business plan, which requires a detailed description of the eco-idea, what that idea gives that is better in terms of what it was until then, as well as a detailed financial plan.

The project has a beginning and an end, it is time-limited and a team is formed in accordance with the requirements of the project. Eco-innovation is a new, improved application of what already exists in the market. Starting a project based on an eco-idea that has not yet been proven can be a big risk in the market. For that reason, it is significantly good to plan all the steps of the project that supports the invention in order to prevent the failure of the eco-idea, giving the fact that a large number of eco-ideas keep staying just that, ideas.

Characteristics of projects that are based on ecological innovations

Technology and eco-innovations are significant for every economy because they are the key factor of increasing productivity through development of new products and services, creation of comparative advantages and environmental protection.

Based on the technological diversity, there is a need for green technology innovation that can reduce the environmental impacts of non-renewable energy technologies (Wang et al. 2022). Some of the innovations are free and those are mainly the one which are based on the innovations of organizational structures, ways of conducting activities in the service sector etc. But, a large number of eco-innovations need investments and financial support. While there is a search for innovations, it is necessary to engage people and make time, it is probably that later would be needed additional funds that have to be invested for the sake of putting eco-innovations on the market. When an organisation concludes to do investments in eco-innovation, it is necessary to direct all the resources on only one eco-idea, because there can come to dissipation of available resources.

When the management of the company decides that the idea is good that it should be turned into an ecological innovation, which will achieve a market advantage and protection of the environment, the development of the project begins. The project consists of several phases:

1. Formation of project team,
2. Deciding about the individual activities,
3. Deadline for completion of phases of every activity,

4. Determining financial resources for each activity,
5. Determining the achieved results of each activity.

When it is judged that environmental invention is something that can succeed in the market, it is necessary to determine human resources, as the drivers of all activities within the project. It is best when the project team includes the innovator himself or a group of people who worked on the eco-invention. They should be involved in the project as experts in technical areas, while it is good to appoint experts in the field of management and finance for the project managers and financial managers, who in cooperation with the persons who came to the eco-invention, should determine individual activities and perform them on time while monitoring the financial resources needed for their implementation.

The five main priorities of eco-innovation are:

1. Material for recycling and recycling (all forms of waste)
2. Sustainable construction products (reduction of resource consumption)
3. Food and beverage sector (new packaging within the production and consumption of food and beverages)
4. Water - efficiency, treatment, distribution (in order to save water)
5. Green business (green production)

The activities within the project that are planned, and which concern ecological innovation, must contain certain steps that are very different from the steps that are planned in everyday business. Activities should consist of: forming teams for creating a technical solution of the eco-idea, their education, research and market segmentation on which the new product or service will be placed, finding ways to promote a new environmental technical solution and service, and finding distribution channels. The activity of promotion and finding distribution channels, i.e. the way in which the new product will reach consumers, represents a key moment after testing and production of an ecologically innovative solution. It often happens that an ingenious eco-idea begins its journey to reach consumers, but is not adequately promoted or distributed, leaving imitators the opportunity to achieve business success (in high technology, many do not know that Xerox invented the earliest prototype of the personal computer, the mouse and click computer. Everyone just remembers the companies that did the best job, like Apple).

Each activity must have its beginning and end, some activities will intertwine, some will begin when the previous one is over, some will begin at the same time. As these are a large number of activities, it is recommended to monitor them with the help of Gantt charts. Also, activities and their execution can be monitored in the MS Project program for monitoring the execution of project activities or a similar project that allows you to monitor the execution of activities. It is extremely important that activities are coordinated and carried out on time, because otherwise the eco-idea itself, although good, can be doomed to failure, and the financial resources invested in it can never be compensated.

What is a challenge for management is getting financial resources for the invention. Since this is something that is new, that does not yet exist on the market, so it does not make a market profit, external sources of financing must often be found. Another challenge is the risk that eco-innovation carries with it.

If the production of an ecological technical solution starts, or human resources are hired for a service, it is not certain that this innovation will be accepted on the market, so the risk of losing the investment is higher than in a business that has already been developed and already has its own market.

Sources of financing can be various family finances, microfinance programs, loans, etc. However, if someone who is an innovator and eco-idea wants to place on the market, but does not have their own funds or does not have the conditions to obtain a loan, it is good to apply for certain grants that are given under various projects in the country and abroad for funding innovation.

In a project that supports the development of an eco-idea, it is more important than in a project that does not bring a novelty that the control of activities is done constantly. This is due to the fact that there are no tried and tested production processes, and the formed teams and individuals who are their members, do not have experience and routine, but work in a new way for them and for the team as a whole. The methods of promotion and distribution channels have not been proven to be successful, but they have yet to confirm their justification. For that reason, there is a high probability of error and the necessity of changing in certain directions of the planned activities.

CONCLUSION

Modern business and economic conditions are characterized by numerous challenges that are posed to both economic organizations and individuals. It is certainly important to introduce innovations in business in all economic branches, to meet the needs in a new way, better than the previous one. Numerous innovations appear as a result of eliminating the challenges of modern society (ways of solving environmental problems, better use of non-renewable resources, etc.).

Regardless of how the eco-idea was created, whether by research to find a better technical solution, in conversation with experts, as a result of creative work or in some other way, it poses challenges that require a complex set of activities to the eco-idea itself came to life on the market. The project is a successful way to place an eco-idea on the market and achieve success.

Innovators should be involved with technical solutions of eco-innovations and they should participate in technical execution of ideas. The remaining activities of the process should be given to experts for planning, organization, finances, control and the rest of the functions that are providing successful placement of innovation on the market. Depending on the complexity of the innovative process, rounding of technical solution innovators with the rest of business functions of eco-inventions can be turned into eco-innovation with project activity. In that way our economy can get near to the completion of strategy for smart, sustainable and inclusive growth, which in the programme for competition and innovativity involves sub-programs for: entrepreneurship and innovativity, for support to the politics of information-communications technology and Programme of Intelligent Energy for Europe.

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CONTRIBUTION TO RURAL DEVELOPMENT THROUGH IMPROVING THE COMPETITIVENESS OF AGRICULTURAL HOUSEHOLDS IN SERBIA

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ABSTRACT

In recent decades, the development of rural areas represents a great challenge and importance for the economic development of the Republic of Serbia. Agricultural households as part of the economic system by improving competitiveness represent a contribution to rural development, because by reducing migration (rural-urban) agriculture is improved, competitiveness problems are reduced, and domestic products are placed on the market.

Improving the competitiveness of the agricultural household can be achieved through the transparent action of supply and demand on the market, that is, through the identification of potential, work and infrastructure, and their integration into the agricultural production system. In this way, the agricultural household is included in the economic system, migration from rural areas is stopped, rural areas are improved, the profit base is raised, costs are reduced, agricultural production is standardized, and the quantity and quality of production and products are improved.

The aim of the paper is to show that improving the competitiveness of the agricultural household contributes to rural development in the Republic of Serbia. In addition to the introduction and conclusion, the paper consists of three parts. The first part of the paper identifies the agricultural household and indicates the potentials and problems of competitiveness. The second part of the paper indicates the importance of information for improving the competitiveness of the agricultural household, while the third part emphasizes the importance of standardization of the quality and quantity of production in the agricultural household.

Keywords: rural development, competitiveness, agriculture, Serbia.

INTRODUCTION

Rural development represents a challenge and importance for the economic development of the Republic of Serbia. Agricultural households, by improving their competitiveness, represent a contribution to rural development, which can be achieved through the transparent action of supply and demand on the market. By including the agricultural household in the economic system, migration from rural areas is stopped, which results in improving the rural environment, raising the profit base, reducing costs, standardizing agricultural production, improving the quantity and quality of production and the products themselves.

The importance of information is one of the essential parts of the agricultural household's competitiveness and is of great importance for its growth and development. Through the good flow of information nowadays, through the Internet, websites and social networks, agricultural households could in the fastest and easiest way become familiar with all the protocols, laws, advancement opportunities, novelties in production, subsidies and many other opportunities that could contribute to competitiveness on the market and thus to the development of rural areas. On the other hand, the standardization of quality and quantity is a very important segment in the operation of the agricultural household. The production environment changes from year to year, from day to day. It is necessary to follow technology and the market, so households can be introduced to the world of new technologies and all current events without much trouble. The questions are where is the potential of the household, i.e. how much is it, how to use it, improve it and market it.

The aim of the paper is to point out the importance of improving the competitiveness of the agricultural household, which contributes to rural development in the Republic of Serbia. The first part of the paper identifies the agricultural household and indicates the potentials and problems of competitiveness, while the second part of the paper indicates the importance of information for improving the competitiveness of the agricultural household. The third part emphasizes the importance of standardization of quality and quantity of production in the agricultural household.

COMPETITIVENESS OF AGRICULTURAL HOUSEHOLDS

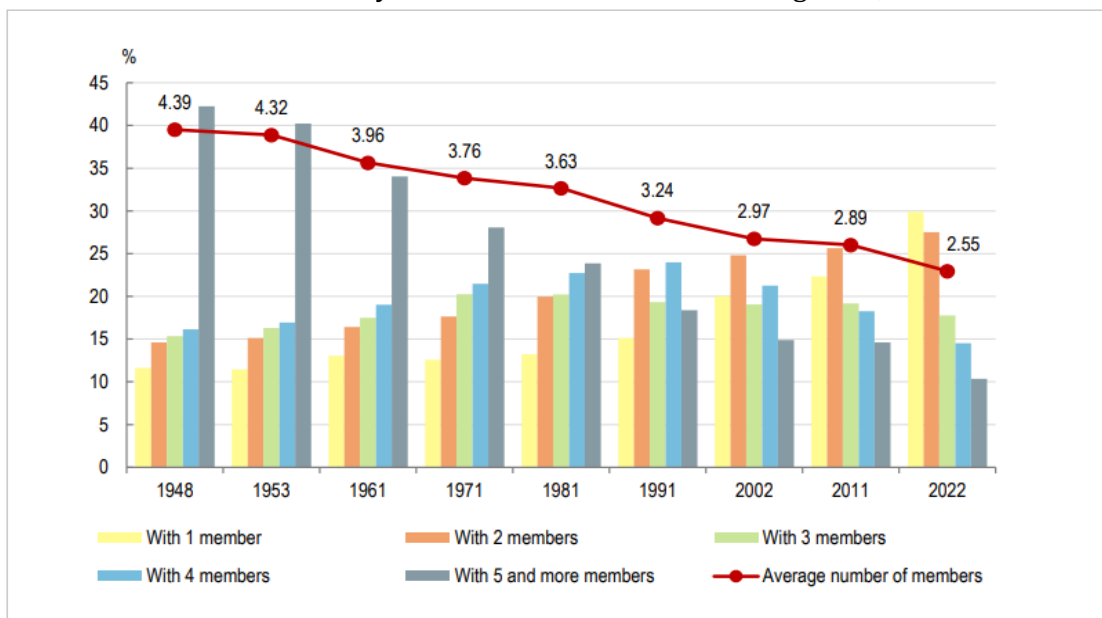
Rural development implies the process of improvement, opportunities and well-being of the rural population, which in addition to agricultural development, includes human development and social, ecological and economic goals (IPBES, 2024). Rural areas have unused economic potential and can be used for national development and the development of the rural population (Ignjatović, Đorđević, 2023). The dynamics of rural development are influenced by age structure, educational structure, social status and lifestyle (Faculty of Agriculture, Novi Sad, 2020). Rural areas can be seen as landscapes of exceptional value, ecological oases, fortresses of traditional culture and ethno-cultural heritage (Šljukić, Janković, 2015).

Also, rural areas are faced with the need to take advantage of new opportunities (which are not easy to recognize) and require determination, creativity and a new view of resources. Agriculture is the oldest branch of the economy and as such is one of the prerequisites for rural development. Precisely for this reason, models and approaches to the sustainability of rural development should be adapted to local development potentials (Đurić et al., 2023), which are often directed at agricultural households.

In modern literature, there is a difference between the terms agricultural farm and agricultural household. Agricultural farm is an organizational-economic category that has the characteristics of a production unit. According to the nature of ownership over the means of production of the economy, they can be private, cooperative, social and state. On the other hand, a household is a socio-economic category that has the characteristics of a consumer unit. A household represents one community (single or one-member) or a community of several persons (family or non-family), in which the income earned by the work of all economically active members is used to meet the needs of all household members. According to the sources of income of economically active members, households can be agricultural, mixed, non-agricultural and households with no income (Janković, Novakov, 2019).

The problem is reflected in the fact that an agricultural household is not equated with an agricultural farm. Unlike agricultural households, agricultural farms are registered and registered for the performance of their agricultural activities. On the other hand, not all agricultural households are farms. That is why one of the questions is what happens to those households that are not registered, how they do business, to whom and how they market their products, what they are like and how many products they have, what they do, how and to what extent they realize production. According to the data of the Republic Statistical Office (2023) in the period 1948-2022., there was a decrease in the number of household members in Serbia according to the number of members in the categories of four, five and six household members, while the number of members with one, two and three members increased (Chart 1).

Chart 1: Households by number of members and average size, 1948-2022.



Source: RZS, 2023.

The analysis of the market of agricultural products shows the problems in standardization as well as the quality and quantity of agricultural goods. This further results in the limitation of the performance in the market where the products should be placed and become competitive. The problem of achieving competitiveness is also increased by the fact that the financial, technological, legal, marketing and market risk is transferred to the population with a high school education or less.

Precisely for this reason, the farmer must know the legal regulations of the legal entity, economic segments, new technological, market and marketing conditions and prerequisites. The most important thing is that the farmer produces and places the product on the market in good quality, acceptable and on time, which will make him competitive. The problem arises in the domain of connecting agricultural producers, through cooperatives and associations, which do not exist as a strategic basic element of the household's actions and actions towards the household. The solution to the problem of the competitiveness of agricultural households in Serbia is primarily related to the identification of the household itself through potentials and problems, rapid transfer of information, connection with the market and standardization of the quality and quantity of production in the household.

The identification of the potential of agricultural households is reflected in the fact that every registered or unregistered household, provided that someone lives in it (if it is not abandoned), has its own potential in terms of infrastructure and workforce. Every household has some agricultural product or production potential that will create a new product, increase competitiveness and ultimately generate income or profit.

THE IMPORTANCE OF INFORMATION FOR IMPROVING THE COMPETITIVE ADVANTAGE OF AGRICULTURAL HOUSEHOLDS

Today's ways of working and progressing in any segment, including in agriculture, require a quick flow of information and a quick response to changes in the environment. This is achieved in the best way precisely by providing good and clear information to the population in rural areas. For farmers, the main source of information is on the Internet and it takes place in two ways: information on current and important matters in the relationship between the state and agriculture and education of farmers. Ways of informing farmers on the Internet in the Republic of Serbia are as follows:

- The website of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia puts news in the foreground; (Ministry of Agriculture, Forestry and Water Management, 2024)
- Agricultural Advisory and Expert Services of Serbia bring news, forum, professional publications to the fore; (Agricultural Advisory and Expert Services of Serbia, 2024)
- Association of women farmers on its website Moba - Serbian agricultural internet magazine brings news, educational information to the fore; (Moba - Serbian agricultural internet magazine, 2024)
- Internet newspapers, forums, websites of farmers who have their own business;
- Agricultural advertisements - E-commerce is reflected through catalogs, orders via e-mail messages, electronic forms and B2C and B2B; (Agricultural ads, 2024)

Information from the household to the market can be transmitted as follows: Presentation on the website, SMS message according to the site and the market, mobile phone. The information collected in this way is transmitted transparently to the market, through portals that are accessible to everyone who owns communication devices (computer, tablet, phone).

Information by household is transmitted as follows: SMS message, by calling a mobile phone, by visiting the household. When it comes to information for the household, which comes from interested groups (legal entities, local self-government, professional services) in the above ways it is possible to carry out the necessary action in the easiest way, more precisely to inform the agricultural household about all the happenings. This information can be informative, advertising, binding.

By analyzing the mentioned sources, we can conclude that there is a large number of texts, different information, news, but not in accordance with the real problems of our farmers. From the mentioned sources, we get a general picture, but not ways of improving and helping people, especially farmers from underdeveloped areas, who should be paid special attention and motivated to include them in modern workflows, in accordance with their capabilities.

THE SIGNIFICANCE OF STANDARDIZATION OF QUALITY AND QUANTITY OF PRODUCTION IN AGRICULTURAL HOUSEHOLDS

In order for an agricultural household to be competitive, great importance must be attached to the standardization of the quality and quantity of production. The goal of the standard is to enable organizations of all sizes and types to implement and implement effective and efficient quality management systems, i.e. to deliver products that satisfy the user and meet the requirements of the relevant regulations. Standards as norms that prescribe the properties and characteristics of production, products and behavior in the very cycle of production to sale, are documents that contain guidelines, rules or specific activities for the introduction of order in a certain area. While standardization defines the process of determining and applying the rules that regulate the standards. In the domain of the agricultural and food industry, organizations related to defining product quality are the "Federal Institute for Standardization" on the territory of Serbia and the "Codex Alimentarius Commission" on the territory of the EU, which, by adopting a series of laws, regulations and standards, established guidelines for quality assurance, management procedures quality and hygiene. The achievements of science and practice, as well as international standards and regulations, are used as a basis for the development of standards:

- ISO (International Organization for Standardization),
- HACCP,
- Organic control system,
- Kosher product,
- Halal,
- GlobalGAP.

ISO (International Organization for Standardization) (ISO, 2024) represents a network of national institutes in 162 countries and is also the world's largest institution for standards development. The key ISO standards developed within this organization and applicable on the territory of the Republic of Serbia are:

- Quality management system - ISO 9001
- Environmental management system - ISO 14001
- Food safety management system - ISO 22000
- Social responsibility system - ISO 26000
- Information protection and security system - ISO 27000
- Employee protection and safety management system - OHSAS 18001.

HACCP (Hazard Analysis Critical Control Points) (HACCP, 2024) is a food safety system based on the analysis and control of potential biological, microbiological, chemical and physical hazards to which raw materials are exposed, possible hazards during handling, production, distribution and consumption of the final product. The HACCP system is adapted to all types of food products and all types of food production and handling. Application of the HACCP system is also a legal obligation in Serbia.

Organic control system (2024). Intensive agricultural production as represented today on the global market and the increasing use of fertilizers and pesticides have resulted in excessive pollution of agricultural areas that cover a large percentage of our planet. For this reason, it was necessary to organize an alternative way of production, which will provide sufficient amounts of healthier food, the production and demand of which will overcome the current conventional production. That's why you should keep in mind:

- It is mandatory to use land that has been free from treatment with chemical fertilizers for a period of several years (3 years and more).
- It is necessary to avoid a large number of chemical substances (eg fertilizers, pesticides, antibiotics, additives, rodenticides and fungicides), genetically modified organisms and water treatment agents
- Detailed data on the production and sale of organically produced products
- Strict physical separation of organic production from conventional production
- Constant inspections and monitoring of production during the production process

The word Kosher in its original (broader) meaning can be translated as appropriate, in accordance, correct. A certificate issued by an authorized Rabbi guarantees production in accordance with Kosher rules and that it can be consumed as such by members of the Jewish religious community (KOSHER Certification Service, 2024):

- Meat and meat products of only certain species of animals are considered Kosher. These are animals that are fed from special containers and chew their food, so veal and mutton belong to the category of permitted types of meat, while e.g. rabbit and pig meat are not kosher foods. In order for the meat of certain animals to be Kosher, the animals must be slaughtered in a precise and ritualistic manner, which must also be certified as Kosher.
- Fruits, vegetables and grainy vegetables, these types of products, as a rule, are Kosher. There is only one exception, and that is certain types of products obtained from grapes.
- Cheese, although cheese is a dairy product, some types of cheese are Kosher, provided they are produced from a Kosher animal.
- Supplements, fish, eggs, vegetables, fruits and legumes can be consumed with dairy or meat products. Therefore, oils such as vegetable can be used in the preparation of dairy and meat products.

The rabbi of the Jewish community in Serbia signs the certificate, but the actual decision to approve the kosher certificate is made by the European Central Koshrut (ECK). The collected documentation (producer's intention to produce a kosher product, description of the technology, list of raw materials entering the production process...) is sent to ECK. If the product is technologically simpler, e.g. frozen fruit, the rabbi himself controls the products, so the ECK official does not have to come. If the product is found to support kosher dietary regulations, two certificates are issued, one from the local rabbi, and one from the ECK. During the validity of the certificate, ECK assigns supervisors who control the standard and ensure compliance with the provisions of the contract that binds the manufacturer in the production process.

Obtaining a kosher certificate is not cheap, since one working day of a technologist from ECK costs 500 euros, and travel expenses are borne by the applicant. It is a regular practice that several companies that have applied for the certificate join together and

share the costs, which in this case are much more acceptable. Otherwise, the applications are sent to Israel only when several of them are collected.

Halal means permissible in Arabic. When we say "permitted" we mean food, which is prepared according to Sharia laws and most Muslims around the world follow this way of eating. In order to meet the requirements for obtaining a certificate in food production, the following ingredients must not be used (Halal, 2024):

- Pork,
- Blood,
- carnivorous animals,
- birds of prey,
- animals slaughtered in the name of someone other than Allah,
- additives and emulsifiers (emulsifier E 120),
- the use of alcohol (liqueurs used in the confectionery industry) is also prohibited, as is gelatin of pig origin.

The number of people of the Islamic faith in the world is about 1.6 billion and there is an increasing demand for certified Halal food in countries with a population of the Islamic faith. Of the total turnover of food and food products at the world level, the Halal market comprises 12% of global trade.

The demands of consumers to buy natural, tasty and fresh products, produced in a natural and healthy way and in a process that does not harm the environment, are increasingly emphasized. *GlobalGAP* is a system of food quality assurance measures, i.e. agricultural products from planting to entry into factory processing. The principles of GlobalGAP (2024) are:

- Limited and controlled use of all types of agrochemicals;
- Hygienic handling during the production and manipulation of agricultural products;
- Providing instructions and recording all activities while ensuring traceability;
- Unique rules that enable unbiased verification (confirmation that everything was done correctly);
- Mutual communication and exchange of opinions between producers, traders and users of products;
- Concern for the protection of the human environment and sustainable development;
- Responsible behavior towards farm employees;
- Concern for the welfare of farm animals.

CONCLUSIONS

Rural areas have untapped economic potential in the Republic of Serbia. That is why agriculture, as the oldest branch of the economy, is one of the prerequisites for rural development in Serbia. Rural development models and approaches should be adapted to local development potentials in Serbia, which are aimed at agricultural households. The identification of the potential of agricultural households is reflected in the fact that every registered or unregistered household (provided it is not abandoned) has its own potential that can give it a competitive advantage.

In terms of information, an important conclusion is reached that it is necessary to create a portal with clear and precise information for the improvement of agricultural production.

The growth and development of agricultural households can be achieved in close coordination with the local self-government, so that expert people from the same environment can best understand the needs of farmers and improve the possibilities of their progress. Also, it would be extremely important to establish direct communication, more precisely the possibility of feedback from households and their greater involvement in modern work and development processes, through the necessary education of professionals.

Standards include prescribed properties and characteristics of production, products and behavior in the very cycle of production to sale. Standards are documents that prescribe guidelines, rules or specific activities for the introduction of order in a certain area, while standardization defines the process of determining and applying the rules that regulate the standards. In the domain of the agricultural and food industry, the organization related to defining the quality of products in Serbia is the "Federal Institute for Standardization", and in the territory of the EU it is the "Codex Alimentarius Commission".

Given that the goal of this work is to indicate that improving the competitiveness of the agricultural household contributes to rural development in the Republic of Serbia, we conclude that it is possible to improve the competitive advantage and contribute to rural development in Serbia with the potential, timely information and monitoring of the standardization of quality and quantity of production in the agricultural household.

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The relationship between the attitude towards religious marketing and the level of consumer behavior change

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ABSTRACT

The attitudes of people towards marketing religions have always been a sensitive topic. While some regard it as inevitable (Ann & Devlin, 2000; Bence, 2014; McDaniel 1986; Mulyanegara et al, 2010; McGraw et al, 2011), others claim that it undermines the credibility of the religion, if the community promotes itself openly (Attaway, Boles & Singley, 1997; McDaniel 1986; McGraw, Schwartz & Tetlock, 2011). Still, recent research has put an increasing emphasis on studying how religions may be promoted efficiently.

In previous research (Bence-Kiss, 2021) it has been confirmed that in the case of Krishna Consciousness in Europe, the Transtheoretical Model of Behavior Change (TTM) (Prochaska and Velicer, 1997) may be applied to analyze the involvement of people into the religion. The question may be raised, if there is a relationship between the place an individual takes in this model, and their attitudes towards the religion they are involved in. This study seeks to analyze if there is a significant relationship between the level of involvement of people in Krishna Consciousness and the ways they see their activities taken to gain new followers.

Study was carried out on a sample of 330, all members familiar with Krishna Consciousness at least on the level of interest. Their level of involvement was analyzed by using the Transtheoretical Model of Behavior Change, and their opinions were asked about the marketing activities of the religion. The analysis has disclosed four factors, which were in line with the ABC model (Cuadrado et al, 2023), however, the cognitive segment had to be broken down into two subsegments, promotion and economic activities. The study has shown that there is a correlation between the different phases of the TTM model and the affective and behavioral elements of the ABC model, and partially promotion within the cognitive factor.

Keywords: religious marketing, Transtheoretical Model of Behavior Change, consumer behavior, consumer attitudes, ABC Model of Attitude.

INTRODUCTION

The attitudes of people towards marketing religions have always been a sensitive topic. While some regard it as inevitable (Ann & Devlin, 2000; Bence, 2014; McDaniel 1986; Mulyanegara et al, 2010; McGraw et al, 2011), others claim that it undermines the credibility of the religion, if the community promotes itself openly (Attaway, Boles & Singley, 1997; McDaniel 1986; McGraw, Schwartz & Tetlock, 2011; Kuzma et al, 2009). Still, recent research has put an increasing emphasis on studying how religions may be promoted efficiently.

In previous research (Bence-Kiss, 2021) it has been confirmed that in the case of Krishna Consciousness in Europe, the Transtheoretical Model of Behavior Change (TTM) (Prochaska and Velicer, 1983) may be applied to analyze the involvement of people into the religion. The question may be raised, if there is a relationship between the place an individual takes in this model, and their attitudes towards the religion they are involved in. This study seeks to analyze if there is a significant relationship between the level of involvement of people in Krishna Consciousness and the ways they see their activities taken to gain new followers.

From a practical standpoint, religious markets can be defined as "present and potential customers" (Kotler, 1969), which might also refer to members of a religious group who are currently active and those who may join in the future. Religious communities sell various services as well as certain belief systems that fall under the definition of product on this market. Since most of these events are free of charge or simply require donations, we may identify them as non-profit groups that also do marketing, just like Greenpeace and WHO. Why would religious organizations operate differently, especially when it comes to marketing, if they are also non-profit organizations?

ATTITUDES TOWARDS RELIGIOUS MARKETING

The nature and history of religion are the main reasons why many people continue to deny the existence of religious marketing. Traditionally, people were only allowed to practice one religion in a community, nation, or area, and were not allowed to express interest any other. Even so, the dominant religion of the those days has engaged in public discourse and sponsored events and activities, but most people do not consider this to be marketing. Additionally, there is a prevalent perception that religion is an ethereal, sacred concept that is separate from all material things. Studies have revealed that a portion of the public feels that churches that participate in commercial or marketing endeavors lose their sacred status and legitimacy. When considering this viewpoint from a practical standpoint once more, it is obvious that we cannot expect religious groups to exist without money because both the community's employees need to make ends meet and costs must be paid. They need money and supporters in order to do this (Andok, 2022; Attaway, Boles & Singley, 1997; Bence-Kiss, 2021; McGraw et al, 2011; Kuzma et al, 2009).

Recently, there has been a modest shift in the public's and religious communities' attitudes regarding religious marketing. The necessity of living in a material world serves as the primary justification for these modifications, as previously noted. According to McGraw et al. (2011), religious communities' communication styles matter a lot, particularly when it comes to soliciting donations. People are more resistant if the communication suggests striving for material rewards. Nonetheless, a greater degree of openness can be anticipated if the goal is maintenance or charitable activities.

According to Mulyanegara, Tsarenko, and Mavodo (2010), churches need to focus on developing their brand and market orientation. Like any business, they should satisfy customer needs, which occasionally entails making adjustments and adjusting to new technologies. Juravle et al. (2016) also point out that, in order to survive and prosper, religions must keep up with contemporary culture and adjust to changing consumer demands (Bence, 2014; Bence-Kiss, 2021; Juravle et al, 2016; Lázár Kovács, 2017; Mulyanegara et al, 2010; McGraw et al, 2011; Sükösd, 2017).

Furthermore, given how much society has evolved over the past few decades, while many religions have not, Einstein (2008) has emphasized that the time has come for religious communities to change. She warned that if communities will not change and adapt to the needs of the modern world, they risk losing more and more followers (Einstein, 2008; Juravle et al, 2016; Woodhead, Heelas & Martin, 2002).

According to Mannerfelt (2022), who studied digitally mediated preaching as a novel approach to religious practice, he found that even though pastors initially expressed some skepticism and resistance, the new preaching system began to function more and more effectively and was also embraced by the general public. Campbell (2017, 2021) concentrated on the application of memes and AR/VR technologies in religious practice. She has called attention to the risks associated with these phenomena, including racism, extremism, and stereotypes, but she has also highlighted the opportunities to use new technologies to assist religious practice rather than resisting its unavoidable progression. The presence of religions in the media, particularly new media, and the existence of content creators – volunteers or employees of media companies – were investigated by Andok, Szilcz, and Radetzky (2023). In addition to confirming the beneficial effects of new media on religion, their research has identified specific types of content creators who may help spread religious ideas online and among the general public (Andok, Szilcz & Radetzky, 2023; Campbell 2017, 2021; Mannerfelt, 2022).

TRANSTHEORETICAL MODEL OF BEHAVIOR CHANGE

Prochaska and DiClemente (1983) created the Transtheoretical Model of Behavior Change (TTM) as a conceptual framework for deliberate behavioral modifications of people. The concept attempted to explain the processes that people are going through when trying to overcome addictions or make changes to their lives. Twelve distinct health behaviors were used for testing and validation, and the results demonstrated consistency in the phases and processes of change. Five phases of behavior change were found by the model: precontemplation, contemplation, preparation, action, and maintenance (Newcomb, 2017; Prochaska & DiClemente, 1983; University of Maryland, 2020; Velicer et al, 1998).

People are not planning to modify their habits in the first, *pre-contemplation* stage, and occasionally they are not even aware that changes are possible. In the following *contemplation* stage, awareness already emerges and a desire to alter behavior in the next six months or so emerges. Weighing the advantages and disadvantages of the changes, actively searching out information, and the start of the logical decision-making process are characteristics of this stage. While gathering information is still ongoing during the *preparation* stage, the decision has already been made to alter behavior within a month or so. People are typically not totally committed to their decision to make changes at this point. People begin actively changing their behavior during the *action* phase, which is also the time when obstacles or a lack of assurance are most likely to cause a relapse to the earlier stages. When individuals have been able to sustain

the altered behavioral patterns for at least six months, they enter the fifth and final stage, known as *maintenance*. While relapse is still possible during this stage, it is less likely than it was during the action phase. The individual's journey through these stages is frequently nonlinear and can take varying amounts of time, depending on a numerous internal and external circumstances (Newcomb, 2017; Prochaska & DiClemente, 1983; Prochaska & Velicer, 1997; University of Maryland, 2020; Velicer et al, 1998).

ABC MODEL OF ATTITUDE

The ABC Model of Attitudes is a tri-component model explaining attitudes from a psychological perspective, where A stands for *affective*, B for *behavioral* and C for *cognitive* elements. The *affective* component involves feelings and emotions an individual has towards events, objects, persons, or situations. *Behavioral* component summarizes the actions individuals take towards the above-mentioned events, objects, persons, situations, etc. The third, *cognitive* component involves beliefs and thoughts of an individual regarding certain things or events. With the help of these three elements, we may understand and interpret the attitudes of individuals towards certain things and situations. (Cuadrado, Macias-Zambrano, Carpio & Tabernero, 2023; Eagly & Chaiken 1993; Lau, Ng, Chan, & Cheung, 2023).

In the area of marketing the model is often used to evaluate the attitudes of customers towards a product, service, or a brand. It has outstanding importance in branding, and when gathering consumer insights, but is also widely used in the area of psychology, especially in CBT (Cognitive Behavioral Therapy), to understand and form the attitudes of people towards certain events, traumas and experiences (Cuadrado et al, 2023; Eagly & Chaiken, 1993; Lau et al, 2023).

MATERIAL AND METHODS OF WORK

The only criterion used to identify the research participants was having visited one of the eighteen communities devoted to Krishna Consciousness in Europe. This criterion was necessary to contact responders because Krishna Consciousness is still a relatively new religious movement in Europe. English-language paper-and-pencil surveys had been sent to communities around Europe, and the largest Hungarian group also had access to Hungarian-language questionnaires. There were volunteers on hand to help responders overcome challenges such as language and comprehension issues.

667 respondents have filled the questionnaire, but as it was a part of a more extended research, 330 valid answers were gathered in this subsection. The rest of the respondents had to be filtered, having given incomplete answers. Female respondents made up 66.5% of the pool, 28.9% were and 4.5% preferred not to say. Most of the participants aged between 36 and 65 years (36-45: 20.2%; 46-55: 21.0%; 56-65: 19.8%). 1.0% of the pool were under 18 years, while 5.2% between 19 and 25 years, 9.0% between 26 and 35. 66 years or older respondents made up 23.5% of the sample. Most of the participants took part in higher levels of education: university or college degrees were owned by 45.4%, 33.1% finished high school, 11.5% took part in vocational school education, 4.5% held only elementary school qualification, and 5.4% preferred not to answer this question.

The majority of the respondents lived in urban areas: 25.0% in capitals 23.3% in regional centers, 25.2% or other towns, and only 14.7% in other types of settlements. 4.9% of the respondents were inhabitants of communities devoted to Krishna Consciousness and 6.7% preferred not to say where they lived.

Considering occupation white-collar workers were in majority (22.8%), followed by pensioners (19.6%) and blue-collar workers (12.9%). 10.3% of the participants worked for Krishna-conscious communities. Other jobs statuses appearing were students (3.7%), inactive earners (1.8%), mothers on maternity leave (1.3%), housewives (1.2%), unemployed (1.2%), dependants (0.1%), and 24.9% did not disclose their occupation.

On attitudes toward religions marketing themselves, nine statements were developed. A Likert-scale – with 1 denoting never and 5 denoting frequently – was used to ask respondents to rate how much they agreed with the statements.

The statistical program SPSS 21.0 was used to examine the data. Kaiser Normalization and Varimax rotation were used to establish homogeneous factors. The KMO value of 0.873 indicates that the sample is appropriate for factor analysis. With a significance level of $p=0,000$, the Bartlett's test validated the test's validity and indicated the possibility of substantial correlations between the variables. Using the Cronbach's Alpha test to examine the factors' reliability, two of the factors received scores greater than 0.8, which is indicative of strong reliability. The third factor's Cronbach's Alpha score was slightly less than 0.7 (0.660). Nevertheless, the four-factor format was selected for the study because, in contrast to other factor counts, four factors produced the maximum variance explained and the most rationally interpretable outcomes. The fourth factor consisted of just one variable (Malhotra, 2009; Sajtos & Mitev, 2007).

The Pearson correlation coefficient, which indicates the degree and direction of a relationship between two variables, was also used to examine the association between the two sets of factors (Malhotra, 2009; Sajtos & Mitev, 2007).

RESULTS AND DISCUSSION

The analysis has shown that the four factors of behaviors towards the religion, which fit on the dimensions of the Transtheoretical Model of Behavior Change, as seen in Table 1. This demonstrates that involvement in a religion can be studied using the model in addition to the previously identified fields of study (such as quitting addictions or healthy behaviors). The factors explained 74.062% of the total variance (Newcomb, 2017; Prochaska & Velicer, 1997; University of Maryland, 2020; Velicer et al, 1998). At the same time the four factors of attitude towards religious marketing can be identified with *affective*, *behavioral* and *cognitive* elements of the ABC model, with the exception of one statement: "A religion loses credibility if it is openly promoted.", as shown in Table 2. Despite having an emotive meaning, this statement did not align with the components of the affective factor or any other factor. However, as this constitutes a significant component of the mindset around religious marketing, the statement was retained as a separate factor rather than being removed. As a result, the two components that make up the affective component are promotion and economic activities. The factors explained 73.023% of the total variance.

TTM RELATED TO KRISHNA CONSCIOUSNESS

The first phase, *precontemplation* is absent from the study because the participants, having visited a Krishna-conscious community, were already somewhat interested in the religion. *Precontemplation* is characterized by people not even expressing interest in the religion or changing their behavior. Nonetheless, the remaining four phases of transformation can be observed in the factors related to Krishna Consciousness.

Table 1 – Factors describing the behavior change of the respondents (N=330)

I follow/check the Facebook page of a Krishna-conscious village.	Contemplation M=2,28 Std.=1,18 Var. exp.=59,50%
I follow the national Hare Krishna site/Facebook page.	
I read the articles about the Hare Krishna community.	
I check the news of the Krishna-conscious community.	
I follow/check the YouTube channel of a Krishna-conscious village.	
I follow/check the Instagram posts of a Krishna-conscious village.	
I buy books/give donations to Krishna devotees on the streets.	
I visit a Krishna-conscious village.	
I attend festivals organized by Krishna-conscious communities.	
I buy products of a Krishna-conscious village.	
I give the 1% of my income tax to a Krishna-conscious community.	Preparation M=2,47 Std.=1,43 Var. exp.=6,73%
I eat vegetarian/vegan.	
I buy vegetarian/vegan products.	
I follow the guidance of the Bhagavad Gita.	
I use the Hare Krishna mantra.	
I read books related to Krishna consciousness.	
I cook from Indian recipes.	
I visit Govinda Restaurants.	
I talk to people devoted to Krishna Consciousness.	
I visit Hare Krishna communities in different countries.	Action M=2,00 Std.=1,21 Var. exp.=4,20%
I celebrate the festivities of Krishna Consciousness.	
I dress in traditional Indian dresses.	
I visit Hare Krishna temples.	
I attend workshops organized by Krishna-conscious groups.	
I visit the Bhaktivedanta College.	Maintenance M=1,52 Std.=0,98 Var. exp.=2,86%
I attend yoga classes organized by Krishna-conscious groups.	

Extraction Method: Principal Component Analysis.; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 7 iterations; KMO=0,909; Bartlett (Approx. Chi Sq.)=4065,100; Sig= 0,000; Total variance explained: 74,062; Cronbach's Alpha: F1=0,857; F2=0,865; F3=0,743; F4=0,717

The first factor, *contemplation*, covers ways to learn about the religion and even making personal connections with it. These ways primarily involve tourism – visiting rural communities and festivals, for example – and contribution – giving money to the religious group. This factor's mean, 2,28 (Std.=1,18), shows that respondents generally do not take these actions frequently. It should be noted, nonetheless, that not everyone in the *contemplation* phase has reached the point of visiting a community; but they may still take other steps related to this issue and obtain knowledge through other sources.

When the level of involvement increases, the respondents move on to the following element, the *preparation* phase. In this phase they have already taken some steps to become a member of the religious community and are therefore focusing on both the religious and touristic products. The change could appear in the form of altering one's eating habits, reading holy texts, or reciting mantras and prayers. These are the behaviors that most respondents take frequently, as indicated by the factor achieving the greatest mean among the respondents ($M=2,47$; $Std.=1,43$). This indicates that many tourists have already taken steps to deepen their involvement in Krishna Consciousness, but these may yet remain unseen by the environment of the individual.

The factor *action* displayed a lower mean of 2,00 ($Std.=1,21$), which is not surprising given that this phase includes all activities that are visible to the public and demonstrate a clear engagement with the religious community. Examples of such activities include dressing in traditional Indian dresses, attending festive events, visiting temples, and taking part in workshops.

At 1,52 ($Std.=0,98$), the fourth factor, *maintenance* had the lowest mean. At this stage of behavior change, one must have successfully changed their behavior to the point of joining the Krishna-conscious community. There may be variations in the degree of involvement among the many individuals in this stage as well, but retaining this status at this stage already calls for consistent, noticeable efforts, like attending regular worships and participating in education.

ATTITUDES TOWARDS RELIGIOUS MARKETING AMONG PEOPLE INTERESTED IN KRISHNA CONSCIOUSNESS

Table 2 – Factors describing attitudes of the respondents towards religious marketing (N=330)

It is a good thing that Krishna-conscious villages welcome visitors and tourists.	Cognitive M=3.82 Std.=1.08 Var. exp.=42.46%
Religious communities should keep up with the modern age and be present on online platforms.	
I am interested in Eastern cultures.	
During my trips I like to visit sacred destinations of religious communities.	
I am open towards people promoting or explaining their religion on the streets.	Behavioral M=3.22 Std.=1.28 Var. exp.=15.50%
I am willing to pay a higher price for products and services produced by religious communities, than for conventional products.	
I like to use services provided by religious communities (accommodation, meals, free-time activities).	
I like to buy products created by religious communities.	
Religious communities should be independent from the economic activities.	Affective (economic activities) M=2.54 Std.=1.25 Var. exp.=7.80%
Religious communities should not engage in economic activities.	
A religion loses its credibility if it is openly promoted.	Affective (promotion) M=1.72 Std.=1.09 Var. exp.=7.27%

Extraction Method: Principal Component Analysis.; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 6 iterations; KMO=0.873; Bartlett (Approx. Chi Sq.) =1464.060; Sig= 0.000; Total variance explained: 73.023%; Cronbach's Alpha: F1=0.850; F2=0.839; F3=0.660

When it comes to religious marketing, accepting that religions should adapt to the times and respecting the efforts they make to educate the public about their beliefs are examples of the rational and open perspective that the *cognitive* factor embodies. This

factor had the lowest standard deviation (Std.=1.08) and the highest mean (3.82), indicating that most respondents are open-minded and reasonable concerning to religious marketing. This factor also included the statement that had the highest mean (M=4.21, Std.=1.189) regarding tourists being welcomed in Krishna-conscious communities. This indicates that the respondents are the most receptive to this type of religious marketing, which involves using tourism to educate people about religion.

The *behavioral* aspect included statements, such as the use of services provided by religious communities and purchasing their goods, even if they meant paying a higher price for them. This factor's mean, 3.22 (Std.=1.28), is only somewhat lower than the first one, indicating that respondents are both accepting of religious communities' activities and prepared to give them financial support by purchasing goods or services.

The third, *affective* element, which is associated with *economic activities*, has a mean of 2.54 (Std.=1.25). Statements regarding religions needing to remain independent economic activity can be found in this factor.

As previously indicated, there was only one statement in the fourth factor, the *promotion* part of the *affective* element: religions lose credibility, when they are openly promoted. This was the factor of the lowest mean, 1.72 (Std.=1.09), indicating that most respondents disagreed with it. Given that the majority of respondents disagreed with this statement explains why it did not move together with any other statement.

RELATIONSHIP BETWEEN TTM AND ATTITUDES TOWARDS RELIGIOUS MARKETING

After the identification of the factors determining the attitudes towards religious marketing and the level of involvement in the religion, the relationship of the two variables were tested using Pearson Correlation, as seen in Table 3.

Significant relationships were found in eleven cases, two of them significant on the level $p < 0.05$ (*) and all the others significant on the level of $p < 0.01$ (**). *Cognitive* and *behavioral* factors of the attitudes positively correlated with all four stages of behavior change. Even though the correlation coefficients were lower than 0.7, showing moderate relationships, but always above 0.2. This shows that the place people take in the process of change positively influences the *cognitive* and *behavioral* components of their attitude towards religious marketing. the *economic activities* factor of the *affective* component did not show any significant relationship with the stages of behavior change, while the *promotion* factor negatively correlated to *contemplation* ($P = -0.195$), *preparation* ($P = -0.113$) and *action* ($P = -0.116$), but not to *maintenance*. Negative correlation means that for the first three stages of change, the more people are involved, the less they agree with religions losing their credibility when promoted. Interestingly, no significant relationship appeared in the *maintenance* phase, even though we could assume that those, who are the most involved would also be the most accepting towards religious marketing. The reason for this phenomenon is yet undiscovered, but may be subject to a further research. However, for the *promotion* factor the correlation coefficients were always below 0.2, assuming only a weak relationship, and also, in two cases, the results were significant only at $p = 0.05$.

Table 3 – Relationship between the stages of change and attitude towards religious marketing

		Cognitive	Behavioral	Affective (economic activities)	Affective (promotion)
Contemplation	Pearson Correlation	0.409**	0.458**	0.004	-0.195**
	Sig. (2-tailed)	<u>0.000</u>	<u>0.000</u>	0,947	<u>0.000</u>
Preparation	Pearson Correlation	0.383**	0.447**	-0.041	-0.113*
	Sig. (2-tailed)	<u>0.000</u>	<u>0.000</u>	0.454	<u>0.041</u>
Action	Pearson Correlation	0.322**	0.386**	-0.044	-0.132*
	Sig. (2-tailed)	<u>0.000</u>	<u>0.000</u>	0.422	<u>0.016</u>
Maintenance	Pearson Correlation	0.220**	0.279**	0.033	-0.042
	Sig. (2-tailed)	<u>0.000</u>	<u>0.000</u>	0.550	0.442

CONCLUSIONS

Previous research results (Bence-Kiss, 2021) have uncovered that the level of religious involvement may be studied with the help of the Transtheoretical Model of Behavior Change (TTM) (Newcomb, 2017; Prochaska & DiClemente, 1983; University of Maryland, 2020; Velicer et al, 1998), and the attitudes towards religious marketing can be analyzed using the ABC Model of Attitudes (Cuadrado et al, 2023; Eagly & Chaiken, 1993; Lau et al, 2023).

These findings have implied the need to study the relationship between these two models, to be able to understand the general attitude towards promoting religions. The current research has revealed that the *cognitive* and *behavioral* attitudes towards religious marketing are moderately, positively affected by all four stages of change, while the *promotion* factor of the *affective* component has a weak negative relationship with the first three stages of change, and the *economic activities* component is completely unaffected by the stages of TTM.

Further studies are going to be carried out to discover the reasons for the presence – or lack – of relationship, and a larger sample including more religions is also being used, to find out whether the model fits to other individuals interested in different religions.

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SMART CITIES AS PART OF THE SUSTAINABLE DEVELOPMENT AGENDA - POLICIES, STRATEGIES AND IMPLEMENTATION

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ABSTRACT

The smart city concept is gaining more and more importance, it is positioned as a city of the future and as the only possible model of sustainable urban development. Migration from rural areas to the city affects the reduction of rural development and at the same time opens up the possibility of even faster development of smart cities. The opportunities that have opened up with the development of smart cities are numerous, from the optimization of city functions and the improvement of living and working conditions in the city, through the acceleration of economic development, to the promotion of sustainability. This paper aims to analyze smart city development as an integral part of the sustainable development agenda from global, European, and regional perspectives, with a special focus on the question of how smart cities contribute to the achievement of sustainable development goals. Consequently, the paper is divided into three thematic parts. The first part refers to smart cities in the context of the 2030 Agenda for Sustainable Development of the United Nations. The second part analyses smart cities as a development priority of the European Union, while the third part is about the situation and perspective of smart city development in Serbia and North Macedonia. In conclusion, final remarks are given. From a methodological point of view, this work presents a desk research analysis and synthesis of data from international and national governments and institutions, with the aim of a detailed presentation and concluding the subject. The research results contribute to the understanding and perception of this topic in several different aspects.

Keywords: smart cities, sustainable development, Serbia, North Macedonia.

INTRODUCTION

Sustainable development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Rao, 2010 22). Sustainability represents development, and the ability to maintain the balance of certain processes in the system, by reducing poverty, improving the quality of life, reducing pollution, and preserving biodiversity (Ignjatovic & Kisin, 2019). It mainly focuses on three dimensions: nature, society, and economy, encompassing economic, ecological, political, and cultural sustainability principles (Fischer et al. 2023).

Sustainable development Goals were defined in 2012 in Rio de Janeiro, at the United Nations Conference on Sustainable Development, and include harmonized goals that are in line with political, economic, and environmental challenges. All 17 sustainable development goals are interconnected (United Nations, 2024): 1) A world without poverty; 2) A world without hunger; 3) Good health; 4) Quality education; 5) Gender equality; 6) Clean water and sanitary conditions; 7) Available and renewable energy; 8) Decent work and economic growth; 9) Industry, innovation, and infrastructure; 10) Reduction of inequality; 11) Sustainable cities and communities; 12) Responsible consumption and production; 13) Climate action; 14) Life underwater; 15) Life on earth; 16) Peace, justice and strong institutions; 17) Partnership to achieve goals.

The concept of a smart city is gaining more and more importance, positioning itself as the city of the future and as the only possible model of sustainable urban development. Smart cities are environmentally friendly or "green" cities, i.e. sustainable cities that implement innovative technical solutions that contribute to various areas of work and life in modern cities (Marković & Tadžić, 2019). The goal of smart cities is to save time, energy, and money, which will be integrated into local development strategies.

Migration from rural areas to cities affects rural development and at the same time, it opens up the possibility of even faster development of smart cities. The opportunities presented by the development of smart cities are numerous, from the optimization of city functions and the improvement of living and working conditions in the city to the acceleration of economic development to the promotion of sustainability. According to UNDP data, in Serbia, about 60% of the population lives in cities, and the tendency is for more and more people to migrate from rural to urban areas. However, cities produce more than 70% of the world's greenhouse gas (GHG) emissions and consume 80% of the world's energy (Marković & Tadžić, 2019).

The paper aims to analyze the development of smart cities as an integral part of the Sustainable Development Agenda, with special reference to the issue of the contribution of smart cities to achieving the goals of sustainable development. The first part of the paper refers to the importance of smart cities in the context of the United Nations Sustainable Development Agenda 2030. The second part analyzes smart cities as a development priority of the EU, while the third part analyzes the state and prospects of the development of smart cities in the Western Balkans region, with special reference to North Macedonia and Serbia. This paper presents an analysis of cabinet-level research and a synthesis of data from international and national governments and institutions, with the aim of a more detailed presentation and conclusion on the subject. The research results contribute to a better understanding and perception of this topic in many different aspects.

SMART CITIES AND UN AGENDA FOR SUSTAINABLE DEVELOPMENT 2030

Commitment to sustainable development, as a necessary condition for survival in future times, is today one of the priorities of development policies both locally and globally. The main challenge of the 21st century is how to solve the accumulated problems of today, from the climate crisis to inequality. The many challenges facing the modern world will require us to work together concerning the planet and our environment to ensure a sustainable future. In the context of accelerated urbanization trends and growing environmental problems, the application of the concept of sustainable development encounters the greatest challenges in the cities themselves. Although there are different interpretations and definitions of sustainable development in the literature, this is surely a central concept both in the domain of economic development and in the sphere of environmental protection (Vračarević, 2019). The United Nations, including the UN Department of Economic and Social Affairs (UNDESA) and member countries, have been dealing with the topic of sustainable development for decades. Back in June 1992, at the Earth Summit in Rio de Janeiro, Brazil, more than 178 countries adopted Agenda 21, a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment. Then the Millennium Summit in 2000 that led to the elaboration of eight Millennium Development Goals (MDGs) and the World Summit on Sustainable Development in South Africa in 2002. At the UN Conference on Sustainable Development (Rio+20) in 2012, Member States adopted the outcome document "The Future We Want" in which they decided to start a process to develop a set of new goals to build upon the MDGs and to establish the UN High-level Political Forum on Sustainable Development. In addition to the above actions, many strategies, policies, and international events deal with the topic of sustainable development, but undoubtedly *Transforming our world: the 2030 Agenda for Sustainable Development*, adopted by all United Nations Member States in 2015 at the UN Sustainable Development Summit, is the most significant in that domain. This global agenda provides a shared blueprint for peace and prosperity for people and the planet, now and into the future (United Nations, 2024a). The very essence of the mentioned agenda is the 17 Sustainable Development Goals (SDGs), with 169 specifically defined objectives, which represent a set of goals related to future social and economic development by the principles of sustainability. SDGs replaced the MDGs, which ceased to be valid at the end of 2015 and will be in force until 2030. Sustainable urban development is a topic that is extremely important to global development efforts and is an integral and very important part of the UN 2030 Agenda for Sustainable Development. Cities are major hubs for ideas, commerce, culture, science, productivity, and social, human, and economic development. In that context, great importance is given to "urban planning, transport systems, water, sanitation, waste management, disaster risk reduction, access to information, education, and capacity-building, which are all relevant issues to sustainable urban development" (United Nations, 2024b). The significance of this was confirmed by the inclusion of one goal on cities and urban development in the 2030 Agenda, Sustainable Development Goal 11, to "make cities and human settlements inclusive, safe, resilient and sustainable". Because of the complexity and nature of urban issues, Goal 11 has an impact on several other SDGs, including 3, 6, 7, 8, 9, 12 and 13. For achieving SDGs Goal 11, the following targets and indicators are defined (Table 1):

Table 1. Sustainable Development Goal 11 - targets and indicators

Target 11.1	By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums
Indicator 11.1.1	The proportion of the urban population living in slums, informal settlements, or inadequate housing
Target 11.2	By 2030, provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons
Indicator 11.2.1	The proportion of the population that has convenient access to public transport, by sex, age, and persons with disabilities
Target 11.3	By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management in all countries
Indicator 11.3.1	The ratio of the land consumption rate to the population growth rate
Indicator 11.3.2	Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
Target 11.4	Strengthen efforts to protect and safeguard the world's cultural and natural heritage
Indicator 11.4.1	Total per capita expenditure on the preservation, protection, and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural), and level of government (national, regional, and local/municipal)
Target 11.5	By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations
Indicator 11.5.1	Number of deaths, missing persons, and directly affected persons attributed to disasters per 100,000 population
Indicator 11.5.2	Direct economic loss attributed to disasters in global domestic product (GDP)
Indicator 11.5.3	Damage to critical infrastructure and (b) several disruptions to basic services, attributed to disasters
Target 11.6	By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management
Indicator 11.6.1	The proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities
Indicator 11.6.2	Annual mean levels of fine particulate matter in cities (population-weighted)
Target 11.7	By 2030, provide universal access to safe, inclusive, and accessible, green and public spaces, in particular for women and children, older persons, and persons with disabilities

Indicator 11.7.1	The average share of the built-up area of cities that is open space for public use for all, by sex, age, and persons with disabilities
Indicator 11.7.2	The proportion of persons victim of physical or sexual harassment, by sex, age, disability status, and place of occurrence, in the previous 12 months
Target 11.a	Support positive economic, social, and environmental links between urban, peri-urban, and rural areas by strengthening national and regional development planning
Indicator 11.a.1	Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space
Target 11.b	By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and development and implementation, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels
Indicator 11.b.1	Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030
Indicator 11.b.2	Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies
Target 11.c	Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials

Source: https://sdgs.un.org/goals/goal11#targets_and_indicators

Implementation of the SDGs began in 2016 and till now certain steps forward have been made. Every year, the implementation is monitored, and the annual SDGs Progress Report is published, which includes an analysis of each of the goals and additionally every four years the Global Sustainable Development Report. The Division for Sustainable Development Goals (DSDG) provides substantive support and capacity-building for the SDGs and their related thematic issues, including water, energy, climate, oceans, urbanization, transport, science and technology, the Global Sustainable Development Report, partnerships, and Small Island Developing States. DSDG plays a key role in the evaluation of the UN systemwide implementation of the 2030 Agenda and in advocacy and outreach activities relating to the SDGs. To make the 2030 Agenda a reality, broad ownership of the SDGs must translate into a strong commitment by all stakeholders to implement the global goals, but at the same time aim to help facilitate this engagement.

Although SDGs are globally the best known, it is important to point out that the United Nations through its other programs pay great attention to the issue of sustainable urban development. The United Nations Human Settlements Program (UN-Habitat) is mandated to promote socially and environmentally sustainable towns and cities and it is the focal point for all urbanization and human settlement matters within the UN system. UN-Habitat works with partners and stakeholders to build inclusive,

safe, resilient, and sustainable cities and communities (United Nations, 2024d). As the outcome document from the Habitat III Conference in 2016, UN-Habitat adopted the New Urban Agenda, which offers national and local guidelines on the growth and development of cities through 2036 (United Nations, 2024e). Also, cities and climate change are part of the UN Environment Programme (United Nations Environment Programme, 2023) The United Nations Center for Regional Development (UNCRD) interventions in developing countries are clustered under three main thematic interrelated and complementary areas of work (UNCRD, 2013):

1. Integrated Regional Development Planning;
2. Sustainable Urban Management; and
3. Knowledge Management.

Under the Sustainable Urban Management thematic area, UNCRD will further strengthen its activities in the areas of urban planning, design and building, integrating disaster management planning, and with a sectoral focus on environmentally sustainable transport, 3Rs (reduce, reuse, recycle) and zero waste policies and programs, and international partnerships (for example, International Partnership for Expanding Waste Management Services of Local Authorities (IPLA)) towards building sustainable and resilient communities and cities (UNCRD, 2013). Among different programs of UNCRD, one is dedicated just to smart city development, called the Smart Cities Programme. UNCRD launched a Smart City Project in 2021 which aims to provide technical assistance and support to urban policymakers, planners, and city officials for building their cities and communities safer, smart, efficient, resilient, inclusive, livable, and sustainable through smart city solutions (United Nations, 2024f).

EUROPEAN POLICY FOR SMART CITY DEVELOPMENT

The optimization of resources and maximization of citizen welfare was always high on Europe's agenda. Together with a strong digital transition, Europe is one of the leading continents when it comes to smart cities and sustainable urban development, and now it has already a tradition of development respecting the principles of sustainable urban development. There are numerous successful examples of implemented smart projects, a few examples that can be singled out are (Pelikh, 2023):

- Zurich, Switzerland - turning infrastructure into IoT-enabled networks with the Long Range Wide Area Network system runs projects involving city challenges like air quality, water management, and parking spaces;
- Helsinki, Finland - With Helsinki's 'Whim' application public transport is connected to taxis, cars, bikes, and other alternatives to plan a trip. By combining all these options in one app, the use of public transport increases, and the smart city citizens of Helsinki can plan their travels in the most user-friendly way;
- The "Amsterdam Smart City" initiative, which was started in 2009, includes more than 170 projects developed in cooperation with residents, the government, and businesses. the city organizes the Amsterdam Smart City Challenge every year, where residents make suggestions for applications that enter the city's development projects;
- Barcelona is one of the leaders in the application of smart initiatives to the city, which are intended for both the local population and millions of tourists. As part of its "CityOS" strategy, it has implemented numerous projects related to the concept of a smart city;
- Copenhagen is already one of the most sustainable and smartest cities in the world, which aims to eliminate the emission of carbon dioxide into the

atmosphere by 2025;

- The implementation of the smart city concept has brought London a reduction in energy consumption by around 60%, and the platform is primarily focused on regulating and reducing excessive lighting, light pollution, and inconsistencies in lighting design.

For the European Commission, cities and urban development are extremely important. Such determination is primarily framed through a policy document *The Urban Agenda for the EU* focuses on three pillars of EU policymaking and implementation: better regulation, better funding, and better knowledge. It was launched in May 2016 with the Pact of Amsterdam and reconfirmed as a valuable initiative in November 2021, with the Ljubljana Agreement. In the 2021–2027 period, support for the Urban Agenda for the EU is provided under the European Urban Initiative, which is now main The European Hub for sustainable urban development. The Urban Agenda's priority themes for cities are air quality, circular economy, climate adaptation, culture and cultural heritage, digital transition, energy transition, housing, inclusion of migrants and refugees, innovative and responsible public procurement, jobs and skills in the local economy, sustainable use of land and nature-based solutions, urban mobility, urban poverty and security in public spaces. Thematic partnerships are the key delivery mechanism within the Urban Agenda for the EU. They include representatives from various governmental levels and stakeholders (The Urban Agenda for the EU, 2023). As part of the urban development policy, several different city initiatives have been defined, such as The Urban Development Network, Covenant of Mayors for Climate and Energy, the Green City Accord (GCA), City Awards – Green Capital and Leaf, collaborative platform for cities Living-in.EU Movement etc. In-city initiatives also included smart cities, defined as places where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and businesses. (European Commission, 2023). The next step forward in supporting the smart cities initiative is the creation of the Smart Cities Marketplace. The Smart Cities Marketplace aims to engage cities and towns of all sizes to deliver more sustainable urban environments and offers all the information needed to explore solutions, shape sustainable urban projects, and successfully close a deal for financing them (European Commission, 2024a). To implement these policies, financial support was sought, which was provided through several EU funds offering support to cities, including advice on implementation. For years, the European Union has been active in encouraging member states to develop smart cities, and the European Commission allocates hundreds of millions of euros for this purpose. The great effort that has been invested has begun to yield results primarily in reducing traffic congestion, saving energy, reducing CO2 emissions, and improving public safety. Cohesion policy is one of the most important policies in the European Union. The goal of the Cohesion Policy is to strengthen economic and social cohesion by reducing inequality in the level of development between regions. The policy focuses on key areas that will help the EU meet the challenges of the 21st century and remain globally competitive. EU members can finance smart city projects from the European Regional Development Fund and the Cohesion Fund. The European Regional Development Fund (ERDF) is one of the main instruments of the European cohesion policy, to strengthen economic, social, and territorial cohesion in the European Union and mitigate differences in the level of development of European regions. Funding priorities in 2021-2027 include (European Commission, 2024b):

- More competitive and smarter, through innovation and support to small and medium-sized businesses, as well as digitization and digital connectivity;
- Greener, low-carbon, and resilient;
- More connected by enhancing mobility;
- More social, by supporting employment, education, skills, social inclusion, and equal access to healthcare, as well as by enhancing the role of culture and sustainable tourism;
- Closer to citizens, supporting locally-led development and sustainable urban development across the EU.

The Cohesion Fund provides support to Member States with a gross national income per capita below 90% EU-27 average. For the 2021-2027 period, the Cohesion Fund concerns Bulgaria, Czechia, Estonia, Greece, Croatia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Portugal, Romania, Slovakia and Slovenia. 37% of the overall financial allocation of the Cohesion Fund is expected to contribute to climate objectives (European Commission, 2024c). In addition to the above, there are many other funding programs to support sustainable urban development, among which we can single out the LIFE Programme, Horizon Europe, URBACT IV program, InvestEU Fund, Urban Innovative Actions, etc. (European Commission, 2024d).

SMART CITIES IN THE WESTERN BALKAN REGION - EVIDENCE FROM NORTH MACEDONIA AND SERBIA

A smart city is a concept that connects changes on a global level, primarily brought about by the global development of the information society and technological innovations, with local outcomes and quality of life in the city through a cooperative management model and cooperation between local authorities and citizens. There are already examples of good practices around the world that testify to the numerous benefits that citizens have received through the successful application of this concept. A smart city as a modern concept has the main goal of ensuring the sustainable development of the city. The essence of the concept can best be seen in the definitions that include holistic approaches to the development of the city (Kozłowski & Suwar, 2021). According to the European Union (EU), a smart city is „a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business“ (European Commission, 2024e). The smart city aims to improve the well-being of its residents, the business sector, and other stakeholders through digitally enabled services that contribute to a better quality of life. Developing the concept of a smart city is the basis for growth, productive investments, and new jobs, leading to a sustainable, low carbon, and environmentally friendly economy, as well as putting the EU at the forefront of renewable energy production. Therefore, smart cities have appeared as a key development priority for the EU, through which better services for citizens will be provided, local challenges will be answered and the goals of the European Green Deal will be reached. Integrated efforts of the EU, local and national governments, the private sector, local and international networks, NGOs, and citizens are essential to turn visions of connected, efficient, and citizen-centric cities into reality (Horning, 2024).

Regarding the Western Balkans region, which historically faces a variety of socio-economic challenges, interest and investments in the process of transforming cities into smart cities have been increasing significantly in recent decades. Western Balkan countries are actively following the trend of transforming cities into smart cities.

However, several significant drivers influence the adoption of smart city transformation initiatives in Western Balkan countries. First, rapid urbanization and population growth impact the need to find more innovative and sustainable solutions. Furthermore, digitalization and increased connectivity contribute to better urban governance. In addition, EU accession aspirations have encouraged Western Balkan governments to align with European standards, programs, and initiatives for the modernization of urban infrastructure (World Bank, 2019). Three cities from the Western Balkans region, i.e. Elbasan (Albania), Sarajevo (Bosnia and Herzegovina), and Podgorica (Montenegro), aim to become climate-neutral and smart cities by 2030 as part of the EU's 100 climate-neutral mission and smart cities. Research and innovation actions, aligned with other EU programs and initiatives, will address energy efficiency, clean mobility, and green urban planning. City benefits include advisory support from the mission platform operated by NetZeroCities and opportunities to finance and join large innovation actions and pilot projects. In addition, the mission enables networking, exchange of best practices between cities, and support for citizen involvement in the mission (Balkan Innovation, 2022). The Western Balkans region, although located at the crossroads of important cultural and trade routes, still faces significant challenges that hinder the transformation process into smart cities. The region faces significant infrastructure bottlenecks that hinder efficient mobility and economic growth. The main challenges are the insufficiently developed road and railway network, limited transport corridors and inadequate maintenance of the existing infrastructure, institutional barriers, digital illiteracy of citizens, and their resistance to change (Letnik et al., 2024).

As a country from the Western Balkans and a candidate country for EU membership, North Macedonia also strives to join the trend for the development of smart cities to improve infrastructure, management, and quality services at the municipal level. The development and transformation into smart cities is a rising trend in North Macedonia, where the government's recognition of specialized strategies for future economic growth is of great importance. The Smart Specialisation process in North Macedonia started in 2018 when the letter of commitment from the country's government on starting the development of the National Research and Innovation Strategy for Smart Specialisation reached the Joint Research Centre (European Commission, 2024f). In that direction, a Specialization Strategy was designed, which is focused on ensuring the future development of North Macedonia by strengthening research, and innovation and creating a new business model for the needs of the national and international markets. The "Smart Specialisation Strategy of the Republic of North Macedonia 2023-2027" is a result of a detailed analytical and wide consultative process, that contributes to defining a strategic vision, priorities, and respective transformative activities that accelerate the transition towards innovative and knowledge-based economy and society. The Smart Specialization Strategy provides smart growth by defining high-priority domains in which there is the highest economic, innovative, and R&D capacity for creating new added value. There are four priority domains: 1) Smart Agriculture and Food with Higher Added Value, 2) Information and Communication Technologies (ICT), 3) Electro-Mechanical Industry – Industry 4.0, and 4) Sustainable Materials and Smart Buildings. All these priority domains of the strategy represent a basis and support for the development and transformation of smart cities (Smart Specialisation Strategy of the Republic of North Macedonia, 2023). The "EU for Municipalities" Program financed by the EU is also in that direction. The program is aimed at providing support to municipalities in North Macedonia for improving local self-government services through innovative concepts. It is expected that the program

will contribute to the local economic and social development of the municipalities in the Republic of North Macedonia by introducing innovations in the development of their policies, planning, management, and service delivery capacity. Some of the component projects of the program are the following: City of Skopje – Re-Cycle and Re-Use of Construct and Demolition Waste, Municipality of Ohrid – Roads Not Taken: Municipality of Ohrid Going Green, Smart, Innovative (OHRID GO), Municipality of Radovich – Green Heat-introduction of efficient customer-oriented small-grid district heating service based on renewable energy sources, Municipality of Strumica – Strumica-Smart Velo City, Municipality of Tetovo – Innovative digital municipal solutions in Municipality of Tetovo, and Municipality of Veles – Smart Solutions Veles (EU for Municipalities, 2024). Of all the cities in North Macedonia, Skopje focuses the most on initiatives for the development of a smart city. The social and environmental challenges facing the capital of the state have contributed to its inclusion in the energy and urban transition. Skopje has been a member of Energy Cities since 2010 and is involved in European initiatives and collaborations with various players at the European level, such as the cities of Dresden and Nuremberg, for the development of smart cities. The city is part of projects such as MatchUp and Power Up!, which focus on urban transition, energy efficiency, and reduction of greenhouse gas emissions. (Energy Cities, 2024). In its efforts to transform itself into a smart city, Skopje is mostly oriented toward reducing urban pollution, improving public transportation, and revitalizing its historic center. In terms of transport, Skopje has implemented innovative solutions for traffic management and control, which are the basis for the introduction of Smart Parking or Share Transport solutions in the city center. Apart from the mentioned initiatives, Skopje has implemented various projects for energy efficiency, urban mobility, and adaptation of the infrastructure to meet the needs of the citizens. Although awareness is growing in the country about the importance of innovation in urban development and the digital transformation of cities as a basis for their transformation into smart cities, significant steps are still expected to be taken. Cities are increasingly initiating partnerships with technology companies and pilot projects to implement innovative solutions related to public services, energy management, and transportation.

The trend of "smartening up modern cities" is increasingly present, both in the world and in Serbia. It can be said that Serbia is one of the countries in the Western Balkans region that recognizes the importance of applying this model of urban development, and according to the current situation, it can be said that it intends to develop cities in Serbia as smart ones. In the last few years, in Serbia, smart cities as a possible model of sustainable urban development have been receiving increasing attention at multiple levels and from different types of actors in society - from citizens to business entities and local governments to the scientific research community. The initiative to develop smart cities in Serbia primarily comes from the central level of government. Serbia unequivocally has intensive development of e-government services and infrastructure. Digital transformation, supported through strong digitization of public administration, has been among the priorities of the Government of Serbia for years. The regulatory framework for this area has seen significant improvements. First of all, with the Strategy of Sustainable Urban Development of the Republic of Serbia until 2030 ("Official Gazette of RS", number 47/2019), one of the important commitments of the Government of Serbia is the creation of a digital society of the future, i.e. smart and safe communities, which is also supported by regulations whose goal is to systematically improve the capacities of cities and municipalities for innovation (Legal information system of the Republic of Serbia, 2023). The Law on

Electronic Business in 2017 and the Law on Electronic Administration in 2018 were passed. A central institution was formed to support this process - the Office for Information Technologies and Electronic Administration of the Government of the Republic of Serbia. The State Center for Data Management and Storage - Data Center was built in Kragujevac, according to the world's highest technical and security standards. Some official projects such as those of the Ministry of State Administration and Local Self-Government under the name "Development of smart cities based on cloud infrastructure" have begun to stand out, which is based on the further development of E-administration with the aim of technical preparation for creating the basis for the development of smart city (Ministry of State Administration and Local Self-Government, 2022). Within the project "Journey to Smarter Future: Building Smarter and More Sustainable Communities in Serbia", which was initiated by the Nordic Business Alliance, in cooperation with the embassies of the Nordic countries in Serbia, the National Alliance for Local Economic Development (NALED) and the Standing Conference of Cities and Municipalities (SKGO), *The Road Map of Smart Cities in Serbia* was recently presented. As announced, Kragujevac will be the pilot project of the first smart city, as well as projects for the development of smart infrastructure and sustainable communities in local governments will be implemented throughout the country (Politika, 2024). Based on related research on medium-sized smart cities in Europe, a ranking of 38 cities and municipalities in Serbia was made, based on which an assessment was made that eight cities have the greatest potential for the development of a "smart" city - Kragujevac, Pančevo, Zrenjanin, Kruševac, Čačak, Subotica, Vršac and Kraljevo. Quantitative analysis indicates that three dimensions were crucial for the ranking of cities: population, economy, and governance and that the most significant differences between cities are made in these dimensions (Vasilić, 2023). In the analysis of the factors of the potential development of "smart" cities in Serbia, exogenous factors refer to EU policy, especially policy related to the development of cities and regions, and global economic flows that, in combination with a specific socialist heritage, have created a kind of hybrid capitalism. At the national level, exogenous factors are embodied in the centralized model of management of political and economic resources the specific territorial distribution of cities, and unequal socio-spatial development. Also, the problem in the socio-spatial development of Serbia is highlighted through the strong centralization, i.e. the dominance of Belgrade and several other larger cities, which created an incoherent and asymmetrical urban system that is not compatible with the goals of forming a European urban system (Vasilić, 2023). The development of a smart city requires a very good IT infrastructure, and in this context, the largest cities in Serbia, such as Novi Sad and Belgrade, have perhaps the greatest potential to be profiled as smart cities. It is evident that demographic and urbanization processes are taking place in the cities of developing and underdeveloped countries. Belgrade can be considered as one such city, which has a valuable chance to direct its urban development in a sustainable direction (Vračarević, 2019), which could be achieved through the application of the smart city concept. With the global digital revolution, Serbia certainly has a chance to catch up and connect with developed countries. However, the concept of a smart city is much more than individual projects and solutions, and in this sense, research so far shows that there is still no smart city in Serbia in the full sense of this concept, but Serbia is certainly on the right track to make this happen in the future. Although they should be a prerequisite for balanced socio-spatial development of the state and its units, there are numerous calls for the development of cities in Serbia as potentially smart cities. Research conclusions point

out that it is necessary to point out the contextual specificities of researching the potential of smart cities in Serbia.

The transformation in smart cities in North Macedonia and Serbia represents a significant opportunity for dealing with all urban challenges, promoting sustainable development, and improving the well-being of citizens. Although significant progress has already been made, there is still much work to be done to overcome all the challenges and limitations in realizing the full potential of the various smart city transformation initiatives. With integrated cooperation between government, academia, industry, and civil society, North Macedonia and Serbia could use technology and innovation to build prosperous and sustainable cities for future generations.

CONCLUSION

The concept of a smart city is gaining more and more importance, positioning itself as the city of the future and as the only possible model of sustainable urban development. Smart cities are environmentally friendly or "green" cities, i.e. sustainable cities that implement innovative technical solutions that contribute to various areas of work and life in modern cities. The goal of smart cities is to save time, energy, and money, which will be integrated into local development strategies. The United Nations, including the UN Department of Economic and Social Affairs (UNDESA) and member countries, have been dealing with the topic of sustainable development for decades. Many strategies, policies, and international events deal with the topic of sustainable development, but undoubtedly Transforming our world: the 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015 at the UN Sustainable Development Summit, is the most significant in that domain. This global agenda provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. Under the Sustainable Urban Management thematic area, UNCRD will further strengthen its activities in the areas of urban planning, design and building, integrating disaster management planning, and with a sectoral focus on environmentally sustainable transport, 3Rs (reduce, reuse, recycle) and zero waste policies and programs, and international partnerships towards building sustainable and resilient communities and cities. Among different programs of UNCRD, one is dedicated just to smart city development, called the Smart Cities Programme. UNCRD launched a Smart City Project in 2021 which aims to provide technical assistance and support to urban policymakers, planners, and city officials for building their cities and communities safer, smart, efficient, resilient, inclusive, livable, and sustainable through smart city solutions.

The optimization of resources and maximization of citizen welfare was always high on Europe's agenda. Together with a strong digital transition, Europe is one of the leading continents when it comes to smart cities and sustainable urban development, and now it has already a tradition of development respecting the principles of sustainable urban development. Smart cities have appeared as a key development priority for the EU, through which better services for citizens will be provided, local challenges will be answered and the goals of the European Green Deal will be reached. Integrated efforts of the EU, local and national governments, the private sector, local and international networks, NGOs, and citizens are essential to turn visions of connected, efficient, and citizen-centric cities into reality.

Regarding the Western Balkans region, which historically faces a variety of socio-economic challenges, interest and investments in the process of transforming cities into smart cities have been increasing significantly in recent decades. Western Balkan

countries are actively following the trend of transforming cities into smart cities. However, several significant drivers influence the adoption of smart city transformation initiatives in Western Balkan countries. First, rapid urbanization and population growth impact the need to find more innovative and sustainable solutions. Furthermore, digitalization and increased connectivity contribute to better urban governance. In addition, EU accession aspirations have encouraged Western Balkan governments to align with European standards, programs, and initiatives for the modernization of urban infrastructure. The transformation in smart cities in North Macedonia and Serbia, as Western Balkans countries and candidate countries for EU membership, represents a significant opportunity for dealing with all urban challenges, promoting sustainable development, and improving the well-being of citizens. Although significant progress has already been made, there is still much work to be done to overcome all the challenges and limitations in realizing the full potential of the various smart city transformation initiatives. With integrated cooperation between government, academia, industry, and civil society, North Macedonia and Serbia could use technology and innovation to build prosperous and sustainable cities for future generations.

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INOVATION PROCESSES AS A RELEVANT STRATEGIC TOOL IN MODERN AGRIBUSINESS

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ABSTRACT

The challenges of today's world bring many pressures on agriculture. Population growth, the impact of climate change, the need to reduce the emission of greenhouse gases in agriculture, the rapid development of emerging economies and the growing instability associated with the lack of land, water and energy condition the dynamic development of agriculture, which causes increasing competition between companies on the market of agricultural products. As one of the modern strategic responses to emerging problems is the application of innovative processes and technologies. The use of innovative technologies for the agricultural sector is necessary to increase the efficiency of the functioning of agricultural production entities and contributes to a radical change in the quality of manufactured products. Therefore, the intensification of innovative processes in agriculture is very topical, as it contributes to the growth of labor productivity, savings in material, labor and financial resources and an increase in the volume of production. This article is intended to substantiate the role of innovations in the development of agriculture. Through a literary review of eminent experts, the authors of the article focused on identifying the importance of innovative techniques and technologies in the modern development of the agricultural industry.

Keywords: innovations, innovative processes, agriculture business.

INTRODUCTION

Global changes, which are increasingly present in modern business, lead to a burden on the agricultural and food system. The growth of the human population imposes a greater need for food in the context of the increasing devastation of nature and the collapse of biodiversity: the reduction of natural resources (land and fresh water), climate change, and the increase of greenhouse gas emissions. On the other hand, agriculture must accelerate changes in terms of reducing the use of inputs such as antimicrobials and pesticides. Also, care must be taken to reduce soil compaction during its exploitation. All this leads to great complexity, which increases instability and increases the risk of failure. Therefore, one of the key activities within agricultural production is the implementation of a strategy for improving production techniques and ways of organizing the agricultural and food system.

One of the most effective strategic responses to the presented problem is the application of innovations and the implementation of innovative processes. Intensification of innovations in agriculture is very topical, because it contributes to the growth of labor productivity, savings in material, labor and financial resources, increase in the volume of production and the like.

Innovation can be interpreted as the implementation of a new or significantly improved product, process, new marketing method or new organizational model into business practice (Zehir et al., 2008). The new product has a lower price, improved features and features that it never had before or even never existed on the market (Baković, Ledić-Purić, 2011).

Innovation represents the creation or improvement of competitive technologies, products or services, which are implemented in the work of the company in a given period of time (Gamidov et al., 2000).

Makaneenko (2008) points to the existence of the concept of agro-innovations, i.e. innovations carried out in the agricultural sector. Innovations in agriculture lead to higher yields, which in turn creates the possibility of reduced exploitation and depletion of land.

There are many approaches to the definition of innovation in agriculture. According to Ivanov (2008), innovation in agriculture is the implementation into business practice of the results of research and development in the form of new plant varieties, breeds and species of animals, new equipment, new technology, the application of new forms of organization and management methods, which can improve the efficiency of production.

Rodionova (2010), believes that innovation in agriculture represents the final result of the implementation of innovations in the field of agriculture related to plant varieties, animal breeds, plant protection technologies, which leads to economic, social, ecological and other types of effects.

Therefore, innovations in agriculture can be defined as changes, which the organization introduces into the company's activities, with the aim of reducing negative impacts on biodiversity and increasing the market competitiveness of products.

CHARACTERISTICS AND IMPLEMENTATION PROCESS OF INNOVATIONS

Innovation in the broadest sense of the word represents a new way of approaching various spheres of human life and work (agriculture, economy, pharmacy, healthcare, education, space exploration, etc.). More narrowly, innovation is a new and revolutionary way of approaching problems in the economy and production, or, to what creates profit.

There are two key characteristics of innovation. The first is that innovation is not a single event, but a process that must be managed. Also, the influences on the process must be managed in order to influence the outcome (Baković, Ledić-Purić, 2011).

Four things are important for successful innovation (Posavec et al., 2011):

- New - something that did not exist before or was achieved by combining available resources in a new and original way.
- Better - introducing something new just because it's new and exists doesn't make any sense and usually does more harm than good.
- Necessary – there must be a need to solve a problem or develop a new product or service.
- Economically justified - in order to fulfill its purpose, the company must realize direct or indirect benefits from the innovation.

The new solution is a relative thing, ie. it can include the application of other people's experience, that is, already known solutions, which have not yet been applied in a certain environment. A special type of innovation are inventions, which are characterized by absolute novelty, i.e. new solutions whose use has not yet been registered.

Pullen (2010) distinguishes incremental and radical innovations as fundamental types of innovation. Incremental innovations imply the continuous improvement of existing products and processes, while radical innovations imply their replacement with completely new forms. Radical innovations are the result of advances in knowledge, while common incremental innovations are the result of improvements in techniques (O'Dwyer et al., 2009).

Based on who implements the innovation, they differ (French et al., 2014):

- Entrepreneurial innovations – entrepreneurial innovations are those carried out only by producers (regardless of the size of the company). This type of innovator can lead to changes in products, processes, marketing or organization to achieve economic, social or environmental improvements.
- Organizational (institutional) innovations – these types of innovations are introduced by different types of organizations or institutions (public, private, academic, non-governmental or governmental). They can also refer to processes, marketing or organizations

The implementation of innovations in agriculture should be seen as a series of four phases: development of innovations, their validation, reconstruction and implementation. A series of innovation classification criteria enables the organization of innovative activity of companies on a rational basis (Almukhambetova et al, 2017). The technology of implementing innovations in the activity of agricultural enterprises is presented in Figure 1:

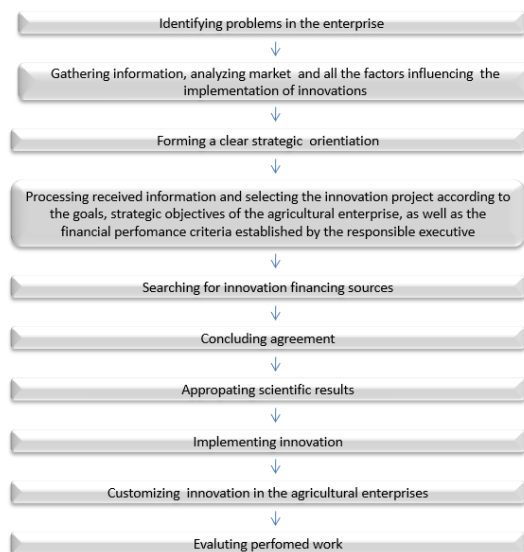


Figure 1. Innovation implementation technology with regard to the activities of agricultural enterprises (Almukhambetova et al, 2017)

Innovation management is a process that includes the whole range of decisions, activities and measures that should be applied to enable the transformation of an idea into business value. This process can be applied to all kinds of ideas, whether it is a product, process or service. The main goal of innovation management is to provide a set of measures and tools that will enable inventors to respond to challenges throughout the innovation cycle and to turn their ideas into innovations on the market.

THE ROLE OF TECHNOLOGICAL INNOVATIONS IN AGRICULTURAL PRODUCTION

Throughout history, technological innovations in agriculture have been extremely diverse and rich. They enabled farmers to successfully cope with natural and biological challenges and formed the basis for the growth and development of agriculture around the world.

Numerous innovations in the mobile, information and energy sectors today have a great impact on agricultural holdings (farms). Advances in technology can have a significant impact by optimizing farmer efficiency, including the use of water, waste, land, energy and time. For example, precision farming technologies can save time and money to create a more productive plantation or farm. (Tamer, 2013).

Innovations contribute in different ways to establishing the compatibility of the economic, social and ecological dimensions of the agriculture and food production sectors. The contribution of innovation is reflected in the following segments of the functioning of the entire food production system (El Bilali and Allahyari, 2018):

- Precise analysis of the situation and needs in production, as well as an improved data collection and processing system, which contributes to the controlled, optimal and rational consumption of all inputs, the excessive use of which leads to pollution or endangering the state of the environment;
- Automation of agricultural activities leads to reduction of losses in production, growth of productivity, as well as reduction of production costs. All this results in the growth of basic economic indicators in terms of economy and profitability of production;

- Innovations contribute to the growth of the yield of agricultural crops, improvement of the quality, healthiness and safety of agricultural and food products, improvements in the processes of processing, preservation, storage and transportation of food;
- The application of innovations in agriculture is an important factor in keeping young people in rural areas, it is an incentive for starting and developing their own business, developing new products and services, new sales channels and the like.

THE IMPORTANCE OF APPLICATION OF INNOVATIVE TECHNOLOGIES IN SUSTAINABLE AGRICULTURAL PRODUCTION

Sustainable agriculture is important because it preserves soil, water and biodiversity, does not degrade the environment, is economically and socially acceptable, and natural resources are managed in such a way as to ensure the satisfaction of the needs of current and future generations. Sustainable development of agriculture is imperative today, which requires modern education, with an innovative approach and greater investments in research and development of "clean" technologies. The role of knowledge and knowledge management is becoming a key strategic issue of agro-economy, and innovation is considered an essential factor for survival and development. For a sustainable competitive advantage, knowledge management, in synergy with modern achievements, is very important.

In agricultural production conceived in this way, emphasis is placed on the least possible disruption of the agro-ecological system and natural disease and pest control mechanisms are encouraged. This type of production requires agrotechnical measures to be carefully selected and coordinated, taking into account the interests of producers and consumers, as well as the capacity of the environment. This also implies that the knowledge of farmers is regularly improved, the stability and balancing of the agro-ecosystem is maintained, insists on the preservation of soil fertility and animal welfare, as well as good agricultural practice. It is believed that modern technologies have the potential to support the agricultural sector in overcoming global challenges. At the same time, new knowledge enables better and more practical solutions. Due to the penetration of information and communication technologies in the sphere of the agricultural sector, new technologies in agriculture are based on computer technology and integrated systems. They provide numerous application possibilities and various benefits, such as the use of satellite navigation and satellite guidance of self-propelled agricultural machines, automatic control during agricultural work and other types of development of precision agriculture (Luecke & Katz, 2003).

In this context, information technologies give great support to a good transition, towards agroecology in territorial food systems and protection of family farms. They make this contribution through the acquisition of information for a better understanding of complex agrosystems, while they are of great use in strategy development and are significant support for concrete actions (Scholz et al., 2014).

THE ROLE OF DIGITAL TECHNOLOGY AS A PREDICTOR OF PRECISION AGRICULTURE

The introduction of new technologies requires huge financial resources, which is more realistic in more developed countries, because they have the capacity to provide greater support to economic entities and thus make the purchase of sophisticated

equipment more accessible. The use of electronics and computers includes: sensors, microprocessors, agricultural software, etc. Aircraft and drones are being used more and more for monitoring crops, experimenting with robotic technology in animal husbandry, crop mapping, yield monitoring, etc.

Digital technology was first applied in agriculture about 50 years ago (satellites, then computing capacity, GPS, etc.) and became more widespread with new data collection systems and the term "digital agriculture" came into use in the early 2000s and is a system for managing the flow of many information such as information about weather data, fuel, organic fertilizer, crop condition, seed, bio-aggressor level, etc.

Digital agriculture refers to a form of agriculture that uses information and communication technologies (ICT) as follows (Bellon-Maurel and Huighe, 2016):

- for data collection (satellites, sensors, connected objects, smartphones, etc.),
- for data transfer and storage (3G/4G coverage, satellites)
- for data processing (computers accessible via very highspeed communication)
- for the availability of data at every level of agricultural production and its ecosystem, whether on the farm (optimization of crop operations, herd management, etc.), in support services (new agricultural advisory services based on automatically collected data), management, or in the value chain (improving inputs such as seeds, improving harmony between production and markets, etc.)

According to Gvozdenac (2017), precision agriculture is based on high technological possibilities:

- Global Positioning System (GPS) - GPS navigation system uses all collected information to accurately determine the position of agricultural machines. The automation of certain tasks, especially driving agricultural machinery, has greatly benefited from the advent of GPS, especially the centimeter-accurate models that offer absolute referencing.
- Geographic Information System (GIS) - enables the collection, analysis, visualization and storage of data from a specific location. It serves to store natural resource databases with a graphical user interface that allows users to easily access this data using geographic maps. GIS ensures that farmers manage land cultivation works in real time, but also plan future activities, based on timely information obtained directly from arable land.
- Remote Sensing (RS) - remote research involves the collection of data from a distance, with hand-held devices, sensors mounted on agricultural machines, from satellites, etc. Sensors located in the field or on machinery enable the integration of spatial and temporal data. Timely received information represents key inputs for precise irrigation, fertilization and use of pesticides; better visibility and early detection of crop conditions; yield forecast; monitoring the dynamics of plant development, etc.
- Variable Rate Technology (VRT) - involves matching input quantities with field conditions. The software has tools for: planning and reporting; recording of data on field conditions, soil preparation works, spraying, amount of fertilizer during feeding, variations during sowing, plant population during planting and weather conditions, etc.

The function of digital agriculture is not limited only to the collection and processing of data. The goal is to use this data in decision-making and determining the actions to be taken, both spatially and temporally, in order to optimize cultivation techniques that can reconcile a high level of production, crop quality and environmental protection.

The principles of precision animal husbandry and precision agriculture can be applied to agroecology as they lead to interventions adapted to the needs of plants and animals. With precision agriculture, it is possible to map the diversity within a crop and apply different measures to different parts of the plot (Bellon and Huighe, 2016). Mixed crop (multi-species, multi-variety) or intercropping agriculture can be applied on a large scale through high precision operations (sowing to harvest) and characterization or sorting of mixed harvest products.

Precision animal husbandry involves monitoring environmental conditions (measuring the atmosphere in buildings or external conditions) and animals. In the last twenty years, sensors on animals or in their environment, imaging (2D, 3D, infrared), accelerometers, sounds, automated measuring devices (scales, water meters, milk meters, feed distributors, etc.) have been used (Chastant Maillard and Saint- Dizier, 2016).

Štefanek (2014) notes that farmers in developed countries are already applying some of the technological possibilities of precision agriculture and cites the following examples:

- intelligent tires, which have the ability to quickly change the pressure during operation, without stopping;
- automatic management of tractors during plowing;
- on-land plowing with modern plows, which use sensors for precise determination of plowing depth;
- on-line fertilization - crop feeding according to the needs of the plant and the potential of the soil, where the sensors, which are located on the tractor or special supports, read the reflected signal from the plant, send it to the computer for processing, so that information about the amount of fertilizer is sent to the device which should be applied;
- modern inter-row cultivators - for mechanical destruction of weeds, with simultaneous feeding of crops;
- yield mapping - yield maps show the heterogeneity of yields by production boards and the causes of yield reduction;
- 3-D scanning of plots in soil preparation for sowing;
- mobile robotized solar power generators - remotely controlled automated devices for the production of electricity;
- devices for scanning the presence of weeds, in order to spray only parts of the plot where they are located, etc.

APPLICATION OF ROBOT TECHNOLOGY AND DRONES IN AGRIBUSINESS

The rise of robotics is historically rooted in industrial applications, particularly automotive, for the automation of production lines (Bahrin et al., 2016). Unlike mobile robotics in industrial environments or in road traffic, mobile robots in natural environments require specific adaptive capabilities to cope with the variety of interaction conditions and their variability. This involves online modification of perception and control parameters (such as modifying response times as a function of speed or adapting detection thresholds to lighting conditions (Bergerman et al, 2016).

As a result, applications of robotics in agriculture have primarily focused on indoor environments, especially for livestock production (Bergerman et al., 2016). In this sense, the largest market for robotics in agriculture is currently in the livestock sector, with feeding and milking robots. They can operate using numerous reference points and benefit from special arrangements to maintain high repeatability. Thus, they can perform demanding tasks (such as milking or feeding animals) and free up the farmer's time. Such developments are increasingly common in agricultural practices (Tse et al., 2018).

In crop farming, the automation of certain tasks, especially driving agricultural machinery, has greatly benefited from the advent of GPS, especially centimeter-accurate models that offer absolute referencing. Thus, many devices aimed at automating the operation of machines under the supervision of a "driver" have emerged, sharing a number of research challenges with advances in driverless vehicles.

Many strategies in agricultural robotics are based on cooperation between less complex robots that can work together or in the same area. This reduces the risks regarding the operation of each robot (limited kinetic energy in case of impact) and their cost, but it shifts the issue of complexity to grouping and synchronization of the group (Blender et al., 2016).

For a more intensive application of robots in agribusiness, one must have access to the widest range of technological possibilities. The introduction of new technologies requires huge financial resources, which is more realistic in more developed countries, because they have the capacity to provide greater support to economic entities and thus make the purchase of sophisticated equipment more accessible.

In addition to robots, drones are used in precision agriculture. The use of drones in agriculture is considered a good platform for the following activities (Ristić L. 2018):

- monitoring crop development; early detection of disorders in plant development;
- determination of vegetation height; determining the need for irrigation;
- detection of diseases, pests and soil erosion; scanning the terrain and obtaining a detailed documented report on the state of the plot and crops;
- checking the operation of machinery;
- assessment of yield and resource savings;
- aerial surveillance and detection of unauthorized access to property.

CONCLUSION

Innovations are the driver of economic growth and well-being in countries. The development and application of new technologies determines the future of agriculture. Without modernization of production capacities and constant investment in education and improvement of expertise, the situation in agriculture cannot be improved.

The field of digitization of agriculture and the application of ICT, as well as the application of innovations in biotechnology and nanotechnology in agricultural production and the food industry, are today fields where all countries of the world compete intensely. Digitization of tools in agriculture, application of agricultural robots, drones, information and communication solutions, then numerous breeding stations, with constant experiments in the segment of cultivation technologies, registration of new varieties and the like, are only some of the innovative solutions that are of key importance for progress in agricultural sector.

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PROGRAM FOR MANAGEMENT OF SPORT ACTIVITIES AT UNIVERSITIES

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ABSTRACT:

Once a strategic decision has been made regarding the positioning of sports service and sports product, the university should start preparing an essential program to fulfill its responsibilities and plans. The organizational program itself is a written document where it generalizes how the process of realization of goals will take place. The global model of managing sports activities within universities is influenced by several factors such as: the external environment, organizational structure, and individual and group priorities. The process reveals how the task is set, how the resources are used, and how the work and development departments cooperate. The management of sport activities of the students in our case is directly related to the management of the University Sport Club. The analysis shows that the University Sport Club should be the leading unit of sport-educational activities of the students, therefore the program that is being worked on should necessarily be in sync with the university authorities and the policy that the university leads itself in society, should correspond to the legal framework that exists for higher education in MES, but creates changes and innovations at the same time. The result of our management program model is student being satisfied by sport, which should be equal to the difference between the health benefits and the expenses incurred. It means that the strategy of creating and developing University Sport Club and specifying specific management program, is an important step towards the necessary reorganization to enrich the educational offer of universities, through the forms of sport as a coordinated and highly standardized product in the world.

Keywords: Program for management, sport activities, universities, students, university sports club.

INTRODUCTION

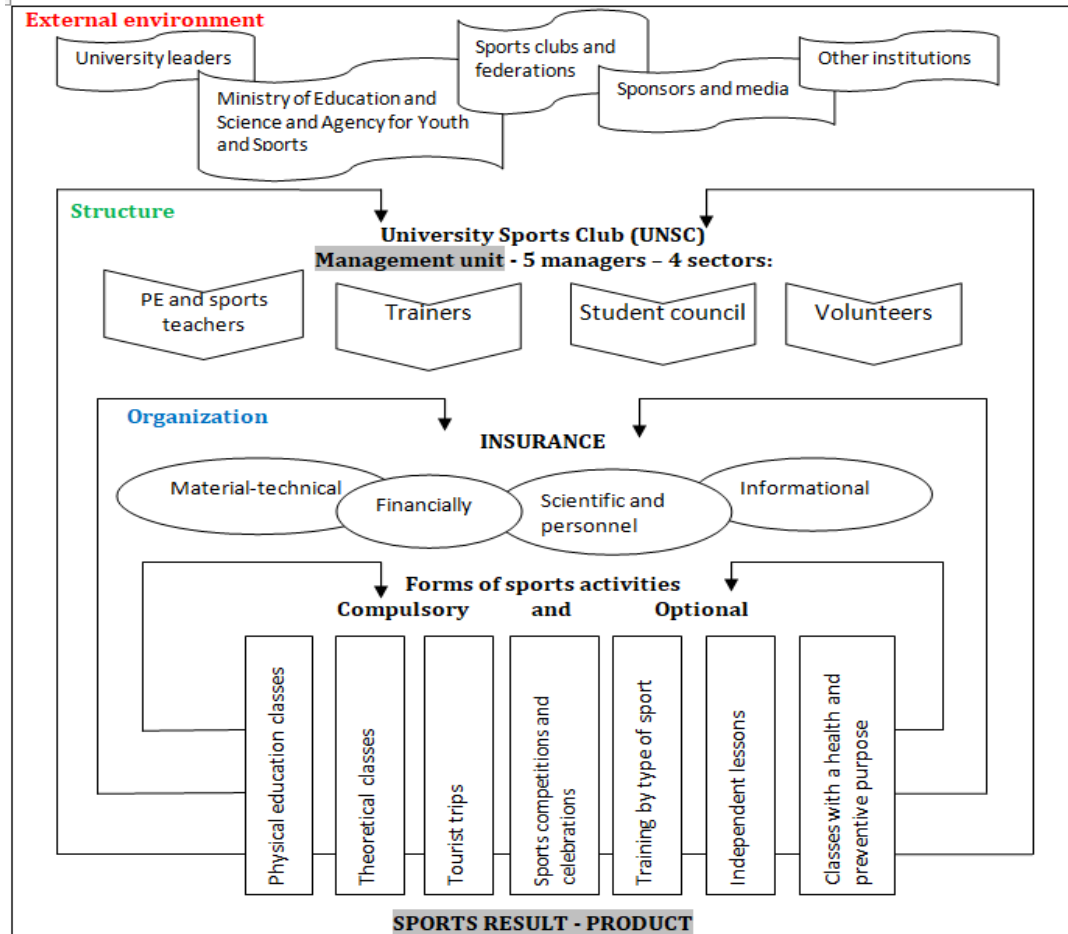
The management of sport activities for students is directly related to the management of the University Sport Club (UNSC). Given the fact that universities need to adapt to external changes, competition is increasing, market share is changing, and technologies, resources and government regulations are changing. The university sport club should be the leading unit for sport-educational activities of students, therefore the program that is being worked on must be in sync with the university authorities and the policy that the university leads itself in society, corresponds to the legal framework that exists for higher education in MES (Ministry of Education and Science), but creates changes and innovations as innovation in terms of "obligatory sport activities" at the same time. On the other hand, the program should follow the Law on Sport and the regulations from AMS (Agency for Youth and Sports), because it is part of the University Sport Federation and claims that each special club of certain sport at the university is the head of corresponding sport organization.

The great importance think for the success of sport activity, both in the various forms of development of sport for high sport achievements and school sport, as well as in student sports, is the relationship between other various institutions, sponsors, media, etc., with which the University Sport Club should cooperate independently of the functioning of other parts and activities at the university and its faculties.

MATERIAL AND METHODS OF WORK

Once a strategic decision has been made regarding the position of sport service and the sport product, the university should start preparing an essential program to fulfill its responsibilities and plans. The organizational program itself is a written document that generalizes how the process of realization of the planned activities takes place. Our goal is a global model for managing sport activities within universities, which is influenced by multiple factors such as the external environment, organizational structure, individual and group priorities. We used an analysis-expertise for the proces that reveals how the tasks are set, how the resources are used, and how the sport works and development departments cooperate (Fig. 1).

Fig.1 - University Sport Club Management Model (original by author)



RESULTS AND DISCUSSION

Management inside UNSC is a conscious and programmatic regulation of activities, following the strategic goals of the University. The authoritative governing body is the "management unit", which includes five heads, signatories of the statute, and the founding board of UNSK:

- one of the managers of UNSC should be from the very top – the Management Board of the University in which UNSC was founded: rector, general director, or president if it is a private university. Above all, it should protect the interests of the university, but at the same time contribute solving serious issues related to the development of the UN;
- the second of the UNSC managers should be a graduated sport manager, who will coordinate sport activities, organize the internal and external needs of university sports;
- the third of the heads of the UNSC should be a legal entity, which will take care of compliance with the legal norms, in one hand, the rights and obligations towards the Ministry of Education and Science - the Law on Higher Education at the other hand, the obligations towards the University Federation, AMS, the Law on Sport and all external organizations, which it will cooperate with;

- the fourth manager of UNSC should be from the field of sport marketing with modern knowledge and skills of an efficient marketing process, which is considered an exceptional competitive advantage today;
- the fifth manager should be a kinesiologist who, will maintain the level and character of the essence of the sport together with the second manager, according to the new times and the new needs of modern students.

Authority, responsibility, the relationship between functions, and the degree of judgment in decision-making in the Management Model affect the "operational unit of management", itself, which are four different sectors of management of the sports activity:

- Professors of physical education, sport, sport management, and sports tourism - these are kinesiologists with a specialized sport orientation through a PhD, who will lead the mandatory theoretical classes in "Sport and health" in the first and second year of undergraduate studies;
- Coaches - appointed to manage the sports competition activity for a given type of sport (depending on the involvement of different sports), which can be chosen by the students themselves for six semesters of undergraduate studies and the absorption of the technique, tactics, and methodology of the chosen sport;
- Student council - sports representatives among the students in the student council, who will protect the rights of student-athletes and inform them about sport event, opportunities to obtain a sports degree, etc.;
- Volunteers - students of the fourth year of undergraduate studies or the fifth year of master's studies, who have already shown and proved themselves as good athletes and competitors in a certain sport while they were in the first three years of studies (regardless of which faculty they study at), and continue to improve as athletes.

An important part of the management program is "Insurance" because it includes essential factors for the realization and development of strategic goals:

- Material - technical insurance - in the form of a sport material base and conditions provide an excellent opportunity to conduct sport lessons, motivating students in that direction. These include a multifunctional sport hall for sport games, martial arts and dances, fitness, and table tennis, as well as appropriate props and equipment;
- Financial insurance - this includes the financial structure that consists of self-funding as a minimum fee from students participating in sport activities, sponsors and donations, and help from the university and the University Sport Federation of Macedonia. Preparation of project programs for activities in the field of sport, actions for recreation, animation, and health before municipal, government, and foreign organizations;
- Scientific and personnel insurance - for the successful realization of the Program for the work and development of the university sport club, and from here also on student sport, the university should invest in: the professional development of specialized personnel - sports managers, professors, trainers, and demonstrators of the clubs, purchase of professional literature: books, video materials, registration of personnel for current and professional seminars and courses in the country and abroad, organization of conferences, etc.;
- Information insurance - in the form of mass notification of students who want to do sport (additional sport activities), creation of different sport clubs, work

programs for each type of club separately, discovery of sport inclinations and talents, all presented through university sport magazine, social networks, etc.

In the last level of management, we present the "forms of sport activities" divided into mandatory and optional sport activities depending on the needs and interests of the students. Different types of professional training are developed in this way:

- Physical education classes - are the basic physical preparation, which students must have. These include improving the physical development of the body, increasing sports qualities, and satisfying the biological need for movement. According to already done research⁷ and analysis of studies, mandatory classes are best in the first two years of undergraduate studies, two hours a week;
- Theoretical lessons with a sports educational focus - this is the basic theoretical preparation through the history and development of physical education and sport, rules for specific sport, physical abilities, planning of sport training, sport tourism, recreation and animation, etc. These theoretical classes should be organized once a month by sharing presentations and experiences;
- Tourist trips - periodic activities over the weekend or during the pre-colloquium week (after the exam period) to improve the mental and moral preparation of students through movement on different terrains or visiting sports events;
- Sport competitions and holidays – optional or facultative activities in the sport clubs and teams of the faculties, participation in university events with other teams from the university, as well as competitions at the national level against other sport clubs and unions, with the help of which students will get the necessary competition experience;
- Training by type of sport – students from all academic years of the faculties within one university enroll and master basic technical-tactical preparation, motor knowledge, and skills for a certain type of chosen sport;
- Independent sports activities - these are activities that students can do in their free time, before or after other theoretical lectures or exercises in their home curricula. Such sports activities include morning gymnastics, fitness, jogging, and of course a gym available near the lecture halls;
- Activities with a health and prophylactic purpose - this includes medical health activities, and practical classes for kinesitherapy, where, through certain precisely determined exercises, young people who need prevention will be helped to reduce physical deformities and physical strengthening of the body.

The result of this management program model is student satisfaction with sport, which satisfaction should be equal to the health benefits (mind and body) minus the costs incurred. This analysis shows that utility should be the highest indicator in sports and for it to continue throughout a person's life, it should be properly managed during the educational period without exception and for students during their studies in higher education.

CONCLUSIONS

It is a challenge to work on problems in the relationship between sport management and formal education, and at a specific time of the existence of both activities because there is great resistance to changing the established stereotyping in Macedonia. Many years of experience through the creation of curricula in the field of sport as a professor at a university and also a coach directed me to the following conclusions regarding the management of a University Sport Club:

1. Due to the peculiarities imposed by the educational system in Macedonia, the sport activities of the faculties are an open project for work, which should start with reorganization first in the universities themselves;

2. The unity between the theory of sport management and the setting of a strategy and program of practice with a special focus on student sport has a double profit. The first is overcoming the profile of a sport manager as an open position and idea of presence in Macedonian sport and especially in education. The second is screening of the situation and creation of measures for corrections in the development policy and curricula of the faculties that will enable sport coordinated functioning in the direction of its revival among students;

3. The creation of a quality product is a complex process and requires analysis along the lines of management and marketing research, and this certainly applies to sport services as well;

4. The model for creating and introducing sports activities in universities is an excellent unit for uniting and managing a more active sport student movement. The management program is a step towards enriching the educational offer of the universities through sport forms as a coordinated and highly standardized product in the world.

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ASSESSING THE ENVIRONMENTAL AND ENERGY ASPECTS OF FERTILIZER APPLICATION IN SUSTAINABLE AGRICULTURE

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ABSTRACT

The adoption of advanced agricultural practices in Serbia represents a significant leap towards sustainability in the sector. Through precision nitrogen fertilization and reduced tillage, a notable 32% enhancement in energy efficiency within cropping systems is feasible, reducing energy consumption per unit of food produced from 5 GJ to 3.4 GJ per hectare, alongside a tangible decrease in greenhouse gas emissions, thus bolstering efforts to combat climate change. Embracing these integrated techniques in Serbia and beyond holds promise in addressing the imperative to augment agricultural productivity while safeguarding ecological balance, amid projections of global mineral fertilizer consumption reaching 200 million tons by 2025. Advocating for the adoption of organic fertilizers in tandem with precision agriculture technologies offers further potential for mitigating adverse environmental impacts, bolstering soil health, biodiversity, and optimizing resource allocation. Moreover, these practices can lead to significant economic efficiency gains, reducing production costs and increasing overall profitability in agricultural operations. Additionally, investing in sustainable agriculture can create new job opportunities and stimulate economic growth in rural areas. Energy efficiency emerges as a cornerstone in modern agriculture, with the transition to integrated and low-intensity farming systems poised to slash energy usage by over 60%, making a significant contribution to overall energy conservation. Achieving these objectives necessitates a thorough assessment of existing agricultural practices in Serbia, alongside collaborative efforts from governmental bodies, agricultural experts, and farmers, underpinned by adequate funding and training. With the right approach and support, Serbia has the potential to emerge as a regional leader in sustainable agriculture, charting a path towards a productive, environmentally conscious, and economically resilient future.

Keywords: Precision agriculture, Nitrogen fertilization, Energy efficiency, Agricultural sustainability, Economic efficiency.

INTRODUCTION

Global agriculture is facing unprecedented challenges, including the growing demand for food due to the ever-increasing world population, which is expected to reach 9.7 billion people by 2050 (UN, 2020; Zaib et al., 2023) and the tripling of the consumption of natural resources such as soil and water in the last 50 years (FAO, 2019). This dynamic has led to an intensification of food production, but also to significant environmental consequences, including the loss of genetic diversity and the contamination of water and soil with agrochemicals (Penuelas et al., 2023; Garcia and Thompson, 2023; Zaib et al., 2023; European Environment Agency, 2024). In this context, the demands for higher productivity with lower consumption of inputs underline the need to introduce sustainable agricultural practices (Pretty et al., 2018; Davis and Lee, 2022; Çakmakçı et al., 2023; Gavrilovic et al., 2023).

In parallel to the global challenges, Serbia is facing similar problems in its agricultural sector. National agriculture, which is dependent on natural resources such as land and water, is at a turning point (Gudžić et al., 2019; Jevtić, 2022). Advanced agricultural practices, such as precise fertilizer application and reduced tillage, are key strategies to reduce energy consumption and greenhouse gas emissions (Aksentijević et al., 2017; Dimitrijević et al., 2020). These practices not only meet the global imperative of sustainable agricultural production, but also offer tangible economic benefits by reducing production costs and increasing profitability (Birovljev and Kleut, 2016; Vukelić et al., 2023). The aim of this study is to evaluate the energetic and environmental aspects of fertilizer use in the context of sustainable agricultural production in Serbia.

Table 1. Challenges in sustainable agriculture in Serbia and proposed measures

Challenges	Characteristics	Proposed measures
Limited water resources	Fluctuations in rainfall and drought affect yield	More efficient irrigation, drip irrigation systems
Soil and water pollution	Accumulation of nitrates and phosphates from mineral fertilizers	Organic and fertilizers with controlled nutrient release
Loss of biodiversity	Reduction in biodiversity due to intensive agricultural practices	Agroecological practices, intercropping, conservation of natural habitats
Energy inefficiency	High consumption of fossil fuels	Renewable energy sources, solar energy and biomass

Source: Authors

Table 1 summarizes the main challenges for sustainable agriculture in Serbia. Each challenge is specific, and so are the proposed measures to overcome them. It provides a comprehensive overview of the problems facing sustainable agriculture in Serbia and proposes practical and feasible strategies to solve them. The proposed measures emphasize the importance of adaptation and innovation in agriculture to ensure the sustainability of food production, the protection of natural resources and the resilience of the environment.

Table 2. Comparison of current state and potential improvements

Aspects	Current situation	Potential improvements
Water consumption	High consumption due to inefficient irrigation	Reducing in consumption through more efficient irrigation systems
Soil and water pollution	High pollution due to the use of conventional fertilizers	Reducing of pollution through the use of organic and controlled-release fertilizers
Biodiversity	Damage to biodiversity due to intensive agricultural practices	Improvement of biodiversity through agroecological practices
Energy consumption	High energy consumption due to dependence on fossil fuels	Reduction of energy consumption through the use of renewable energy sources

Source: Authors.

Table 2 provides a comparative analysis of the current state and possible improvements related to four key aspects of sustainable agriculture in Serbia: water consumption, soil and water pollution, biodiversity and energy consumption. The table clearly shows how changes in agricultural practices can significantly contribute to solving Serbia's environmental problems while promoting the economic and environmental benefits of sustainable agriculture.

Given the need to produce larger quantities of food with fewer inputs, the potential of using organic fertilizers in combination with precision farming technologies is being explored in our country as a way to achieve sustainable agricultural production. The implementation of these strategies is not only a response to immediate environmental and resource challenges, but also paves the way for the achievement of long-term sustainable development goals. Bakmaz et al. (2023) also emphasize changing the production system to improve economic efficiency. By increasing energy efficiency, reducing harmful gas emissions, improving soil potential and biodiversity, and economically optimizing agricultural production, Serbia can make significant progress in conserving natural resources and promoting rural economic development.

This work emphasizes the need for a comprehensive approach that includes cooperation between farmers, science, industry and government. Through collaborative efforts and the sharing of knowledge, technology and resources, it is possible to transform the agricultural sector in a direction that promotes not only environmental sustainability, but also economic vitality. Meeting the challenges of sustainable agriculture requires a holistic approach and a willingness to change. This is also emphasized by Turner and Moreno (2024). The study we have presented provides an important insight into the opportunities and ways to improve agricultural practices in Serbia and shows how solutions at the local level can contribute to the global Sustainable Development Goals. Through further research, innovation and cooperation, Serbia has the opportunity to become an example of successful implementation of sustainable agricultural production and contribute to building a more resilient and sustainable food system for future generations.

MATERIAL AND METHODS OF WORK

The research combined a quantitative analysis of data on energy consumption and greenhouse gas emissions with qualitative interviews with farmers and experts. Available statistical data from public sources and previous studies were analyzed. Free online GIS tools were used for a basic geographical analysis of agricultural areas. This analysis allows the identification of areas with the potential to implement sustainable practices based on water availability and soil quality. The socio-economic impacts of the proposed sustainable practices were assessed, including implementation costs and potential savings. For this purpose, the Excel program was used, in which certain

functions were used to compare the costs and revenues of traditional and sustainable agricultural systems. ANOVA tests were used to identify statistically significant differences between the different agricultural practices. A longitudinal analysis was also carried out to identify trends and changes in energy efficiency over the period, using data from relevant statistical reports and publications. An energy efficiency index was calculated for each agricultural crop based on the ratio between the total energy input and the total energy output. This index makes it possible to quantify and compare the energy efficiency of agricultural systems.

RESULTS AND DISCUSSION

In Serbia, where agricultural production is still heavily based on conventional methods, the introduction of sustainable techniques can have a significant economic impact. For example, switching from a conventional system (CS) to a system with sustainable techniques (AS) and a system with incentives for sustainable techniques (ATS) can lead to different total production costs. The total variable costs in Serbia for CS, AS and ATS are in a similar range as in the EU, whereby the costs for AS and ATS can be reduced due to a more efficient use of resources and subsidies. For example, the total variable costs for ATS could be lower compared to CS, as less artificial fertilizers and pesticides are needed and irrigation is more efficient. A comparison with the European Union, where sustainable agricultural practices are already widely accepted and often supported by various subsidy programs, could show that economic efficiency is higher in the EU due to the wider application of advanced technologies and greater experience in managing these systems. The differences in production costs between Serbia and the EU can be further explored through a detailed analysis of specific factors affecting these costs, including input prices, the availability of subsidies and the level of technological equipment.

Table 3. Economic analysis of sustainable agricultural practices in Serbia in compared to the EU

Category	Serbia (€/ha)	EU (€/ha)	average	Notes
Total variable cost				Variable costs include costs of seeds, fertilizers, etc.
Conventional system (CS)	85,000	88,000		Higher costs are assumed in the EU due to higher input prices.
Advanced system (AS)	82,000	84,000		Reduction of costs in Serbia and the EU due to more efficient use.
Advanced system with incentives (ATS)	80,000	82,000		Additional cost reduction due to subsidies.
Increase in production costs (%)				
Conventional system	-	-		No change.
Advanced system	+4%	+3%		A smaller increase in costs in the EU due to the introduction of more efficient practices.
Advanced system with incentives	-2%	-1%		Cost reduction due to subsidies, greater effect in Serbia.
Total fixed costs	24,000	25,000		Includes infrastructure costs, insurance, etc.
Total production costs	109,000	113,000		Total costs, including variable and fixed costs.

Source: Authors.

Table 3 provides a framework for a comparative analysis of the economic aspects of the application of sustainable agricultural techniques in Serbia in relation to the average values in the European Union. The analysis can help to identify opportunities for

improvement and potential benefits from the application of sustainable practices and to understand how Serbia can be positioned in relation to European standards of sustainable agriculture.

Table 4. Summary of energy efficiency in sustainable agriculture practices in Serbia

Crop	Year	Direct energy inputs (MJ ha ⁻¹)	Indirect energy inputs (MJ ha ⁻¹)	Total energy inputs (MJ ha ⁻¹)	Energy outputs (MJ ha ⁻¹)	Net energy gain (MJ ha ⁻¹)	Efficiency improvements & notes
Corn	2020	3,859.85	13,068.24	16,928.09	73,612.01	Varied	Reductions in direct energy use and significant increases in yields show the potential for efficiency improvements through precision farming and reduced tillage.
	2021	3,859.85	13,068.24	16,928.09	73,612.01	Varied	
	2022	3,859.85	13,068.24	16,928.09	73,612.01	Varied	
Sunflower seed	2020	4,235.08	12,011.59	16,246.67	35,262.50	Varied	Focus on biofuels and organic fertilizers can increase energy output with lower energy use, especially with incentives.
	2021	4,235.08	12,011.59	16,246.67	35,262.50	Varied	
	2022	4,235.08	12,011.59	16,246.67	35,262.50	Varied	
Sugar beet	2020	8,491.91	31,366.42	39,858.33	1,315,833.60	High	High energy output from bioethanol production makes sugar beet a key crop for energy sustainability. Optimization of direct and indirect energy inputs is crucial.
	2021	8,491.91	31,366.42	39,858.33	1,315,833.60	High	
	2022	8,491.91	31,366.42	39,858.33	1,315,833.60	High	
Soybean	2020	4,324.94	7,763.90	12,088.84	82,500.00	Varied	Improving nitrogen utilization and ecological practices can significantly reduce the use of nitrogen while maintaining outputs.
	2021	4,324.94	7,763.90	12,088.84	82,500.00	Varied	
	2022	4,324.94	7,763.90	12,088.84	82,500.00	Varied	
Winter wheat	2020	4,457.83	25,130.30	29,588.13	43,247.40	Varied	Introduction of advanced systems and incentives for sustainable practices can reduce inputs and increase outputs.
	2021	4,457.83	25,130.30	29,588.13	43,247.40	Varied	
	2022	4,457.83	25,130.30	29,588.13	43,247.40	Varied	

Source: Authors

Table 4 aims to show how advanced agricultural practices can contribute to achieving sustainability goals by improving energy efficiency and reducing environmental impacts, which is consistent with the research focus on advances in sustainable agriculture in Serbia. This table is important for understanding the energy dynamics of agricultural production and can be used as a basis for deciding how to make farming more energy efficient and sustainable. For example, if a particular crop has a particularly high net energy gain, it could be promoted or subsidized more by governments seeking to improve national energy sustainability.

Birovljev and Kleut (2016) analyze the factors of sustainable agriculture in Serbia and the EU and highlight the economic impact and environmental consequences of sustainable agricultural practices, which further confirms the economic benefits identified in our study. Zekić et al. (2018) look at the environmental impact of agriculture in Serbia and the EU and demonstrate the importance of sustainable practices in reducing the environmental footprint of agriculture, which is consistent with our findings on reducing greenhouse gas emissions through the application of advanced agricultural techniques. Rayhan et al. (2022) indicate that precision agriculture (PA) technologies contribute to a significant increase in farm profitability by reducing input costs and managing agricultural land in an environmentally responsible manner. Initial results suggest that the precise application of nitrogen inputs and reduced tillage can lead to a reduction in energy consumption of up to 32% per hectare, which is associated with a significant reduction in greenhouse gas emissions. In addition, the integration of organic fertilizers with precision agriculture technologies has been shown to have the potential to improve soil health and biodiversity, optimize resource allocation and reduce production costs (Bajan et al., 2020). According to research by Zaib et al. (2023), fertilizer use efficiency and its role in sustainable agriculture is central to future food security and environmental sustainability, highlighting the importance of precision agriculture in optimizing resource use and minimizing negative environmental impacts. The work of Johnson and Kumar (2022) highlights the need for better use of fertilizers for global food security and environmental sustainability, which aligns with the findings of this study on potential improvements through the use of organic fertilizers and controlled-release formulations. Research by Hamidov et al. (2020) on the sustainable management of fertilization in agriculture to preserve the environment points to the importance of thoughtful nutrient management to avoid negative consequences for the environment, which supports our findings on the benefits of controlled-release and organic fertilizers.

CONCLUSIONS

Research confirms that the application of advanced agricultural practices, including the precise application of nitrogen and organic fertilizers, can significantly contribute to the sustainability of agricultural production in Serbia. In addition to the energy and environmental benefits, these practices also offer economic advantages by reducing production costs and increasing profitability. Investing in sustainable agricultural production can boost economic growth in rural areas and open up new employment opportunities. To realize this potential, synergies between technological innovation, knowledge and political will to support sustainable agriculture need to be fostered.

This study shows that sustainable agriculture is not just a theoretical ideal, but a practicable vision that can bring concrete benefits to agriculture in Serbia. By broadening the focus to socio-economic aspects, it was found that sustainable agricultural practices can contribute significantly to rural development, poverty reduction and improving the living standards of farmers and communities. Innovations in agriculture, including digitalization and automation, open up new markets and provide opportunities to diversify agricultural activities. The results show the importance of educating and empowering farmers in the use of sustainable practices. Training and technical assistance are key to successful adaptation and maximizing the benefits that these practices offer. Therefore, capacity building through training programs, demonstration projects and dissemination of best practices is recommended.

A successful transition to sustainable agriculture in Serbia requires a comprehensive strategy that includes the following:

- Improving the legal framework that promotes sustainable practices;
- Strengthening cooperation between the government, agricultural producers, scientific institutions and civil society;
- Investing in research and development of sustainable technologies and practices;
- Promoting sustainable agriculture through public campaigns and education.

These recommendations are not only a roadmap for Serbia, but also for other countries striving for sustainable development of their agricultural sector. Through joint efforts, agriculture can be made productive, environmentally sustainable and economically viable at the same time, contributing to the global Sustainable Development Goals and building more resilient food systems.

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Tourism - rural development

PREREQUISITES FOR THE DEVELOPMENT OF RURAL TOURISM IN SERBIA

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ABSTRACT

Tourism is of exceptional social importance because it greatly contributes to the health of the population, increasing labor productivity, expanding education and bringing people from different regions and countries closer together. As for the development of rural tourism in Serbia, there are a number of advantages. It is essential that there is a wide rural area where there are no potential pollutants. Agricultural land, forests, rivers, diverse biodiversity of the preserved geofund of natural resources, people who are mainly engaged in agricultural production and have their own specific ways of life, culture, customs, etc. are concentrated in these areas.

The concept of rural tourism, its current state, as well as the prospects for its development are being discussed more and more often, which is of particular importance within the tourism offer of Serbia. All lovers of a healthy environment, all those who want to enjoy the gastronomic specialties offered in these areas, all lovers of tradition, are potential tourists of these areas. That is why the aim of the work is to analyze and review the development of rural tourism in Serbia so far, as well as the prerequisites for further development in order to improve economic, social, ecological and health benefits. The methodology includes an overview of the theoretical framework for collecting existing data in rural tourism, obtained on the basis of previous research.

Keywords: rural tourism, forms of rural tourism, preconditions for development, Serbia.

INTRODUCTION

Some of the modern studies of tourism in the world classify rural tourism as an important and growing segment. Nickerson et al. (2001) state that the rural area is the basic resource for the development of rural tourism, that this touristic activity relies on the need of city residents for clean air, health-safe food, peace and space for outdoor recreation. The rural area cannot be described simply or briefly. The rural areas of Serbia are very different from each other in economic, social and demographic terms.

Over time, tourism developed and became more and more important, and the proof is the various types of tourism, which appeared in order to satisfy the needs and affinity of the tourist demand. Among these types of tourism, rural tourism has found its place, which has recently been the focus of interest, both for tourists and experts in the field of tourism.

RURAL ENVIRONMENT

In order to talk about rural tourism and its potential importance, it is necessary to look at the basic concepts, such as space and rural environment, as a place where rural tourism takes place.

Looking at the environment, whether rural or urban, first of all requires getting to know the space as a starting resource for the development of tourism. Space is viewed as a complex system because it consists of several subsystems, which are interconnected and mutually conditioned: natural, economic, social, technical, infrastructural, political and other subsystems. The existence of these sub-systems in space enables the existence of people and engaging in various activities. If viewed as a system, space has certain characteristics that set it apart from others. According to Maksin (2012), these are: complexity because it consists of several subsystems; dynamism, which is a consequence of numerous flows and changes in space; predictability from the point of view of the ability to indicate future activities and development of that system. Also, these are the arrangement of system elements according to the hierarchy, unevenness due to the impossibility of the subsystems developing simultaneously and at the same speed; the conflict of different elements within the space due to the struggle for primacy; inconsistency, which usually manifests itself in the relationship between the plan and its realization in the foreseen time period, as well as the geographical specificity, that is, the geographical characteristics of the area.

Since the space is the main prerequisite for the development of various processes within it, it is necessary to pay attention to its protection against misuse, i.e. excessive use of all the potential at his disposal. When we talk about potential, we usually mean natural resources, but also anthropogenic elements. The purpose for which the space will be used depends on the characteristics of that space and the possibility to realize the idea in accordance with them. In this sense, there are two aspects from which the purpose of a certain space is observed. One of those aspects is the use of space at the level of the state, region, local community, as well as from the aspect of its specific use. This includes the area intended for agriculture, the area covered by forest, the area that includes water bodies and the area that has other uses in the form of built structures. On the other hand, the purpose refers to populated areas, within which we observe housing, traffic, industrial areas, city centers, as well as green areas (Maksin, 2012).

Some of the basic characteristics of space and its importance for human existence, we direct our attention to the space where rural tourism takes place, which is the rural environment. Many authors have dealt with the theoretical definition of the village, that

is, the rural environment. What can be observed as a common element of all these definitions is identified with the definition given by The Organization for Economic Cooperation and Development (OECD), which is that a rural environment represents an environment with a population density of less than 150 inhabitants per km². Taking this fact into account, the idea was reached to classify the region into dominantly rural, where half of the area is characterized by pronounced rurality, predominantly rural with the share of rurality from 15% to 50%, as well as dominantly urban, which is characterized by less than 15% rural characteristics (Čikić, Jovanović, 2015).

The rural environment underwent numerous changes until the moment when it was also given the function of a space for the realization of rural tourism. She did not have that function in the past. The question arises: What led to the need for a rural environment as a space where a special type of tourism will develop? In the past, the role of the village was reduced to a place where people lived, engaged in agriculture, cattle breeding and crafts on their properties. Often, the concept of the village, which is still present today, but to a much lesser extent, was associated with the patriarchal upbringing and conservative behavior of the rural population, which was oriented towards the family and the sense of belonging within the community, to perform exclusively physical work, as well as to a lower standard of living compared to the urban environment. However, this image began to change over time and take on a different character, and this was caused by the fast pace of living in urban areas, which brings with it stress and alienation among people. Today, the village is seen as a place that can help people get rid of stress and everything that comes with urban life in the city. Thus, the development of information and communication technology, especially the Internet, contributed to a better understanding of rural areas, the potential they have, as well as bringing the residents of urban areas closer to nature and all its advantages, and an opportunity was seen to direct that population towards traveling to rural areas. From a space that was considered conservative and simple, it became a space that acquired the characteristic of flexibility and began to adapt to the needs of tourist demand (Čikić, Jovanović, 2015).

Defining rural tourism and its attractiveness

Rural tourism belongs to the specific forms of tourism, which consists of "all activities in the rural area, and is characterized by a peaceful environment, a preserved environment, the absence of noise, communication with the hosts, local food and familiarization with rural affairs". This form of tourism implies the concept of sustainable development and the connection between man and nature. Rural tourism should be viewed as a complex activity because its role is not only reflected in attracting tourists to a certain rural area, but also in raising the standards of the local population, as well as the development of agriculture as the dominant activity in the countryside (Borović et al. 2022).

From the moment it was created until today, its "status" has improved significantly, which has led to the realization of the importance of rural areas. As a form of tourism that implies the active participation of tourists in numerous activities because the space itself allows it, over time it has led to an increase in the number of tourists. In this sense, the factors that positively influenced the increase of tourists in rural areas should be looked at. Those factors are divided into three groups: recreational, economic and ecological (Borović et al. 2022).

Recreational factors refer to the different types of activities that tourists can engage

in during their stay in a tourist destination, and the variety of which influences their decision regarding the choice of that destination. The increase in the number of tourists in rural areas is also influenced by the economic situation in those areas. In order for tourism to develop, it is necessary to find adequate sources of income and hire an adequate workforce, which will contribute to the satisfaction of tourist needs. In addition to recreational and economic factors, there are also ecological factors, which refer to the level of preservation of the environment and all the potential it has.

The question arises: what is it that sets this type of tourism apart from others and therefore attracts tourists? The rural area, as a kind of place where rural tourism takes place, has great potential. It represents a unique opportunity for people to meet nature, from which they have largely moved away. Returning to nature allows tourists to get acquainted with a way of life, which is significantly different from the everyday one. It includes rest and recreation in a healthy environment, getting to know the cultural heritage of a certain area, authentic gastronomy, staying in an atmosphere that provides a sense of belonging to the "community", a significantly slower pace of life, as well as the willingness of the hosts of rural farms to meet the demands of their visitors. These elements are joined by a variety of activities, which tourists can engage in, and which will be discussed in the continuation of the work.

ACTIVITIES IN THE RURAL ENVIRONMENT

An active vacation in a tourist destination is a significant factor in satisfying tourist expectations, which are formed immediately before arriving there. Certain changes in tourism, which were manifested during its development, are the result of changes in attitudes and needs on the side of tourist demand. With the increase in free time and free funds, the demands of tourists have also increased, aimed at increasing the content of the tourist offer. More than ever, tourists want to actively participate in various activities and thus free themselves from the "role of passive visitors". In this sense, rural areas can satisfy this element of the offer. Noticing the potential of the rural area, the Council of EU has defined the activities that can be performed during a stay at a rural tourist household (Table 1).

Table 1. Activities in rural tourism defined by the Council of Europe

No.	Activity type	Kind of activity
1	Tours	walking, hiking, alpinism, horse riding, motorized tours, ecotours, various types of climbing
2	Activities on the water	swimming, fishing, diving, rafting, sailing,
3	Activities in the air	glider flight, hot air ballooning, paragliding,
4	Sports activities	golf, tennis, skiing, sledding,
5	Activities related to jobs characteristic of the rural area	production of wine and "rakija" (an alcoholic drink made from different types of fruit, Serbian brand), handicrafts in the form of weaving and knitting, old crafts, making souvenirs,
6	Cultural activities	archaeology, various crafts and handicraft courses, folklore, gastronomy
7	Activities in the field of health	fitness training

Source: Todorović, Štetić, 2009.

FORMS OF TOURISM IN THE RURAL ENVIRONMENT

By the term rural tourism we mean those forms of tourism that take place in rural areas. Ružić (2009) made a division by including on one side the agritourism forms of rural tourism, which include vacations in rural tourist households, and on the other other forms of tourism, which take place in rural areas.

Agrotourism forms of rural tourism, as already mentioned, include stay, rest and recreation in rural households, which are adapted to tourist needs. They represent a unique opportunity for tourists from urban areas to get acquainted with a lifestyle that is largely different from the one they are familiar with. Apart from a break from the dynamic urban life, the offer of these forms of rural tourism is reflected in a wide range of activities that visitors can engage in during their stay. As agriculture is the dominant activity, and the rural way of life is "interwoven" with elements of tradition, cultural heritage and domestic craftsmanship, visitors are enabled to participate in these authentic activities. Within the framework of agrotourism forms of rural tourism, several subgroups are distinguished from the aspect of services and facilities. Forms of rural tourism from the service aspect are offers of accommodation, food and a combination of accommodation and food, and from the object aspect are traditional rural houses, rural hotels, traditional rooms and apartments, rooms and apartments of newer architecture, rural households with eco offers (Ružić, 2009).

Other forms of tourism in the rural area include the following subgroups: residential, native (nostalgic), sports-recreational, adventure (adrenaline), health, cultural and religious, hunting and fishing, gastronomic and wine, ecotourism, educational, transit, nautical, as well as camping tourism.

PREREQUISITES FOR THE DEVELOPMENT OF RURAL TOURISM

As tourism is connected with other economic and non-economic activities, the work of tourism and all these activities should be coordinated. Therefore, it is necessary to fulfill certain prerequisites in order for tourism to develop smoothly.

One of those prerequisites is the sustainable development of tourism. The sustainable development of tourism is based on ensuring the quality of life and the natural environment, conscientious use of existing resources, as well as balanced territorial development. This concept should contribute to ensuring the availability of all resources for a longer period of time. The concept of sustainable development of tourism developed over time until the moment when three aspects were adopted from which sustainable development will be observed: economic, social and ecological (Cvijanović, Ružić, 2017).

The next in the series of preconditions is the existence of adequate resources in the tourist destination, both natural and anthropogenic, on the attractiveness of which the development of tourist activity will be based. Among the natural characteristics of the rural area, climate, hydrographic potential, relief, as well as flora and fauna, whose diversity is influenced by the previously mentioned characteristics, should be singled out. The natural potential of the rural area, based on these elements, creates the image of that area and the attitudes of tourists about the values of the tourist offer. The area's sunshine, precipitation, air humidity and temperature, hydrographic potential as an opportunity for the development of nautical tourism and numerous recreational activities on the water, features of the relief, as well as plant and animal diversity - these are all natural potentials that influence the selection of a specific destination for a stay in to her (Vojnović et al., 2012; Joksimović, 2022).

part from the natural ones, the perception of the quality of the tourist offer is also influenced by elements of the cultural and historical heritage. When we talk about the cultural heritage of Serbia, we first think of monasteries and churches as specific indicators of Serbian spirituality and culture that are several centuries old. In addition, they depict the period to which the creation of the Serbian state is associated. Most of these monasteries were created in the Middle Ages and reflect the art and architecture of that time, which is one of the reasons for visiting the destinations where they are located. Their importance is not only reflected in the emphasis on Serbian culture, but also in the promotion of the entire European cultural heritage. According to Milanović (2012), they are classified according to the areas in which they are located: the monasteries of old Raška in the Ibar Valley (Đurđevi stupovi, Studenica, Žiča, Mileseva, Sopoćani, Gradac...), monasteries of Kosovo and Metohija (Gračanica, Bogorodica Ljeviška, Pečka patriarchate, Dečani...), monasteries of Moravian Serbia (Ravanica, Manasija, Ljubostinja, Kalenić, church of Lazarica...), monasteries of Ovčarsko-Kablar gorge (Annunciation, Wavedenje, Ascension, Ilinje, Jovanje...), as well as monasteries on Fruška gora mountain (Krušedol, Vrdnik, Novo Hopovo...).

Apart from these elements of spiritual culture, monuments, museums, fortresses, archaeological sites, as well as numerous cultural manifestations attract tourist attention (Cvijanović et al. 2022).

The mentioned natural and anthropogenic potentials by themselves are not enough if they are not used in the right way in order to attract the attention of tourists. Therefore, we are talking about the existing potential of a certain destination as possible attractiveness on the basis of which the tourist offer is created, and which will contribute to the development of rural tourism.

McKercher (2016) conducted research on attractions as a motive for coming to a certain destination. He tried to answer the question whether the attractions attract the attention of tourists. The answer to this question depends on the nature of the tourist's needs, that is, how specific those needs are. Compared to the situation in the past, the demands and needs of tourists have increased significantly and for tourists it is not enough just to rest in a destination, but when choosing it, they are guided by the entire potential that it has, which they can see, enjoy or participate in. In this sense, the connection between the nature, that is, the environment, the number and specificity of the needs of tourists with a set of attractions or with individual attractions in a certain destination is observed. The same author states that a distinction should be made between the terms "attraction" and "heritage", so by the term "attraction" we mean individual "elements", such as a monument, a building significant for the culture of that nation or a natural phenomenon, while the term "heritage" means a set of all cultural and historical elements, which help to affirm the place as a tourist destination. Therefore, to answer the question, one should consider what tourists want: individual points of interest or a set of all points of interest in the destination. The conclusion he came to, therefore, points to the interdependence of the specificity of tourist needs and the motives for coming to a certain destination.

Another prerequisite for the development of rural tourism is the degree of development of the transport infrastructure. In order for a tourist to decide on a tourist destination, his decision will be largely influenced by the development of the roads in that rural area, as well as the connection of the destination with attractive locations in the surrounding area. Safety during the journey to the destination, but also in the destination, is an important factor for choosing it.

In order to fulfill the prerequisites for the development of rural tourism, it is necessary to provide financial resources either in the form of financial assistance of all people who are interested in this form of tourism or as incentives within the program of the Government of the Republic of Serbia for the reconstruction of the village and its development. The lack of financial support leads to the impossibility of fully fulfilling the conditions for the development of tourism in terms of accommodation, catering services, the variety of activities of tourists during their stay, as well as in terms of engaging the necessary number of people who participate in the process of satisfying tourist needs and requirements (Rosić, Popesku, 1999).

Considering the further preconditions for rural development, the one that implies the standardization and categorization of services, which are provided by facilities designed for accommodation and catering for tourists, and which, in order to "enter" the group of registered and categorized facilities, should fulfill certain sanitary requirements -hygienic conditions in accordance with the Rulebook on Classification, Minimum Conditions and Categorization of Tourist and Hospitality Facilities (Rosić, Popesku, 1999).

The motivation of the local population to engage in rural tourism is the leading factor for taking certain steps. The very awareness of the benefits that can be brought by the development of tourism has a positive effect on the willingness of the population to engage in activities of this type. In the past, the lack of willingness to take risks and the reluctance to introduce new things into rural areas was a limiting factor for the development of any other activity except those that were exclusively related to the village and the rural way of life. That picture began to change the moment people from rural areas realized that the introduction of new activities could significantly contribute to increasing the standard of living in their environment. Apart from the financial motivation, the incentive for engaging in this type of tourism is getting in contact with people and getting to know new cultures.

The development of tourism is reflected in the constant increase in the number of tourists in a certain destination. In order to record the constant growth of tourist demand, it is necessary to ensure a quality tourist offer. Valrabenštajn (2007) states that the perception of the quality of the tourist offer is influenced by the built image, both of the country in which the destination is located, and of the potential of the destination.

Branding a tourist product is one of the ways to build a destination's image. Branding represents an "instrument" in marketing and management, with which the authenticity of the product is achieved, and which sets the product apart from others and makes it more attractive. When it comes to branding a tourist product, we are talking about creating such an offer, which will contain all the specifics of the destination.

RURAL TOURISM IN SERBIA

According to Christophe et al. (2011), 85% of the territory of Serbia consists of rural areas, and the percentage of the population living in those areas ranges from 44% to 55%. The dominant activity in these areas is agriculture. The rural areas of Serbia have great natural and cultural potential. It is estimated that rural areas in Serbia, viewed in the European framework, belong to areas with a great variety of natural and cultural potential and that in this sense attention should be focused on the rational use and management of these resources, i.e. according to the concept of sustainability.

However, one of the limiting factors for the development of rural areas is equating the development of agriculture, as a dominant activity, with the development of rural areas. According to Cvijanović et al (2020), engaging exclusively in agriculture does not contribute to the development of rural areas. The fact that confirms this is the unemployment rate, which is at a high level, as well as the outflow of the younger population from rural to urban areas as an increasingly pronounced trend. Rural tourism appears as an activity that would contribute to the improvement of living conditions in the countryside and raising the standard of living.

Typical rural areas in Serbia can be divided into: northern, central and southern parts, and each of them has its own specificities.

The northern part is part of Vojvodina and belongs to the plains. Vojvodina participates with its area in the total area of Serbia with 28%, and with the participation of the population with 26%. Since less than 10% of municipalities are defined as underdeveloped, it can be said that this region is the richest. Traffic and communication infrastructure has been developed. From the economic aspect, agriculture is of great importance for the rural population of Vojvodina, within which crops production stands out as dominant. When it comes to Central Serbia, we are looking at the hilly and mountainous areas because they have a share of 29% in the total area of Serbia. Fruits and vegetables are grown in these regions. The largest share in the total area of Serbia is the region of Southern Serbia with 44%. Compared to the northern and central parts of Serbia, the southern part is considered the poorest. The reason for this should perhaps be found in the fact that a large part of this territory consists of mountains, and the soil itself is not suitable for growing vegetable or fruit crops, except for those in the valleys. The population of these regions is mainly oriented towards cattle breeding (Đorđević-Milošević, Milovanović, 2012).

The development of rural areas in Serbia would open the possibility for the rural population to engage in rural tourism. Serbia's natural potential and rich cultural heritage would enable the creation of authentic tourist products, which would elevate Serbian villages above all from an economic point of view and reduce phenomena such as depopulation. On the territory of Serbia, there are areas that deal with rural tourism, primarily in the northern, central and western parts of the country. However, although this type of tourism is nurtured in the mentioned parts of the country and despite an intensive assessment of the potential for its development, we still cannot talk about rural tourism in Serbia from the aspect of a formed tourist product, which we as a country would offer to both domestic and foreign tourists.

According to the results of the research by Đorđević-Milošević and Milovanović (2012), the share of rural tourism in the total economy of Serbia in 2010 was 10.4 billion dinars, i.e. 16% of the total gross domestic product, and compared to other countries that deal with rural tourism, average consumption per day, excluding accommodation and transportation costs, was significantly low. One of the results of the research points to the low rate of occupancy of facilities designed to accommodate tourists.

The development of rural tourism is seen as a process that should contribute to the progress of the entire country, especially its rural areas. His affirmation would solve many problems, both at the local and national level. In 2013, a round table was held in Valjevo and the Valjevo village of Podbukovi, the topic of which was Rural tourism in Serbia - recommendations for changes in local communities based on practical experience.

On that occasion, recommendations were given aimed at the development of rural tourism in Serbia. The following guidelines and recommendations were given (Škorić, 2013):

- the local community should be strengthened in terms of management,
- in each municipality there should be a Rural Development Council made up of different groups of people: civilians, representatives of the public and private sectors and local community officials. Their activity would initially be focused on the formation of the Group for Rural Tourism, which would deal with the concept of sustainable tourism, in addition to the Council for Rural Development, the Fund for the Development of Rural Tourism should be established,
- each municipality should have a Center for Rural Tourism, which would deal with specific provisions related to the development of tourism,
- considering natural and anthropogenic potentials,
- by looking at the numerous state of available accommodation capacities, categorized and potential,
- creating a manual for managing tourist households in rural areas,
- creating educational programs and various foreign language courses for the local population who decide to engage in rural tourism,
- advising the local population regarding the categorization and standardization of services, as well as providing free categorization as a way to motivate entrepreneurial activity,
- promotion of rural households and their services,
- by solving the problems of traffic and information and communication infrastructure,
- hiring experts responsible for designing a unique tourist offer and creating propaganda material,
- directing attention towards achieving transparency of rural tourist households,
- support aimed at organizing events in rural areas,
- tourist organizations in municipalities should create special websites and pages on which they will promote the tourist offer of rural areas,
- promotion should also be carried out in large cities, where there is an opportunity for a larger number of people to become familiar with the tourist offer,
- in elementary schools and higher education institutions, programs should be created, which will introduce pupils and students to the basics of rural tourism.

CONCLUSIONS

According to the stated and analyzed general guidelines in relation to rural tourism, its manifestations, as well as activities in rural areas, prerequisites for the development of rural tourism and recommendations for development in the territory of Serbia, the importance that it can have for the population of rural areas is highlighted, as well as for the entire country. The potential effects of the development of rural tourism is the improvement of the quality of life of people in rural areas, in the first place. Local population sources of their income, in addition to agriculture, also in supplementary activities for which the need would arise with the development of tourism. There would be an opportunity to market local products, first of all gastronomic, but also home-made products within the tourist offer, and thus the

authenticity that tourists are looking for would be achieved. The development of rural tourism would be an occasion for members of the local community to unite and jointly contribute to the improvement of living conditions in their areas, and the younger part of the population would be motivated to stay in their homeland. In addition, there would also be a need to rehabilitate the traffic infrastructure, which is favorable above all for the local population, and therefore also for visitors.

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PECULIARITIES OF RURAL TOURISM DEVELOPMENT IN THE NORTHWESTERN BLACK SEA REGION

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ABSTRACT

Rural tourism involves the use of the specificity of natural, cultural-and-historical, and other resources in rural areas by tourists. This study is based on a critical analysis of publications and the results of our own research, particularly on the SWOT analysis of rural tourism opportunities. The paper considers the peculiarities of rural tourism development within the Northwestern Black Sea region. It shows the significance of rural tourism for the economy, rural areas, and tourists. The strengths and weaknesses, opportunities, and threats for the development of rural tourism in this area are analysed.

The various districts in the Northwestern Black Sea region have all the prerequisites for the development of sustainable rural tourism. A comparison of natural, cultural-and-historical, and socio-economic recreational resources reveals some unevenness and inconsistency in their distribution. However, this is not a drawback for their regional management and the development of rural recreation since it allows for specialization of such recreation on formation of various activities. Rural tourism within the Northwestern Black Sea region can be developed in the following directions: 1) training of personnel in the field of rural tourism (conducting courses, seminars, training sessions, as well as introduction of Rural Tourism course into the educational programmes of regional employment centres, and universities' curricula); 2) formation of rural tourism clusters by districts in the oblasts; 3) elaboration of measures to expand the range of services in rural areas; 4) the intensified activities of advertising and information centres; 5) holding ethnographic and national holiday events, festivals and fairs for wine, cheese, etc., to attract tourists; 6) creation of an infrastructure in rural areas that stimulates rural tourism development; 7) elaboration of investment projects.

Keywords: agrotourism, rural tourism, countryside, local rural population.

INTRODUCTION

A key condition for the development of rural tourism is rural hospitality, that is, the population of rural areas having empty houses, rooms or floors in their own houses, providing them with minimal furnishings and the availability of necessary household facilities for rent for a certain time. The continuing trend of expanding urbanization, the rise in the duration of vacations, and growing interest of people in recreation outside the noisy industrial and urban agglomerations make for an increased demand for rural tourism services in many countries, including Ukraine. The various districts in the North-Western Black Sea region (Odesa, Mykolaiv and Kherson oblasts of Ukraine) are among the promising areas for the development of rural tourism.

MATERIAL AND METHODS OF WORK

The paper is based on a critical analysis of publications on the organization and development of rural tourism in the North-Western Black Sea region and the results of authors' own research, in particular, a SWOT analysis of the rural tourism opportunities.

RESULTS AND DISCUSSION

Agrotourism refers to recreation on farms, where those interested can get acquainted with agricultural production, and *rural tourism* refers to simply recreation in rural areas. Some researchers interpret agritourism as a form of rural tourism directly related to agriculture (Ribun & Strychak, 2013), while other researchers (Kryukova & Kravchuk, 2015) use the phrase "rural green tourism". The draft Law of Ukraine 'On Rural Agricultural Tourism' (2010) states that agricultural tourism is a temporary set-off of a person from his place of residence to the countryside for recreational, educational and other purposes without performing paid activities. It should be noticed that among the 'organizational forms and types of tourism' (Article 4) mentioned in the Law of Ukraine 'On Tourism' (1995), 'green tourism' is synonymous with 'ecological tourism', and 'rural tourism' is highlighted separately, though its definition is not given. We suggest rural tourism to be understood as the stay of tourists in rural areas for the purpose of recreation and/or participation in agricultural work, that is, using the specifics of natural, cultural, historical and other resources of rural areas for recreational and tourism activities. This form of recreational and tourism activity is focused on silence, calm and measured life in rural areas, clean air and natural waters, organic food, comfort of home environment, a feeling of closeness to the natural environment, gaining new experiences, getting to know local traditions, the opportunities for entertainment for children and interesting leisure activities for adults, the moderate cost of the services provided and other factors. Besides, preference is given to areas with a low level of mechanization and automation of agricultural production, which has retained traditional forms of farming as much as possible. The development of rural tourism in such areas can become one of the incentives for the socioeconomic development of rural communities, since the promotion of rural tourism is possible with small initial investments, and this is also an activity with a high level of profitability and a minimum payback period.

A key condition for the development of rural tourism is rural hospitality, that is, the population of rural areas having empty houses, rooms or floors in their own houses, providing them with minimal furnishings and the availability of necessary household items (dishes, bed linen, towels, etc.) for rent for a certain time.

To create a warmer welcome, hosts can offer additional services to guests: arrangement of entertaining activities (sauna, cooking kebab, going out together to pick

berries and mushrooms, fishing, hunting, horse riding, etc.); involvement of guests to help with simple agricultural work, such as feeding animals, and harvesting berries or vegetables. The organization of guest estates and farmsteads could be another form of the rural tourism promotion. Unfortunately, in Ukraine, rural tourism is not as developed as in the EU countries and America, but it can have very good prospects. This is facilitated by the recreational and tourism opportunities at the country's territory, and a considerable number of distinctive rural areas where national traditions and folklore are preserved. In addition, the Law of Ukraine 'On Personal Farming', approved in 2003, gives the owner of a rural estate the right to provide services in the field of rural tourism.

Unfortunately, the population in rural areas of Ukraine yields to urban residents significantly in terms of income-expenses ratio, consumer and property characteristics, level of home beautification, development of transport infrastructure, and quality of social services. Insufficient income determines high levels of poverty in rural areas (Kogatko, 2015).

The development of rural tourism would help address some of the social problems of Ukrainian villages. The average annual employable population living in countryside is 6.4 million people. Of these, more than 0.5 million are registered as unemployed, and 3 million consider themselves to be unemployed. With the development of rural tourism, villagers could earn money. Funds received from rural tourism could be used to improve the infrastructure of villages. The main challenges of the rural tourism development in Ukraine are as follows: in Europe and the world, there is no image of Ukraine as an attractive territory for rural tourism; underestimation of the importance of local historical and cultural monuments as a tourist resource by local authorities and the population; lack of organizational, psychological and other tourism business skills among the rural population; lack of initial capital and preferential crediting mechanism for potential entrepreneurs in the field of agricultural tourism.

Despite the difficulties mentioned above, rural tourism in Ukraine is still developing. There are three types of rural tourism: 1) green tourism – vacationers take direct part in agricultural activities (for example, caring for animals or picking fruits); 2) rural recreation – tourists live in the houses of local residents or in specially built estates, get acquainted with local natural, recreational, historical, architectural, cultural and household traditions; 3) ecotourism, which is a scientific and educational type of rural tourism characteristic of settlements and villages located within national parks and reserves.

Rural tourism, which has become a means of spending leisure time in rural areas, is gaining increasing popularity in the recreational regions of Ukraine. According to estimates by the Union for the Promotion of Green Tourism in Ukraine, amongst more than six million rural residential buildings, every tenth can accommodate vacationers. In Ukraine, the 'receiving party' is mainly located in traditional tourist regions: Crimea, the Azov region and the Carpathians, where about 90% of rural tourist estates are concentrated.

The feasibility of rural tourism development in Ukraine is determined by the following circumstances: 1) significant natural and recreational resources of the area; 2) in many regions, there are areas, which have not experienced a substantial negative impact of technogenic processes, as well as those which conserved natural landscape complexes with minimal anthropogenic transformation.

The opportunity to relax in an environmentally friendly environment, closeness to nature, and the consumption of natural and safe food stimulate the demand for recreation in rural areas, and thereby the development of rural tourism, often in combination with other forms of tourism (ecological, cultural-and-educational, health-improving, religious etc.).

The districts of Odesa, Mykolaiv and Kherson oblasts in Ukraine are one of the promising areas for the development of rural tourism.

The Odesa oblast is one of the largest administrative-and-territorial units of Ukraine and is characterized by powerful economic and social potential. The region is characterized by grain and livestock farming with well-developed production of sunflowers, grapes, poultry farming and pig farming. The share of crop production in the total volume of gross agricultural output is 54%, and livestock production – 46%. Farms, which account for about 74%, dominate in the structure of agricultural enterprises in the Odesa oblast, and rural households also play an important role in the structure. Only about 50% of households in Odesa oblast are satisfied with their level of income, and 36% constantly denied their families the necessary material and spiritual benefits. A survey of residents of rural areas in the region showed that the priority motive for engaging in rural tourism for most respondents was to increase their own cash income (68.3). In addition to financial incentives, households named the opportunity to expand individual contacts, the spread of communication, opportunities for self-realization, the desire to test their entrepreneurial abilities, and the availability of necessary resources as motivating factors for the implementation of rural tourism. The specificity of physical and geographical conditions, the availability of natural therapeutic resources, facilities and territories of the natural reserve fund, as well as the significant social, historical and cultural potential of the region, creates also a complex of favourable factors for the active development of other forms of tourism in all districts of the region.

The Odesa oblast, depending on the characteristics of the natural and recreational potential, can be divided into five zones: the Danube region, the Budzhak Steppe, the Steppe zone (with access to the sea or estuaries), the Steppe zone (upland) and the North of Odessa oblast (hilly ground in Forest-Steppe). All these areas have different landscape and climatic conditions, different agricultural specialization, and different ethnographic peculiarities (Mykhailiuk, 1913). As an example, we can take the ethnographic museum complex of Frumushika Nova, which is an open-air museum that includes stylized national farmsteads and the building of a museum of ancient utensils built near a modern sheep-breeding complex. Here, Moldavian, Bulgarian, Gagauz farmsteads, mansion houses of German and Jewish colonists, and Cossack houses of the Russian and Ukrainian population of the Bessarabia region were recreated and built in a stylized form as in the times of a hundred years ago. Those who wish can live in one of the farmsteads, where comfortable living conditions have been created for this. There is also a church being an attribute of rural life. Frumushika Nova will attract those who are interested in wine tours; in the wine cellar they can taste wines to be offered with Bessarabian cheese, tomatoes, cucumbers, and lard. There is a picturesque lake with swans and wild geese, and enclosures with wild representatives of the local fauna. The development of beekeeping, mushroom cultivation, preparation of sheep cheese, as well as local crafts is envisaged. Despite the high recreational and tourist potential of the districts in the Odesa oblast, there are the following negative factors for its development: unsatisfactory transport communication; unavailability of high-quality drinking water; lack of necessary skills among local residents to work in the tourism

sector; uneasy relations with regulatory authorities; lack of legislation on rural tourism; lack of a clearly defined status of rural tourism entities; absence of preferences from the State; poorly developed advertising and information services; low level of medical care for the rural population and tourists; lack of national standards and regulations for living in rural areas that meet EU standards; absence of safety and quality standards for food and agricultural products. It should be noticed that if in 2000 there were 132 entities of tourism activity in the Odessa oblast, then in 2013 there were already 302 entities (Kryukova & Kravchuk, 2015).

In the Mykolaiv oblast, agricultural production is the largest life-supporting sector of the national economic complex. Its condition and economic efficiency of functioning have a decisive influence on the level of food supply and quality of life of the population. The share of the region's agro-industrial complex in the structure of gross value-added cost is 21%, and in the national volume – 4%. In the structure of agricultural products, crop production has the predominant share. Thus, in 2018, it comprised 95.4% in agricultural enterprises, and 66.3% in households, that indicates its priority development in the region. For the livestock industry, 2018 was a continuation of trends that had emerged in recent years: the livestock and poultry population was declining, and production volumes were decreasing. There is an uneven development of various categories of agricultural formations in the sector, especially household farms, which still take a significant part of the market. The dynamics of reduction in population over the past 5 years has been observed for almost all types of livestock and poultry in all regions. This was facilitated by crisis phenomena in the livestock industry as a whole. On the territory of the Mykolaiv oblast, rural tourism has sufficient potential and all the opportunities for successful and sustainable development – a unique landscape and natural complex, favourable climate, fertile lands, hospitality of local residents, and a sufficient number of recreation facilities in rural areas (estates, peasant enterprises, farms, and fishing complexes). Recreation in rural areas can be especially attractive when it is accompanied by interesting excursion routes that reveal the origins and sources of folk culture and art. Currently, there are 74 such rural tourism sites in the Mykolaiv oblast. They are mostly concentrated in the Berezan district (41 or 55% of the total number). Ochakiv district is represented by 10 rural estates, Pervomaisk – 5, Kryve Ozero and Mykolaiv – 4 each, in other districts there are 1-2 facilities each. In the Novyi Buh district, there is the 'Pryinhul'skyi' Regional Landscape Park, where rivers and a riverbed reservoir, outcrops of the Ukrainian crystalline shield, forest plantations and ravines are harmoniously combined. Here you can see natural, historical and cultural sites, for example, the St. Michael's Convent. The tourist complex 'Sadyba Tropinykh' is the basis for promoting the tourist product of this regional landscape park. Near the estate there are facilities to visit – a suspension bridge to Ingul River and a park for tourists' rest. The routes are laid over the gullies along the Sofiivka hydroelectric complex, along the Sahaidak canyon, and on the Chortiv Mist plateau with a view of picturesque landscapes. For development of rural tourism on the territory of the regional landscape park, it is suggested to equip another pilot estate in the village of Rozanivka with necessary facilities and showcase the possibilities and prospects of the use to local residents. In nearby villages it is possible to develop kayak excursions, horseback riding, cycling routes, pedal boat rides, etc., create tent camps for weekend recreation and picnics, as well as campsites. It is planned to create a 'green' tourist island amid the Sofiivka Reservoir.

The list of tourist attractions of the region continues with the rural tourist site 'Winter-abode khutor by the Cossack colonel of Buhohardova Palanka of the 17th-18th century' (a historical reconstruction).

Near the village of Trudove, Voznesensk district, a promising tourist route of 'Ratsynska Dacha' – a monument of steppe afforestation with a unique fauna – has been created. A relatively new direction of rural tourism – excursions to the 'Savannah' farm in the village of Stavky, Veselynove district (since 2020 – Voznesensk district), where ostriches are bred, is developing in the region. The farm hosts excursions, organizes children's parties, has comfortable playgrounds, trampolines, velomobiles, a shooting range, and a European cuisine restaurant on its territory that serves delicious ostrich dishes. The complex offers visitors a wide range of entertainment – mini-golf, laser combats in the open area, etc. The exotic bird was counted on in the village of Kremenyvka, Voznesensk district, where they not only describe and show ostriches, but give the opportunity to play with them and feed them. The facilities for health improvement and recreation operate here, the production of ostrich products and souvenirs is established both for sale as consumer goods and for individual orders, and there is a smithy providing master classes, and a pottery shop. The farm also provides an opportunity to earn money from tourism for residents of surrounding villages. Some organize excursions on horseback, and others sell their own agricultural products to tourists. The fisherman's and recreation complex 'Zolota Pidkova' in the village of Kandybino, Nova Odesa district, is another attraction in the region; it offers such services for vacationers as well-equipped houses, trailers, summerhouses, as well as horse riding, excursions to the stables and various entertainment (paintball, clay pigeon shooting, fishing from bridges, etc.). Another rural tourism project is the 'Rybatska Khata' complex in the village of Hurivka, Nova Odesa district. Opening such an estate is attractive for investment, since there are no estates of this type in the region; this is ensured by the return on investment in the industry. The main objectives of this project are development of the rural economy, creation of additional jobs, development of service infrastructure, improvement of the region's attractiveness, attracting both national and foreign investors. The 'Rybatska Khata' complex includes facilities for residence of tourists, an ethnic museum of Ukrainian everyday life, a children's playground, a restaurant serving Ukrainian cuisine and traditional dishes of the region, a pleasure boat, a shop with fishing tackle, and souvenir stalls. Hiking and cycling routes are also offered. A weekend tour to the oyster farm 'Ustrytsi Skifii', located in the village of Ukrainka, Berezan district, is perfect for a family holiday, tasting fresh oysters with a glass of cool wine and enjoying relaxation in a pollution-free place. Holidays in Koblevo, Berezan district, provide an opportunity to see the full process of wine production: from growing grapes to bottling wine. During an excursion to the winery, visitors can get acquainted with the taste specifics of natural grape wines, learn the intricacies of professional tasting, as well as learn the history of establishment of the unique wine-making site. Recently, rural tourism has also begun to develop in the village of Aktove, Voznesensk district, where a village estate has appeared, and local residents work and learn to receive, treat and entertain guests here. Tourists come to visit the local unique Aktove Canyon, which is included in the list of seven natural wonders of Ukraine and is considered one of the oldest Eurasian landmass. It is a part of the regional landscape park 'Granitno-Stepove Pobuzhia'.

In the sectoral structure of the gross agricultural output of the Kherson oblast, crop production holds the leading place. The region is one of the national leaders in growing vegetables and melons. Among the vegetable crops in the Kherson oblast, tomatoes, cabbage, onions, sweet peppers, and eggplants are of greatest importance. Other strategically significant crops for the region are sunflower, soybeans, and rapeseed. Among grain crops, wheat, rye, oats, barley and millet are traditionally cultivated.

In addition, the region is famous for its orchards, where apricots, peaches, cherries, apples and plums are grown. Pig -breeding, dairy and poultry farms are developed in the Kherson oblast. The agricultural sector of the economy at the Kherson oblast is the basis of its stable development, and this is not only production, but also the development of rural areas, employment, and conditions for rural tourism development.

The advantageous economic and geographical position of the Kherson oblast, especially access to the Black Sea and the Sea of Azov, and favourable climatic conditions contributed to the formation of a powerful recreational and tourism complex in the region. The development of this complex in recent years has been characterized by a dynamic growth of key performance indicators, that qualitatively affects the socioeconomic situation in the region. The volume of tourism services is increasing due to the expansion of domestic tourism. However, the realities of the tourism sector and its opportunities in the region are significantly separated from each other. The oblast has a number of advantages and opportunities, the full use of which can ensure sustainable economic development and a significant increase in the level and quality of life of the population. First of all, these are considerable natural therapeutic resources: the length of sea beaches exceeds 200 km, deposits of therapeutic muds, unique salt lakes, healing thermal waters on the Arabatska Spit, deposits of mineral waters, as well as the presence of 79 objects and territories of the natural reserve fund (including two biosphere reserves - Chornomorskyi and Askania-Nova), as well as more than 5 thousand historical and cultural facilities. Rural tourism is becoming increasingly important. The rural tourism base has been established in Hola Prystan. Rural tourism departments have been organized in Skadovsk, Henichesk, Beryslav and other districts of the oblast. More than 100 thousand people, according to companies licensed to provide tourism services, are annually on vacation in the region, but the actual number is five times higher. There are about 300 recreation centres in the oblast. In terms of medicinal properties, the iodine lakes in the Oleshky district, Syvash in Kalanchak and Soliane Lake in Hola Prystan are not inferior to the Dead Sea, but there are no beaches, boarding houses, or access roads on the coast of Syvash yet. But not only climatic conditions should attract vacationers, but also an appropriate level of comfort and the provision of quality tourism services. Unfortunately, most recreation facilities are in improper condition, so the priority direction for the development of health-improving facilities is to create attractive conditions for investors (Arbuzova & Yakovenko, 2013).

An assessment of opportunities (strengths and weaknesses, opportunities and threats) for the development of rural tourism within the Northwestern Black Sea region from the perspective of SWOT analysis is given in the table 1.

Table 1. SWOT analysis matrix for rural tourism opportunities within the Northwestern Black Sea region

Strengths (S)	Weaknesses (W)
1) the existent Law of Ukraine 'On Personal Farming', which gives the right to the owner of a rural estate to provide services in the field of rural tourism; 2) availability of areas with favourable landscape, climatic and environmental conditions; 3) the presence of objects and territories of natural reserve fund; 4) availability of natural therapeutic resources; 5) availability of natural, environmentally safe food products; 6) ethnographic diversity; 7) the presence of monuments of historical and cultural heritage; 8) the developing rural tourism infrastructure.	1) lack of regulatory and legislative documents in the field of rural tourism; 2) unsatisfactory transport communications; 3) lack of high-quality drinking water in some districts; 4) local residents not having necessary awareness and work experience in the field of rural tourism; 5) complicated relations between entrepreneurs and regulatory authorities; 6) unavailability of necessary advertising and information services; 7) a low level of medical care for the local population and tourists; 8) lack of national standards and regulations for performance of activities in the field of rural tourism; 9) lack of certification of food and agricultural products.
Opportunities (O)	Threats (T)
1) the elaborated draft Laws of Ukraine 'On rural and rural green tourism' and 'On agricultural tourism and agrotourism activities'; 2) reorientation of the tourist flows from coastal recreational areas in the summer period; 3) additional employment for the rural population and an increase in their income; 4) stimulation of holding ethnographic and national holidays and events, festivals and fairs of wine, cheese, etc. 5) revival of handicrafts;	1) instability of the regulatory and legislative framework; 2) conflict between legislative acts and conditions for the legalization of rural tourism facilities; 3) lack of state support for entrepreneurship in the field of rural tourism; 4) increasing competition with other regions of Ukraine in the field of rural tourism; 5) development of hazardous natural processes (floods, flooding, hurricanes, droughts, etc.); 6) higher levels of technogenic impact, and negative consequences of military activities and hostilities (from February 2022).

CONCLUSIONS

Thus, summing up the material stated above, we can say with confidence that in the North-Western Black Sea region there is every reason for the development of sustainable rural tourism. A comparison of natural, cultural, historical and socioeconomic recreational resources allows us to notice some unevenness and inconsistency in their distribution. But this is not a disadvantage for their regional use and development of rural recreation, since it makes it possible to specialize such recreation in the formation of various activities.

Rural tourism in the various districts of the North-Western Black Sea region can develop in the following directions: 1) training personnel in the field of rural tourism (conducting courses, workshops, trainings, introduction of a rural tourism course into the curricula at regional employment centres, and educational programmes at universities); 2) formation of rural tourism clusters in various districts of the relevant oblasts; 3) development of measures to expand the scope of services in rural areas; 4) intensification of the activities of advertising and information centres; 5) holding ethnographic and national holidays and events, festivals and fairs of wine, cheese, etc. to

attract tourists; 6) creation of infrastructure in rural areas that stimulates the development of rural tourism; 7) development of investment projects.

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PROSPECTS FOR THE DEVELOPMENT OF RURAL TOURISM IN THE STEPPE PART OF KHARKIV REGION (UKRAINE)

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ABSTRACT

Before the war, rural (green) tourism was hardly represented in the steppe areas of Kharkiv region. However, this territory has a high natural-recreational and historical-cultural potential for its development. Mild climate with a long period of cloudless weather, large forested areas, various water bodies, rich historical and cultural heritage and large nature conservation areas will attract the tourists.

We have determined promising villages for the rural tourism, developed a network of tourist trails for children's and scientific tourism, economically justifying their operation, determining optimal prices for services in Kharkiv region. The article estimates the volumes of services providing the desired net profit on invested capital, ensuring reimbursement of all activity costs. The authors have calculated a break-even point for different prices for services and invested capital, allowing the entrepreneur to choose the activity program.

Due to rural tourism, the owners of "green" estates can sell their products on the spot, not as raw materials, but as ready-made food products after appropriate processing and preparation. The families, receiving vacationers, improve the structure of crops on their homesteads, considering the needs of guests, expanding vegetable crops, fruit trees, berries, etc., diversifying domestic animal husbandry, starting a greenhouse. Green tourism will also improve rural estates, streets, and villages, stimulating the development of social infrastructure.

Developing rural tourism, people should not intervene in natural environment, keeping their knowledge of the nature, historical and cultural heritage of the region, preserving local color. We need a proper management system for the tourism industry. Thus, to intensify rural (green) tourism in Kharkiv region, it is necessary to develop its innovative types and forms. However, this requires significant financial investments.

Keywords: green tourism, recreational resources, social infrastructure, break-even point, profit.

INTRODUCTION

Ecological tourism is one of the types of tourism carried out in an ecologically preserved natural environment for the purpose of learning about nature and recreation. In recent years, it focuses on the ecological component, explaining the increased attention to places with an unchanged or little changed natural environment. Numerous surveys of tourists show that among the leading motives of tourist trips, the desire of people to communicate with nature is increasingly coming to the fore. Hence, here comes the origin of the terms "soft tourism", "green tourism", etc., which are close in meaning.

Today, the understanding of rural green tourism is being formed as a specific form of recreation in the countryside with a great possibility to use natural, material and cultural potential of the region (Law of Ukraine "On Tourism", 1995). In most countries, rural green tourism is an integral part of the complex socio-economic development of the village, helping to solve numerous rural problems.

The positive impact of rural green tourism is that it expands the scope of employment of the rural population, especially women. It also provides the villagers with additional income by expanding the possibilities of the farmers' employment not only in the production sphere but also in the service sphere. With a growing number of vacationers, there is a need to satisfy their various requests. This, in turn, stimulates the development of the service sphere: transport, communication, trade, household services, recreation and entertainment, etc. (Galushkina, 2009, Korotetska & Maksymenko, 2023).

The development of rural green tourism plays a significant role in raising the cultural and educational level of the rural population. Preparing to receive and serve vacationers, members of farmer families have to update their knowledge of housekeeping, hygiene and sanitation, cooking, etc. Moreover, communication with guests broadens their horizons, making new acquaintances, friends in other settlements.

Organization of any tourist activity relates to the use of natural resources and involves obtaining profits from the sale of tourist products or services. Consequently, a number of environmental problems arise because of its active development, namely:

- pollution of the main components of the environment (atmosphere, hydrosphere and soils);
- depletion and degradation of natural landscapes;
- decrease in the number of plant and animal populations;
- partial loss of biodiversity and disruption of natural ecosystems.

It is necessary to find a compromise between the preservation of a high-quality ecological state of the environment and the development of tourist activities with significant economic profits.

One of the ways to solve these contradictions can be the development of ecological management and rural tourism. The latter, being ecologically oriented, should not only improve the state of the environment, but also solve the existing socio-economic problems of one or another region of the country (Semenov et al., 2004). Primarily, all this applies to rural areas, which are currently little or partially developed.

Activation of tourist activity in the village will be able to improve its economic development and increase the level of economic profitability of the villagers themselves due to the creation of additional jobs. Farmers will be able to expand the range of their employment, given the chance to sell the products of their personal economy locally

(within rural estates). There is also a possibility for the farmers to receive tourists and provide them with accommodation services; arrange tourist routes and paid excursion services; transport service for tourists (meeting at the station, organization of excursions by the host's transport, etc.). Culinary services, production and sale of environmentally friendly food products to tourists; the work of guides or tour guides (from among local residents who have the appropriate education) – all this can improve their financial situation.

The system of environmental tourism management should be based on the following principles (Semenov et al., 2004):

- orientation to the ecological awareness of tourists and organizers of tourism activities;
- economic performance and profitability of the industry;
- timely and effective resolution and prevention of environmental problems;
- responsibility for the economic consequences of management activities.

The organization of rural tourism will stimulate the development of infrastructure and other services within the boundaries of the regions, increasing the attractiveness of the area, contributing to the development of transport links, energy, heat, water supply, communication, trade, garbage removal, etc. However, all this develops only when there is economic efficiency.

The economic efficiency of rural tourism depends on obtaining a certain profit from activities in this area. The direct economic effect of its development is the result of the tourist's expenses for the services, goods and products, additional services (excursions, trips, etc.) within the existing agriculture, as well as expenses for improving and stabilizing the ecological situation in the region. Money spent by tourists in the place of stay creates income, which leads to a chain reaction: expenses - income - expenses - income, etc.

Modern experience and scientific research prove that the accelerated development of rural green tourism can be a catalyst for the restructuring of the economy, ensuring demographic stability and solving urgent socio-economic problems in rural areas. It is strategically important for Ukraine to quickly overcome the backlog in this area and realize the existing rich tourism potential by conducting a balanced policy of state regulation, in particular, at the regional level.

Rural green tourism is a specific form of recreation in private farms in rural areas with the use of property and labor resources of a farmer, subsidiary or farm, natural and recreational features of the area and the cultural, historical and ethnographic heritage of the region (Bilyavskiy & Furduy, 1995). Every year, the number of tourist destinations in Ukraine increases, and rural ecological tourism, which arose not so long ago, is gaining more and more popularity. The main attraction of rural tourism is the original appearance of natural monuments, their inviolability and non-interference of man to improve them.

The following factors contribute to the development of rural green tourism in Ukraine:

- growing demand of residents of Ukrainian cities and foreigners for recreation in the countryside;
- unique historical and ethnographic heritage of Ukrainian villages;
- rich recreational resources;
- environmental cleanliness of the countryside;
- relatively free rural housing stock for receiving tourists,

- available free labor resources to serve tourists;
- traditional hospitality of the hosts and affordable prices for rest;
- a set of additional services for excursions, fishing, picking berries and mushrooms, riding horses, etc. (Skryl, 2009).

The goals of creating rural ecological tourism are:

- to expand primary information about the objects, processes and phenomena of the surrounding nature;
- to teach to see, to notice various manifestations of the anthropogenic factor that can be observed in the area of the routes, and to be able to comprehensively assess the environment;
- to contribute to the education of the ecological culture of human behavior, as part of the general culture of people's relations with each other, and the relationship of man to nature;
- to contribute to the education of the ecological culture of human behavior as part of the general culture of people's relations with each other, and the relationship of man to nature;

Ukrainian rural tourism can become a business card of our country on the international tourist market, which is evidenced by the desire of foreigners to get acquainted with the historical and natural potential of Ukraine.

The topics and types of excursions that can be conducted in rural areas are very diverse. After all, important historical events took place not only in cities, where famous figures of social and cultural life lived, and where important buildings were constructed.

The most common types of excursion activities in rural areas include local history. These tours cover both nature and history, ethnography, architecture of the area, biographies of prominent people who were born or lived there.

The basis for preparing excursions in rural areas can be the materials of local history and memorial museums, both from state museums and those working on a public basis (in schools or at clubs). It is the employees and activists of these centers who organize and carry out search, methodical and excursion work in rural areas.

There are different types of rural estates at present. Agritourism stands out separately, the cottages built specifically for the reception of tourists in recent years and continue to be built in the area are among the green estates.

Rural green tourism continues to develop actively for the following reasons:

- the district has invaluable natural and recreational potential;
- hardworking residents of the region invest free funds in the development of their estates;
- people feel considerable financial benefit from receiving tourists;
- in Ukraine, the number of unspoiled nature corners is sharply decreasing;
- advertising on the Internet attracts more and more tourists to the area.

Some scientists (Boychuk, 2012, Kudinova, 2011, Marynych & Shyshchenko, 2003, Mashkina & Salimon, 2018, etc.) investigated the problems of rural ecological tourism development in Ukraine. In 2008, the All-Ukrainian Association for the Promotion of the Development of Rural Green Tourism introduced the "Ukrainian Hospitality Farm" categorization program in the field of rural tourism.

Here, we distinguish three categories of quality:

The basic (lowest) category – the estate meets the minimum requirements set for places of accommodation for tourists and vacationers.

The first category - the homestead meets the established requirements related to the landscaping of the territory, parking of motor vehicles, the minimum size of beds, the area of sanitary premises, and the completion of training by its owners.

The second category - the estate meets the established requirements, which include an illuminated sign, a separate entrance for guests, a children's playground, a bathhouse/sauna, and access to the Internet.

The third (highest) category - the estate meets the established requirements, which include a swimming pool, a garage, a television in every room, a telephone and a refrigerator, decoration of rest areas with natural materials, round-the-clock hot and cold water supply (Malska et al., 2004, Malska & Hudo, 2007).

MATERIAL AND METHODS OF WORK

In sustainable tourism, the topic of price, like any other business, is a delicate one. The problem is that the consumer wants to get good, high-quality services at a low price. That is why reasonable calculations are important. But what seems simple in theory, looks a little different in reality.

Thus, studies in Switzerland have shown that more than 1/3 of hotel owners set their prices based not on an analysis of the situation, but on their own calculations.

When forming the price for green tourism services, it is necessary to take into account the fact that any element in the market system must be evaluated from two points of view:

- the manufacturer, for whom the cost of providing services is the main one;
- a consumer for whom the main thing is the benefit from using the service. It is the user who decides what price he can pay for using a service or item (Table 1) (Ecological atlas, 2005).

Table 1. The mechanism for calculating the initial price of an environmentally friendly product.

Stages of analysis	Stage content
Setting the task and goal	Formation of demand for ecologically clean products and conquest of the appropriate market share. Profit maximization. Stabilization of market share.
Definition of demand	Upper price limit.
Calculation of production costs	Lower price limit.
Analysis of competitors' prices and products	Prices and products of competitors.
Choosing a pricing strategy. Choice of pricing method	Based on current prices at this cost. Average costs + profit. Breakeven with target profit. Liquid price. The price based on the effect in the field of operation. Price based on market demand. Based on the perceived value of the product. Based on closed trades.
Setting the final price option	Initial offer price.
Setting the final price	Final sale price, including discounts or surcharges.
Product price adjustment	Adjustment of the product price depending on the stage of its life cycle, degree of competitiveness, environmental safety and useful properties.

The main goal of entrepreneurs who plan to provide ecological tourism services is the formation of demand for these services.

To achieve this goal, it is advisable to use low prices, the so-called penetration prices. They are designed to help increase sales, to encourage the purchase of tourism services with improved environmental performance.

Moreover, it is necessary to take into account the demand for green tourism. A company or a private entrepreneur should evaluate it at different prices and try to find out the reasons for its demand.

When forming prices, including those for green tourism services, the demand determines the upper limit of the service price. At the same time, the costs of green tourism services (the sum of fixed and variable costs) determine its minimum value (Principles of Ecology, 2007).

Therefore, in our work, it is necessary to divide services into variable and permanent. Fixed costs of an enterprise or an entrepreneur for a certain period do not change with an increase in the volume of service provision. In our case, it can be, for example, expenses for the purchase of a car to ensure excursion activities.

Variable costs of an enterprise or an entrepreneur directly depend on the volume of services provided, such as food and living costs.

The price level of competitors significantly affects the price of tourist tickets. Every entrepreneur should know the price of competitors' products and the distinguishing features of their products from those of competitors. Moreover, for environmental services, which are green tourism services, it is advisable to consider price ranges, both for ecological products and for ordinary ones that are not environmentally friendly.

RESULTS AND DISCUSSION

The landscapes in Shevchenko community have the following distinctive features, which allow the development of rural tourism and excursion activities with tourists of different age groups (Fig. 1):



Figure 1. The research area - Shevchenko community of Kharkiv region

- moderate continental climate with the longest duration of cloudless weather in Kharkiv region;
- large, for the steppe zone, areas of forest massifs;
- variety of water bodies (rivers, lakes, ponds, reservoirs, springs);
- rich historical and cultural heritage (mounds, relict gullies, memorial estates, museums);
- presence of entomological and biological sanctuaries (Ecological atlas, 2005, Troyner, 2007).

Provided that the recreational resources on the territory in Shevchenko community are properly used, this area can become a popular tourist destination attracting many people who like to spend their free time in unaltered natural areas. The results of research and calculations testify to the significant economic prospects of rural tourism and its importance for the socio-economic and ecological development of rural areas in Kharkiv region (Maksymenko & Zhadan, 2012a).

With the proper organization of environmental management, rural tourism will change the economic situation of villagers, reducing the level of unemployment in the countryside, expanding the spectrum of employment of the rural population (especially young people). It will also improve the rural estates, village streets and the network of transport routes in the region, simultaneously increasing the cultural and educational level of villagers as well as their level of environmental awareness.

The tourism and recreation sphere performs another very important function - the function of sustainable development of human capital. This function is system-forming. It is the final result of almost all generally recognized functions. The tourism and recreation sphere functions and fulfills the function of human capital development within the framework of production-consumption of certain services, serving end consumers. The tourist and recreational sphere is part of the social sphere and, therefore, functions in the sphere of social services of a certain type (Rutynskyi, 2006). Therefore, the general problems of management in the service sector are quite relevant for the tourism and recreation sector as well.

To popularize and activate rural tourism on the territory of Shevchenko community t, it is necessary to make a number of management decisions within the boundaries of regional, district and village administrations to stimulate and encourage rural residents to participate actively in the development of this type of activity.

In our own research (Maksymenko & Zhadan, 2012b, 2013)., we determined the cost of a tour on "green" routes for one tourist in Shevchenko community in Kharkiv region, which is UAH 180. Due to current problems in the market economy, the cost of all tourist services is increasing, and, consequently, the prices are increasing, too.

Analyzing the interrelationship of costs, volume of activity and profit for any type of activity, we used various methods: mathematical (equation method, marginal method), graphical methods (break-even graph, graph of the relationship "volume - profit", graph of marginal income).

The break-even graph (Break-Even Graph) shows the profit or loss at certain costs of the activity. To do this, it is necessary to determine the fixed and variable costs of tourist services from green tourism (Semenov et al., 2004).

Variable costs include:

- the cost of 3 meals a day;
- the cost of accommodation during the validity period of the voucher;

Fixed costs can be considered:

- the cost of purchasing a minibus for excursion services;
- payment for the tour guide.

Taking into account the norms of consumption and modern local prices for food products, we determined the costs for 3 meals per one person for a period of 5 days, which amounted to 250 hryvnias.

Living expenses are UAH 280/5 days, taking into account the norms of water and electricity consumption, as well as taking into account current tariffs.

Furniture, bed linen, equipment of common areas (kitchen equipment and other common areas) are planned to be used for a short-term period at the expense of the host party. Thus, we calculated total losses (variable and constant), which are shown in Table. 2.

Table 2. Planned expenses for the provision of tourist services.

Expenses	The price of a voucher for 5 days/person.
Price, UAH	300
Variable costs, UAH, including:	
- for 3 meals a day;	250
- for accommodation (consumption of water, electricity).	30
The amount of variable costs, hryvnias.	280
Fixed costs, UAH, incl:	
- expenses for the purchase of vehicles, hryvnias;	24 000
- payment for guide services.	500*
The amount of fixed costs, hryvnias	24 500 hrn

* the work of the tour guide for 6 hours is taken into account, considering the tariff of UAH 17/person for 5 days.

Thus, based on the determined cost data, we calculated the break-even point using a mathematical method (Semenov et al., 2004):

$$F = C / (Z - V),$$

Here: F – is the break-even point in natural units,
 C – Fixed costs,
 Z – Price for 1 voucher,
 V – Variable costs for 1 person/5 days.

For clarity, a break-even graph (Break-Even Graph) (Galushkina, 2009) is constructed in several stages:

1. The X-axis shows the volume of activity (sales) in monetary or kind units. Y axis shows costs (with their distribution into variable and fixed) and sales revenue.
2. Fixed cost lines are drawn. The line of fixed costs goes parallel to the X axis at the level of UAH 24,500.
3. Calculated total costs. For several volumes of activity (sales), we calculated the sum of total costs, displayed on the graph in the form of points.
4. The line of variable costs is plotted. The line of variable costs is drawn from the point of fixed costs on the Y axis and through the point of calculated total costs.
5. Estimated revenue from voucher sales. We calculated the amount of income (revenue) from the sale of vouchers for several volumes of activity (sales), displayed on the graph in the form of points.
6. The total income line is plotted. Through the income points plotted on the graph, a line of income from the sale of vouchers is drawn from point "0". The point of intersection of the total cost line and the sales revenue line is the break-even point (Fig. 2).

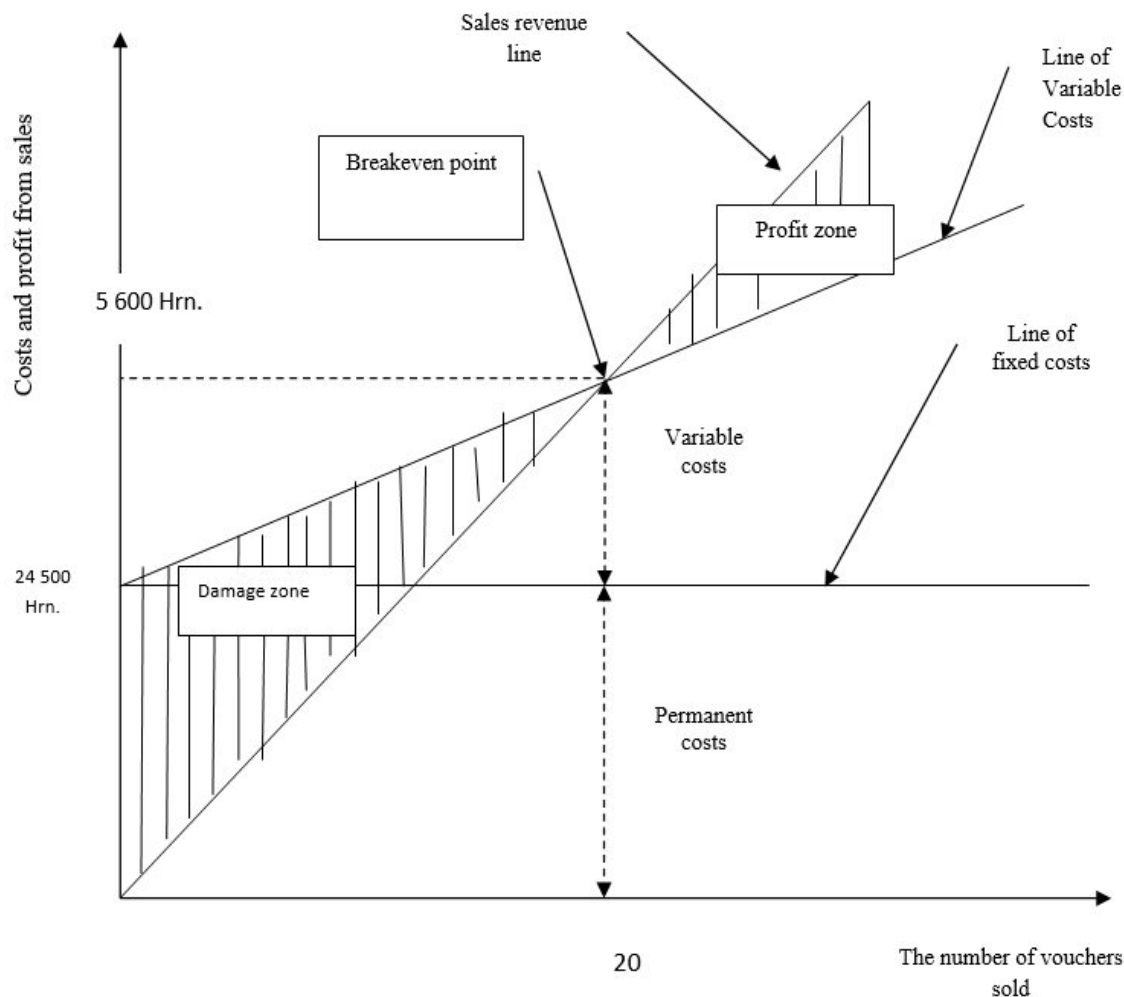


Figure 2. Break-even chart.

So, as we can see from the calculations, accepting 20 tourists in 5 days, we do not get any profit or expenses, this is the number of vouchers sold as the break-even point.

In this case, we calculate all services for the duration of the trip - 5 days.

For the relationship between total profit and sales volume, it is advisable to build a "Profit - Volume Graph" (Profit - Volume Graph), which illustrates the dependence of profit on sales volume in kind or monetary units (Semenov et al., 2004). We can see from the given schedule that in the absence of income from the sale, the entrepreneur's losses are equal to the amount of fixed costs, i.e. UAH 24,500 (Fig. 3).

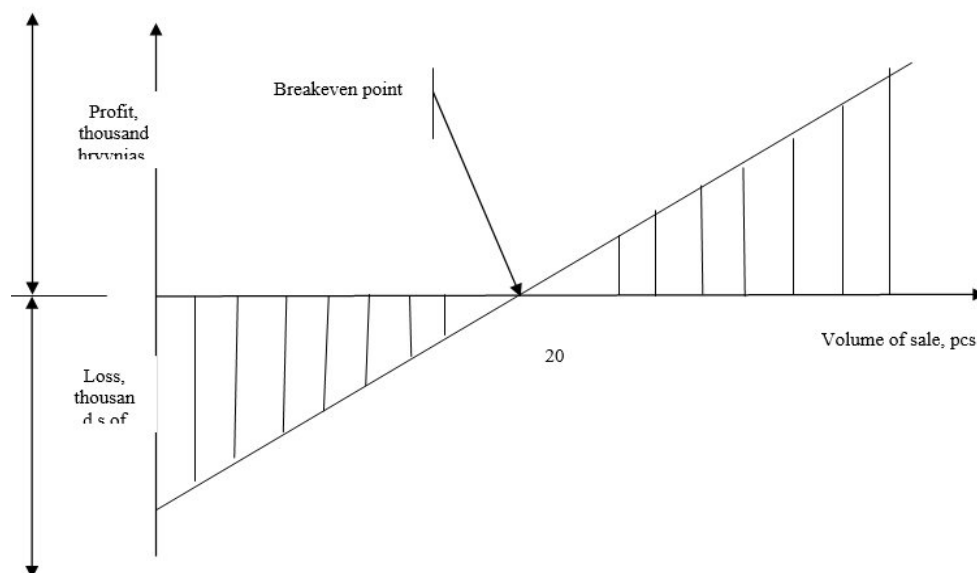


Figure 3. Graph of the relationship "volume - profit"

Also, to illustrate the dependence of the marginal income on the volume of sales and expenses of the entrepreneur, it is advisable to build a graph of the marginal income (Fig. 4) (Galushkina, 2009). The graph shows that the marginal revenue increases as the volume of ticket sales increases.

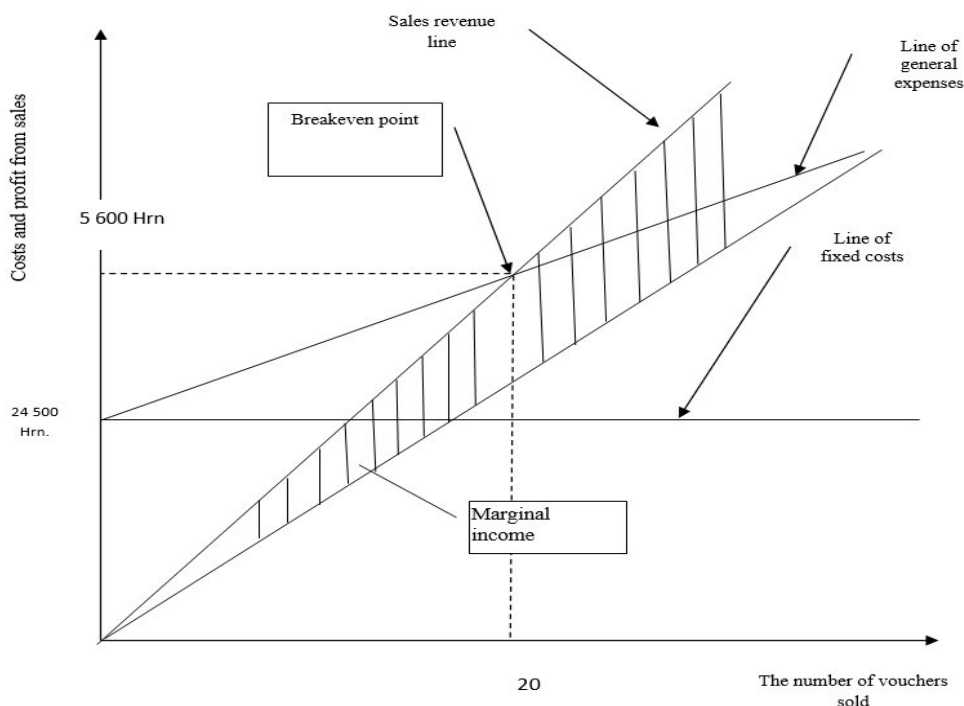


Figure 4. Marginal revenue graph.

In addition, an important result of rural green tourism development is the expanding opportunities for the sale of personal farm products, and their sale on the spot. The people can sell these products not as agricultural raw materials, but as ready-made food products after appropriate processing and preparation. Experience shows

that the families who receive vacationers improve the structure of crops on their homesteads, taking into account the needs of guests, expand the assortment of vegetable crops, fruit trees, berry trees, etc.; develop and diversify domestic animal husbandry, start a greenhouse.

By developing rural green tourism, we encourage improvement of rural homesteads, streets, and villages as a whole, stimulating the development of social infrastructure. Of course, at the beginning, the reception and service of vacationers occurs on the existing housing stock, using local recreational and infrastructural resources. However, with a certain income from this activity, those who are engaged in it, begin to invest in the communal arrangement of housing and streets; achieving changes for the better by joint efforts in the service sphere. At the same time, this is a significant contribution to the development of the village.

The emergence and rapid development of alternative (ecological, sustainable, soft) types of tourism has become an innovative approach in modern tourism. Sometimes, alternative types of tourism are understood as opposed to traditional, mass types. Therefore, each country has its own alternatives. In Ukraine, among the alternatives, there are religious, sports, extreme (adventure), rural, ecological, and other kinds of tourism (Malska et al., 2004, Malska & Hudo, 2007, Sokol, 2006).

The development of rural tourism and its further expansion is possible not only through the creation of tourist trails, but also through the involvement of additional equipment and innovations in the inspection and study of tourist objects. Having analyzed the use of additional equipment when planning a tour of the tourist route, the tourists prioritize hot air balloon flights and airplanes. Thus, for example, using balloons and airplanes, we receive a new type of tourism - extreme. Tourists want to get new experiences from vacations and remember the trip, while tour organizers have the opportunity to get additional income and increase the number of visitors.

CONCLUSIONS

The following factors have a positive influence on the development of rural green tourism in Ukraine:

- growth in demand for recreation in rural areas;
- unique historical and ethnographic heritage of Ukrainian villages;
- rich recreational resources;
- environmental cleanliness of the countryside;
- availability of free labor resources to serve tourists;
- traditional hospitality of the hosts and an affordable prices for vacation.

During the implementation of the research program, we established that the Shevchenko community of Kharkiv region has a high natural-recreational and historical-cultural potential for the development of green tourism. The main advantages are:

- availability of cultural monuments;
- rich, diverse natural fund;
- temperate continental climate;
- absence of objects polluting the environment;
- low economic expenses for recreation.

The development of green tourism will make it possible to solve many rural problems. Analyzing the circumstances in our country, we can say that air tourism and sports (use of hot air balloons) is only in its infancy.

As a type of economic activity, green tourism includes other forms of entrepreneurship (agritourism, farming and ecological tourism). It is a set of relations regarding tourist and recreational activities with various goals in rural areas under the influence of localization factors (rural area or environment), selectivity (potential consumers) and implementation (green tourism industry and infrastructure). From an entrepreneurial point of view, it is an independent, systematic, risky economic activity, providing a complex of basic and related services with the aim of obtaining an economic, social or other effects.

Thus, to intensify tourism in Shevchenko community of Kharkiv region, it is possible to develop its innovative types and forms. However, this requires essentially significant financial investments.

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THE OFFER OF LOCAL FOOD AS A FUNCTION OF TOURISM DEVELOPMENT IN THE MAČVA DISTRICT

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ABSTRACT

In addition to investing in tourism, to become touristically attractive, a destination needs to identify potentials that can be utilized for promotion and market placement. Contemporary trends in tourism lean towards natural and unspoiled environments, where Mačva, untouched by technological waves of development and globalization in food production and consumption, may have a chance for development in a discerning market. Gastronomic tourism is described as a form of cultural tourism aimed at attracting food-motivated tourists. Gastronomy is one of the most important factors influencing destination choice and satisfies the specific needs of consumers, local producers, and other stakeholders in tourism and hospitality. Local food plays a significant role in preserving tradition, attracting tourists, and supporting the regional economy. Local food showcases the culture of residents and elements of everyday life, providing an authentic experience of tradition. When traveling, tourists seek authenticity and local experiences. The gastronomy of a place and local food offer an opportunity to experience a unique experience. The main goal of this paper is to assess the gastronomic potential that could attract tourists to Mačva and to analyze the current gastronomic offer. The paper discusses the significance of food from a theoretical perspective and highlights identified potentials that could represent an opportunity for the development of the Mačva district. The role and effects of local food are becoming increasingly important for the competitiveness of the destination's tourism.

Keywords: food offer, gastronomy tourism, tourism, Mačva district, hospitality.

INTRODUCTION

According to research (Gheorghe et al., 2014), tourism holds a significant place in people's lives, with tourists increasingly seeking new experiences while traveling. Recognized by the state and regulated according to destination needs, tourism can represent an opportunity for new job creation, attract foreign direct investment, and stimulate national, regional, and local economic growth (Királ'ová, 2021). Tourism represents a key sector of the economy that not only plays a vital role in the development of specific areas but also makes a significant contribution to the promotion and better understanding of the environment. Destination marketing studies emphasize that food can be a key attraction for tourists (Vuksanović et al., 2016), given that the needs for food and drink are basic biological needs of humans that arise periodically and independently of tourist desires (Samardzić, 2021).

Food and drink represent universal aspects of every culture, with customs related to gastronomy reflecting specific characteristics of a destination's cultural heritage. Therefore, gastronomy and identity are interconnected on multiple levels. Food is often described as a simple pleasure of life, but in fact, it encompasses complex processes such as production, preparation, processing, and serving (Samardzić, 2021).

Gastronomy as a scientific discipline studies the characteristics of food and methods of their preparation to create delicious dishes (Kalenjuk, 2017). Gastronomic tourism is becoming increasingly popular among tourists, emphasizing the importance of authentic food and drinks as a key reason for visiting a particular destination (Banjac et al., 2016; Björk, 2016).

According to the Tourism Development Strategy of the Republic of Serbia (2016-2025), gastronomic tourism involves traveling to regions rich in culinary resources, resulting in the creation of local experiences through activities such as visiting food producers, participating in festivals, and tastings. The World Tourism Organization observes a growing trend in gastronomic tourism, considering that more than a third of tourist spending goes to food (Tourism Development Strategy of the Republic of Serbia 2016-2025). Interest in local food is increasing, attracting "foodies" seeking authentic local culinary experiences. The experience of consuming food is a crucial factor in tourists' perception of a destination (Vuksanović et al., 2016).

Recognition of local cuisine as a destination attribute and understanding its impact on tourists' perception are key research questions in gastronomic tourism (Vuksanović et al., 2016; Királ'ová, 2021). The cultural heritage of food and characteristics of local cuisine are crucial for visitors and integral parts of the tourism experience at a destination (Vuksanović et al., 2016; Királ'ová, 2021).

Destination management organizations consider local food an essential tourism resource and an indispensable part of the destination's image. Food also plays a key role in promoting local products through social media, attracting visitors (Királ'ová, 2021). The need to research local gastronomic characteristics arises from the richness and diversity of gastronomy, which can make a certain region an attractive tourist destination (Samardzić, 2021).

This research focuses on the local food and beverage offerings as a key factor in attracting gastronomic tourists and developing tourism in the Mačva District. The primary objective of this study is to explore and analyze the significance of gastronomic tourism as an increasingly popular segment in the tourism industry, focusing on the role of authentic food and beverages in attracting tourists and their impact on destination perception. The secondary objective is to examine how local gastronomic offerings can contribute to tourism development in the Mačva District by identifying key factors and

strategies for enhancing tourism offerings through gastronomy. Through the analysis of relevant research, strategies, and trends in gastronomic tourism, the aim is to provide insights into the potential role of gastronomy in destination development and highlight the importance of promoting local cuisine as a key element of tourism identity and destination attractiveness.

The first part of the paper presents various research models exploring the relationship between food and tourism development, considering the significance of different approaches in research. Understanding the connection between consumers, distributors, and producers of gastronomic products and services is essential to establish appropriate theoretical research models. The second segment of the paper focuses on the Mačva region, its natural and touristic potentials that can be leveraged to better valorize Mačva in the tourism market. Within this section, the importance of gastronomic tourism and local development is discussed, highlighting that local food plays an increasingly significant role in the selection of a tourist destination. The final segment of the paper concerns the analysis of the current gastronomic offerings in the Mačva region.

ANALYSIS OF KEY FACTORS IN TOURISM DESTINATION DEVELOPMENT

Considering the relationship between food and tourism encompasses various concepts and perspectives, including gastronomic tourism, culinary tourism, food tourism, tasting tourism, restaurant tourism, wine tourism, and gourmet tourism (Samardžić, 2021). Additionally, there are other relevant divisions such as food as a tourist attraction, the role of food in tourism as an attraction and obstacle, foodstuffs as a component of the tourist product, food experience in tourism, and the role of food in culture (Kalenjuk, 2017).

Examining consumer perception (Durmaz et al., 2022) suggests that gastronomic tourism plays a role in creating satisfaction with a tourist destination. By preserving local tastes and gastronomic heritage, it can enable better marketing and positioning of the region.

Researching gastronomic potentials with a focus on the regional context involves a detailed analysis of literature on gastronomic tourism. Banjac et al. (2016) emphasize the importance of research within specific areas to gather relevant data. In this context, identifying culturally and historically significant destinations involves analyzing museums, cultural institutions, and historical monuments to assess their contribution to gastronomic tourism.

Analysis of natural attractions that can attract gastronomic tourists includes vineyard areas, natural reserves, and riverside restaurants offering local gastronomic experiences. Additionally, it is necessary to analyze the food offerings in local restaurants as a key factor in tourism development (Green & Dougherty, 2008). Björk (2016) explores the socio-demographic characteristics of tourists to understand their interest in local food and the factors influencing their food experiences at destinations.

The importance of the role of employees in tourism organizations in conducting surveys and obtaining relevant data for drawing conclusions is emphasized by Vuksanović et al. (2016). Approaching research on values and motivations related to tourists' food choices during vacations through interviews with tourists enables a deeper understanding of their preferences and perceptions about local food and beverages (Sims, 2009).

Research models on local food experiences, such as those proposed by Kim et al. (2009), aim to identify key themes and questions related to the selection of local food and beverages during travel. These studies contribute to the development of theoretical models related to local food and consumption at tourist destinations.

PERSPECTIVES AND DEVELOPMENT POTENTIALS OF LOCAL GASTRONOMY IN TOURISM FUNCTION

The Mačva District represents a diverse region in terms of tourism, where tourism is considered an additional activity in all eight municipalities of the Mačva District (Milićević, 2010). The tourism position of Mačva is closely linked to the rivers Drina and Sava. Due to this geographical location, Mačva is traversed by several local and regional roads, as well as the railway line Ruma-Šabac-Zvornik (Ćurčić & Ristanović, 2000).

Mineral and thermal waters represent a special resource of the Mačva District, and well-known health resorts such as Banja Koviljača, Banja Badanja, and Radaljska Banja have the potential to become prominent tourist destinations, although they have not been fully utilized thus far (Milićević, 2011). The most significant tourist potential of this area lies in the richness of its waters, both surface and underground. The rivers Sava and Drina surround Mačva and attract tourists with their diverse fish, sandy shallows, and beaches. Mačva is also known for its abundance of drinking water, and research has shown that these waters are found in the wider area of Mačva and can be used for various purposes, including spa treatments, pool construction, the development of bathing tourism, fishponds, food production, and energy purposes (Ćurčić & Ristanović, 2000). Rural tourism is on the rise in the Mačva District, as it is predominantly a rural and untouched area. Visitors are offered authentic food, relaxation in nature, visits to monasteries, hunting and fishing opportunities, as well as direct contact with domestic animals (Vasić Popović et al., 2023). Some of the attractive facilities providing such experiences include "Etno Selo Avlija" in Glušci, "Etno Park Mačve" in Sovljak, "Penića Vajat" in Dublje, "Etno park Pocerine" in Nakučani, "Vajat Hajduk Stanka" in Crna Bara, "Etno park" in Vladimirci, and others (Grčić, 2010). In the territory of Mačva, especially in the municipality of Bogatić, significant cultural and tourist events are organized during the summer, such as "Izažanjac," Mačva Assembly, and "Hajdučke večeri," allowing visitors to experience the tradition of the time of the hajduk Stanko (Ćurčić & Ristanović, 2000).

In Šabac, the most famous events are Čivijada and Šabački vašar. Čivijada is a cultural and tourist event that celebrates the original humor of the residents of Mačva and the city of Šabac. Šabac fair is an authentic tradition of Šabac (Gligorijević & Novović, 2018).

THE SIGNIFICANCE OF GASTRONOMIC TOURISM FOR LOCAL DEVELOPMENT

Food and tourism are closely linked to the image of tourist destinations, which can be achieved in various ways. The integration of food into tourism marketing has been increasingly applied and expanded over the last few decades.

Food is used as an attractive offering in brochures, videos, and television programs, and new products and authentic experiences are based on heritage, which destinations use by opening food factories with a long tradition. Food becomes a central element of festivals and events that attract tourists and the local population, and local products that are part of the culture are used during travel (Vukolic, 2020).

In order to develop gastronomic tourism, it is emphasized that rural areas could promote the cuisine of specific rural regions, and destinations with rich food products could become leading tourist attractions. The destination's food can be part of a larger tourism event or represent a good potential for the development of culinary tourism (Vukolic, 2020).

The preparation and consumption of food in tourism are specific because they involve physical and material products of various shapes, colors, textures, tastes, and smells that can be preserved. Unlike services that do not have physical characteristics, food is a multifunctional attraction in tourism, becoming a tangible material component of the tourism product (Banjac et al., 2016).

The development of local areas through tourism can also be linked to the wine industry, which involves promoting regional wineries and breweries. Instead of directing marketing efforts towards specific local destinations, the importance of promoting the entire region is emphasized. Local breweries and wineries often offer tours and organize festivals, while restaurants can host culinary workshops to demonstrate the preparation of regional dishes. Local farmers can also organize tours and farm visits, as well as participate in direct marketing activities such as farm shops and self-service opportunities. Tourists increasingly seek authentic experiences that connect them with nature, and experiencing local cuisine and regional culture is one way to satisfy this demand (Green & Dougherty, 2008).

In order to obtain the status of a traditional gastronomic product, the method of production and manufacturing must be at the national, regional, or local level. Products must have authentic recipes and ingredients. The sensory components of traditional gastronomic products are of vital importance for the destination's good image. Consumer reaction depends on the appearance and taste of the food. If the product is traditional and authentic, consumers appreciate it, making local gastronomic products attractive. However, it is desirable to somewhat adapt the offer to consumers' preferences (Kalenjuk Pivarski et al., 2022).

The hospitality and tourism industries benefit from recognizing the importance of local food and the local food market. Understanding the benefits of food-related segmentation allows for tailoring marketing activities to the diverse needs, desires, and behaviors of tourists. Studies exploring tourist types help understand their attitudes and behaviors, enabling adjustments of promotional activities to meet their needs (Bjork, 2016).

CURRENT STATE OF LOCAL FOOD OFFERING IN THE MAČVA DISTRICT

Based on research conducted between February and April 2023, authors Vasic Popovic et al. (2023) highlight that the gastronomic offerings of Mačva are shaped by managers and owners of hospitality establishments. However, it was found that employees are not sufficiently familiar with traditional dishes.

When asked about the preparation of traditional Mačva dishes, employees responded that they prepare the dish called "listići" (pieces of dough fried in deep fat) and cabbage salad, while traditional dishes are completely neglected. Analyzing the available websites of hospitality establishments in Mačva, it was noticed that some establishments presented their menus. The menus were organized into groups of dishes such as breakfast, appetizers, pasta and risotto, meat dishes, grilled dishes, pizzas, and cooked dishes. The dish offerings in the analyzed menus were quite uniform and similar. Appetizers included Caesar salad, carpaccio, cheese selection, bruschetta, Caprese salad, homemade cream cheese, and grilled mushrooms. The group of pasta

and risotto dishes was prepared in a Mediterranean style, while some restaurants offered porcini and chanterelle mushrooms, associating them with the authentic flavors of the region. The main shortcoming in the gastronomic offer of Mačva was the lack of local fish specialties, considering the richness of the Drina and Sava rivers. Most hospitality establishments offered salmon, tuna, and squid, while a very small number of establishments had trout, carp, and pike on their menus. Meat dishes were the most abundant group of dishes in Mačva restaurants, including lamb, beef, veal, pork, chicken, and turkey, prepared in various cooking methods. Dish names reflected the local character, such as "Hajdučki zalogaj" and "Čivijaška šnicla". The group of cooked dishes stood out with bean stew, cooked knuckle, stuffed cabbage rolls, and goulash. Most establishments offered international food options, with only a few traces of authentic, local products.

OPPORTUNITIES FOR FURTHER DEVELOPMENT OF MAČVA'S GASTRONOMY

The gastronomy of Mačva is shaped by its climate conditions, tradition, and indigenous ingredients that can serve as the basis for an authentic culinary offer. The Sava and Drina rivers can serve as inspiration for creating a variety of fish dishes such as soups and stews. As a predominantly rural area, one of the primary occupations in Mačva is livestock farming and agriculture. The region abounds in a rich livestock population and represents the majority of the local population's diet. Meat products and labels indicating that visitors can consume meat originating from Mačva can be well-received by tourists.

Cooked dishes can be enriched by using naturally sourced vegetables such as potatoes, peppers, and cabbage. Fruit is also an essential part of the Mačva diet and, in combination with various desserts, could be found in the current gastronomic offer as well as through various jams, brandies, and compotes. It is common in this area to prepare various types of pastries and dough traditionally in wood-fired ovens.

Mačva, as a region in Serbia, has variations in the preparation and processing of dishes, so communication with local producers should aim to form an authentic, local gastronomic offer.

CONCLUSION

The tourism-gastronomic attributes of Mačva are still not sufficiently known to potential tourists, implying the need for more active promotion of local gastronomic products to better position this destination in the tourism market. Local food plays a crucial role in tourism, and recognizing its potential for market positioning can bring numerous benefits, including increased employment and overall economic development of the destination.

A sustainable approach to food production can serve as an example of good environmental practice, which can further attract tourists who value ecologically preserved destinations.

Promoting local gastronomy can attract new types of tourists interested in authentic experiences, contributing to the diversity of the tourism offer and extending the visiting season. The gastronomy of a region is an important part of its cultural heritage, allowing tourists to experience authentic tastes and traditions of Mačva, which can strengthen the local identity and community pride.

The current gastronomic offer of Mačva is based on international cuisine, but in the future, it should be directed towards reintroducing indigenous flavors that reflect the gastronomic heritage of Mačva. Events such as Čivijada and Šabački vašar can be

utilized to promote local gastronomy and provide visitors with additional experiences through gastronomic activities and food offerings.

The gastronomy of Mačva, combined with other tourism potentials, represents an important opportunity for further advancement, but a clear plan for further development and implementation is necessary. This overview serves as a foundation for future research, which would involve conducting field studies for a deeper and more comprehensive understanding of the current state and untapped potentials of this specific area.

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THE ROLE OF MARKETING FOR THE CITY OF ŠABAC AS A TOURIST DESTINATION

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ABSTRACT

Marketing as a single management process represents the basics of organization, planning, analysis, policy and activities of a company, and as such it is applicable at the level of every tourist destination. Its role is based on opening various opportunities for the development and progress of tourism in a certain place, through the improvement of various strategies and techniques to attract as many tourists as possible to the destination, which is the ultimate goal of all marketing activities related to each tourist destination.

Achieving previously established marketing goals at a tourist destination is based on the mutual cooperation of destination marketing organizations (in Serbia known as tourism organizations) and the entire tourism, hospitality and hotel industry of a place.

As at other levels of tourism study, the emphasis is on meeting the needs of tourists, so the basic role of marketing at the level of a tourist destination is reduced to meeting the needs of all visitors. The aim of this work is to show how all marketing activities work in the tourist destination of Šabac. Therefore, the paper examines the characteristics of the tourist destination of the city of Šabac, as the basic foundations of the development of tourism in the city, connecting them with the tourist, hospitality and hotel economy, which represents a significant segment of the possibilities of progress and growth of the tourist destination.

Keywords: marketing, promotion, tourist destination, tourism.

INTRODUCTION

Every tourist destination strives to satisfy all its elements and align them in a way that justifies its attractiveness. For tourists, the most important fact is that arriving at a certain destination is worth their free time and invested financial resources. Therefore, all elements of the tourist destination must be aligned, because if something in the system does not have the appropriate quality, it directly reflects on the entire tourist destination and produces dissatisfaction among users (tourists).

The city of Šabac itself, as a cultural and economic center of the region, represents a significant condition for the development of tourism. Starting from the Sava River, which has a calm flow and all the advantages for the development of water sports, as well as for the development of fishing tourism. The proximity of Mount Cer can contribute to the development of excursion and mountain tourism, and many preserved rural households contribute to rural tourism. However, the people of Šabac, famous as good hosts, have devoted the most attention to organizing and preparing various events, so this type of tourism is developing best and fastest. And what Šabac has to offer, as the First Town of Serbia, as it was called in the past, is certainly a unique cultural and historical story that extends through all the pores of the past and present of this city.

The first chapter of this work presents the characteristics of the tourist destination of the city of Šabac, through the explanation of the concept of a tourist destination, a review of the basic characteristics, and an examination of the most significant elements of the destination. By analyzing the tourist potentials of the city of Šabac, we go through the most important facts about the city itself, which make up the tourist offer of this destination. The second part of the work represents marketing activities at the destination level, analyzing tourist traffic, as the main indicator of tourism movements at the destination, as well as an analysis of accommodation capacities in the city. The third part of the work discussed the Tourist Organization of the city, as the main driver of all marketing activities and the development program for future investments in tourism.

CHARACTERISTICS OF THE TOURIST DESTINATION OF THE CITY OF ŠABAC

The term 'destination' originates from the Latin language and signifies determination, decision, purpose, and ultimate goal. A more recent explanation of the term comes from the English language (from which it was adopted into all other languages) and denotes a destination as a place to which things or a person go, the end of a journey (Popescu, 2016). We further explain the tourist destination using the concept of a tourist place or a resort. It implies a place that attracts a large number of tourists, where tourism with its special characteristics plays an important role in economic functioning (Woosnam et al., 2020). This includes cities that possess significant tourist facilities, regions within which there are tourist centers, as well as enclosed facilities with various recreational and social contents at one location (Khairi et al., 2021). Such diversity of tourist places has necessitated the need to define the concept of a tourist destination.

We can define a tourist destination in different ways, depending on what our perspective is. Therefore, there are definitions that focus on the destination as a place of arrival and reception of tourists, then those whose focus is on what is offered to tourists, while for some, tourists are in the foreground as an integral part of the destination. Determining the destination's development policy must be in accordance with its nature, characteristics and uniqueness (Damjanović, 2021).

We can also say that a tourist destination is a set of different components within which visitors achieve different forms of tourist experience (Godovykh et al., 2020). A tourist destination is considered a special geographical region, which ensures the satisfaction of tourists needs through a variety of products, services, natural resources, created elements and information (Kyriakaki et al., 2022).

Most often, the basic element of a tourist destination is its attractiveness, which represents one of the most important characteristics for attracting visitors (Khairi et al., 2021). Apart from attractiveness, other resources, such as infrastructure, people, knowledge, financial capital, hospitality, entrepreneurship and political factors, influence the development and positioning of the destination. The broad division of the elements of a tourist destination, with the inclusion and classification of all segments, can be summarized as follows (Popesku, 2016):

- attractions - most often represent the main motivation for visiting a certain destination and are one of the main focuses of visitors. They can be classified into: natural, built and cultural.
- services and facilities - refers to different types of facilities that provide accommodation, food and recreation services for visitors. This includes facilities and services providing information, travel agencies, guides, infrastructure, public transport, various sales facilities and the like.
- accessibility - the possibility for visitors to easily reach the destination, favorable conditions for transporting a large number of passengers by road, air, rail or water transport. Also, easier conditions when crossing the border, simplified visa regime and conditions for entering the destination.
- human resources - one of the most important aspects in the overall experience of a destination is a well-trained workforce, as well as a local population that is ready and aware of the benefits and responsibilities that this activity brings.
- image - for the success of a tourist destination, in addition to attractions, services and facilities, it is crucial to create a good image, which implies uniqueness, localities, level of service, hospitality, security, etc. Various means are used to promote the image of the destination, such as advertising, branding, electronic marketing and others.
- price - one of the main factors when deciding which destination to visit. It depends on the cost of transportation to and from the destination, as well as the cost of accommodation, food and other services.

The classification of tourist elements can help us in better management of the destination, by seeing the potential of the destination itself in the best way, the most important thing that the destination has to offer tourists, as well as answering the question of how to improve what the destination lacks.

Tourist potentials of the city of Šabac

The city of Šabac covers the northern part of western Serbia, it is the administrative and economic center of the Mačva district, which is located between the lowlands of Mačva, the hilly Pocerina and Posavina, under the mountain Cer. The Sava River, one of the most important navigable rivers in our country, flows through the northeastern part of the city's territory.

The geographical position itself represents a great advantage, because it is located near the large city centers of Belgrade and Novi Sad and is extremely well connected by road, rail and river transport routes with its surroundings and other parts of the country.

Every city is made up of people, but also the buildings in which they live. Different historical and stylistic directions, which have been created here in the last two centuries, today form the unique ambient and architectural value of Šabac. In the period 1816-1831, Jevrem Obrenović lived and ruled here, and in that period Šabac became a model for its planning development and the first detailed urban plan.

One of the first urbanistically resolved intersections in Serbia is the very center of today's town of Šabac, an intersection that was conceived as a base around which the city further expanded and developed. Those two streets that intersect at right angles formed the main city roads, and it is the same today. At that time, merchants and craftsmen began to settle in the center of the city, who brought new customs with them and began to build houses and their shops on the same lot. More beautiful houses are being built with various architectural styles. All architectural buildings in this period were created under the influence of Middle European architecture, and some buildings have traces of neoclassicism, art nouveau, and even modernism. As the city went through different periods of peace and wars, certain buildings appeared and disappeared, but most of them were preserved and constitute the ambient and architectural heritage of the city of Šabac, which we must take care of and preserve in the future.

As indicated in the previous part of the paper, the attractiveness of a tourist destination is crucial for a tourist's decision to spend his free time in a certain tourist area, as well as to invest his financial resources in that place in order to satisfy his tourist needs.

The characteristics of the tourist offer of each nation, region or local community represent its recognizable cultural identity. What makes one country or city different from others is the culture of the people. This includes history, languages, national monuments, customs, beliefs and all those specific local, cultural values that exist only in that place and that is what attracts or does not attract tourists. (Đukić Dojčinović, 2005).

The attractiveness of the tourist destination Šabac, according to its most significant characteristics and advantages, could be divided into three groups:

- natural resources - Sava river, Cer mountain;
- cultural and historical resources - Šabac Fortress, National Museum, Cathedral Church, Pedestrian Zone, culture, customs;
- Manifestations - Čivijada, Carnival, Šabac Fair, Lipolista Rose Festival, Swimming Marathon, ŠLF, Horse Races.

MARKETING AT THE LEVEL OF TOURIST DESTINATION ŠABAC

Marketing is a social and management process that serves to analyze, organize, plan and control potential customers, policies and activities of the company. Marketing tends to devise a strategy that will engage target customers and build profitable relationships with them (Čerović et al., 2022). As at other levels of tourism study, here too the emphasis is on meeting the needs of tourists. The goal and basic strategy of marketing at the level of a tourist destination is to know, analyze, adapt to the needs and wishes of existing and potential customers and consumers, i.e. tourists.

The importance of marketing activities at the level of a tourist destination is reflected in the division of responsibilities and specifics of organizing tourism at the macro and micro level. Activities at the macro level are carried out by appropriate state bodies and institutions and form a consistent framework for marketing the tourist destination, while activities at the micro level are related to companies in the field of

tourism and hotel management, which are significantly influenced by the characteristics of the destination itself (Schmude et al., 2020). Achieving marketing goals at the level of a tourist destination is based on broad cooperation between destination marketing organizations and the entire tourism and hotel industry (Popescu, Gajić, 2020).

Tourist destinations are places where tourism products are created, which have hedonic value and psychological benefits for tourists, so the competition in tourism is primarily focused on tourist destinations. Given that the nature of tourism includes different types and structures of capabilities (social, economic, cultural, etc.), the competitiveness of a tourist destination can be presented as the ability to increase tourist consumption, attracting a significantly larger number of tourists, ensuring them experiences that satisfy them and that they remember. All this needs to be done constantly in a way that brings profit, along with the prosperity of the inhabitants of the destination and preservation of natural resources for the future (Popescu, 2016).

To look at all the elements of a tourist destination, in addition to highlighting its attractiveness, availability, human resources, image, it is very important to look at accommodation facilities and tourist traffic. In order to evaluate the destination in the best way, analyze its advantages and disadvantages, it is important to know how many and what kind of accommodation facilities it has, as well as what are the wishes and needs of the tourists who come. In the continuation of the work, tourist traffic in the city of Šabac, as well as accommodation facilities, were analyzed.

Analysis of tourist traffic at the destination

By analyzing the tourist traffic at the destination, we can conclude the movement of tourists and the length of stay at the destination. From this information, significant conclusions can be drawn, which can be further analyzed and used in the preparation of a plan and strategy for the development of tourism and attracting more tourists. Table 1 shows statistical data for the period 2013 - 2022 for the tourist destination Šabac, which is collected every year by the Republic of Serbia Statistics Institute from all participants in the tourism economy of our country. From the given data, we can conclude that in the observed period there was a significant increase in domestic and foreign tourists, as well as in the number of overnight stays at the Šabac destination, until 2020, when the number of tourists dropped sharply due to the Covid 19 pandemic. The year after the recession recorded an increase in the total number of tourists, as well as the number of overnight stays, while the year 2022 saw the largest number of tourists, both domestic and foreign, as well as twice the number of overnight stays (compared to the year before). According to the given data, Šabac has a larger number of domestic tourists, but foreign tourists spend more nights at the destination than domestic tourists.

Table 1: Tourist traffic in the destination Šabac for a period of 10 years (2013-2022.)

Year	Tourists			Overnights stays of tourists			Average number overnight stays of tourists	
	in total	domestic	foreign	in total	domestic	foreign	domestic	foreign
2022	20.075	13.018	7.057	65.088	33.297	31.791	2,6	4,5
2021	15.146	11.112	4.034	30.255	21.410	8.845	1,9	2,2
2020	7.895	5.953	1.942	18.178	13.230	4.948	2,2	2,5
2019	17.893	9.474	8.419	56.473	19.001	37.472	2,0	4,5
2018	17.074	8.977	8.097	40.396	15.461	24.935	1,7	3,1
2017	16.655	10.172	6.483	30.234	16.274	13.960	1,6	2,2
2016	12.232	7.250	4.982	21.400	11.527	9.873	1,6	2,0
2015	7.186	3.886	3.300	11.155	5.553	5.602	1,4	1,7
2014	5.186	3.566	1.619	9.242	6.192	3.050	1,7	1,9
2013	3.026	1.584	1.442	8.870	2.867	6.003	1,8	4,2

Source: Republic Institute of Statistics of Serbia, Publications

Conditions for staying at a tourist destination

The conditions for staying at a destination are first of all accommodation facilities, then restaurants, cafes, shops, parks, swimming pools, promenades and everything else that can be interpreted as the needs of tourists in the specific area where they are staying. Given that Šabac is an important city center, it has all the necessary facilities, both for the local population and for tourists who come.

In the past, the city of Šabac had problems with an insufficient number of accommodation facilities. In recent years, the situation has changed significantly, primarily with the renovation of the Sloboda Hotel (which was not in operation for more than a decade) and the opening of several smaller city hotels, as well as other types of accommodation.

Hotel Sloboda, built in 1978, has the greatest importance for the development of tourism and hotel industry in Šabac. It was successfully privatized in 2003 and is now part of the first Serbian hotel chain, A hotels. The complete renovation lasted until 2014, when it was opened as a four-star luxury hotel. It is located next to the town square and the pedestrian zone. The hotel has 95 accommodation units, which can accommodate 193 guests, as well as a restaurant, lobby bar, cafe - pastry shop, SPA & Wellness center. The hotel is suitable for various symposia, seminars and congresses, as it has three multifunctional halls with a total capacity of 950 seats (Hotel Sloboda, 2024).

In Table 2, we can see the categorized hotel accommodation in the city, as well as the number of accommodation units and capacity. Categorization of hotel facilities is done at the level of the Ministry of Trade, Tourism and Telecommunications, under the tourism sector.

Table 2: Categorized accommodation facilities on the territory of Šabac - hotels

Name of object	Total number of accommodation units	Total number of beds (facility capacity)
Garni hotel Ušće 2*	14	24
Garni hotel Euforia Lounge 3*	30	78
Garni hotel Morava 3*	16	29
Garni hotel Barut 4*	15	28
Hotel Sloboda 4*	95	193

Source: <https://mto.gov.rs/tekst/308/sektor-za-turizam.php>

Table 3 shows the categorized home-made catering facilities according to the Decision of the Head of the City Administration of Šabac, which was recorded and issued by the Committee for Categorization of Home-made Tourist Accommodation in the territory of the city of Šabac.

Table 3: Categorized accommodation facilities on the territory of Šabac - other accommodation facilities

Name of object	Total number of accommodation units	Total number of beds (facility capacity)
Apartments (3*, 4*)	34	77
Rural Tourist Households (2*, 4*)	3	24
Rooms (2*, 4*)	27	64
Holiday Homes 2*	1	10

Source: City of Šabac, City Administration, 2021

CITY TOURIST ORGANIZATIONS AND DEVELOPMENT PROGRAM

The tourist organization of Šabac was founded in 1996 by the City Administration. The main role of the Tourist Organization of Šabac is reflected in promotional activities and the organization of events (Tourist Organization of Šabac, 2024):

- *Promotional activities:* organization of informative and propaganda activities, presentation of Šabac's tourist offer at tourism fairs, tourist events in the country and abroad, initiation and design of new activities to improve the quality of Šabac's tourist offer, design, issue and distribution of souvenirs in Šabac, etc.
- *Organization of events:* The tourist organization of the city of Šabac has the role of organizer and co-organizer of events in the area of Šabac, some of the most significant events over the years are: Čivijada, Carnival, Šabac Fair, Lipolist Rose Festival, Swimming Marathon, Šabac Summer Festival, Horse Races, etc.

The website of the Tourist Organization of the city of Šabac (sabacturizam.org) is informative, well-reviewed, modern in design and is an online place where you can find all the necessary information about the city itself and tourist attractions. Accommodation facilities, restaurants, cafes, offer of tourist tours with guides, sights of the city, rural tourism, calendar of events, news, useful information can be found on the site. The categories on the site are: Sightseeing, Hospitality, Events, Accommodation, Info and Čivijada. The Šabac tourist organization is actively engaged in informing citizens and tourists, as well as promoting the city through social networks - Facebook and Instagram.

The tourist organization of the town of Šabac is the customer of the document called the Tourism Development Program of the town of Šabac for the period 2020-2025. year. In this document, the strategic goal of tourism development in the area of Šabac is singled out, which represents the acquisition of competitiveness and recognition of the town of Šabac as a tourist destination in Serbia and the region.

According to the Tourism Development Program of Šabac for the period 2020-2025. strategic vision of the city of Šabac as a potentially important tourist destination in Serbia was formulated. The starting point in the development of the Tourism Development Program is the observation of the destination through the prism of sustainable development. This means that the conception of studying tourism based only on economic effects has been overcome and that the modern conception in its focus equally perceives ecological, socio-cultural, economic and institutional concepts.

It is necessary that the strategic coverage of tourism development is based on the positioning and branding of the city of Šabac as a tourist destination. The development goals in the five-year period should be aligned with the realistic assumptions of the current position of Serbia and the city of Šabac on the tourist market, which is achieved by creating various projects in the field of tourism and complementary activities, the main task of which should be the development of tourism, improving the quality of life of the local community and encouraging economic development in a way that will not endanger the environment.

In the Tourism Development Strategy of the Republic of Serbia for the period 2015-2025. the tourist destination Šabac is recognized as a destination with the following key products: events, circular tours and cultural-themed routes. Today, the main role in designing and implementing these activities is played by the Tourist Organization of Šabac, while in the future it should be the Destination Management Organization - DMO, in order to better promote the city and meet the needs of tourists.

According to the tourism development program of the city of Šabac, the vision of the city of Šabac reads: The city of Šabac - the city of greenery, young people and experiences of exceptional quality - is a recognizable tourist destination in Serbia and the region. Basing tourism on the concept of sustainable development, the city of Šabac offers tourists, excursionists and the local population a unique experience, and investors and entrepreneurs significant opportunities for the growth and development of business ventures. (Tourist organization of Šabac, 2020)

CONCLUSIONS

According to the mentioned details and analyzes in this paper, we can say that the city of Šabac, as a tourist destination, has several prerequisites for significant and better investments in tourism, as well as great potential.

The city of Šabac represents a unique cultural-historical story that, along with cultural monuments, protected cultural assets, and museum exhibits, could combine the past and present of this city in an interesting way.

The very proximity of Šabac to the largest city centers in our country (Belgrade, Novi Sad), as well as the international airport, with well-connected roads is a prerequisite for the development of tourism in the city. Accommodation capacity has been significantly improved in recent years, first with the renovation of the Sloboda Hotel, and then with the opening of several smaller city hotels, as well as other accommodation facilities.

Through defining the term tourist destination, we have seen that the satisfaction of the consumer, in this case the tourist, is always and everywhere highlighted as the main actor in the creation of the tourist offer. That is why it is important to highlight all the elements of the destination, which serve to create a real tourist product. Given that a tourist destination is a set of different and diverse elements, it is important to classify related elements in the best way and make the best possible classification.

By analyzing all the mentioned facts, characteristics and information about the city of Šabac, the conclusion is that we can present the city of Šabac as a complete tourist destination, with its specific attractions, good accessibility and conditions for staying. The main role in marketing activities is played by the Tourist Organization of Šabac, and according to the Tourism Development Strategy of the Republic of Serbia for the period 2015-2025. the tourist destination Šabac is recognized as a destination with the following key products: circular tours, cultural-thematic routes and events, so special attention should be paid to the creation and promotion of precisely these tourist potentials.

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THE INFLUENCE OF ZLATIBOR'S BIOCLIME ON HEALTH AND MEDICAL TOURISM

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ABSTRACT

Introduction: Bio-climatic conditions are an important factor for all forms of tourism, and especially for health tourism, because they should contain therapeutic and prophylactic features. In the last two decades, the development of tourism on Mount Zlatibor has been on the rise both in terms of the number of tourists and the development of tourist infrastructure. This paper shows the bio-climatic and climatic conditions on the Zlatibor mountain from the aspect of influence on tourist movements with special reference to health tourism.

Material and methods: The necessary data for the research were obtained based on the physiological equivalent temperature (PET) and the universal thermal index (UTCI). The Transfer Information Scheme (CTIS) was used to display climate and bio-climatic information for tourism purposes. The weather suitability index (WSI) was used to calculate the weather suitability for recreational and tourism activities.

Results: Bio-climatic conditions should be viewed as stimuli from the atmosphere that affect the thermoregulatory, respiratory, circulatory, nervous, immune and digestive systems. The result of this research is the creation of a bio-climatological informant, with which tourists will choose the best moment to visit this mountain based on their habits and other needs.

Conclusion: From the point of view of health tourism, this information can be very significant for those people who have certain health problems and for whom the existence of such information would be very helpful when choosing the most favorable moment to visit Zlatibor.

Keywords: bio-climatic conditions, health, medicine, tourism.

INTRODUCTION

Tourism represents an economic branch that experienced the greatest expansion in the second half of the twentieth century. Having information about when is the best time to visit, which clothes are suitable for which time of the year, expected weather extremes of a tourist location, contribute to the tourists being well informed and the proper use of tourist facilities. Knowing the climatic characteristics of an area can help to offer tourists alternative contents that can be less dependent on the climate, which can insure that the tourist returns in the future (Stojićević, 2016, p. 29).

The influence of nature on the human organism has been decisive throughout the development of civilization in the formation of human characteristics and habits. As we moved away from nature and advanced technologically, we succeeded in mitigating negative climate impacts, but we still remained dependent on nature.

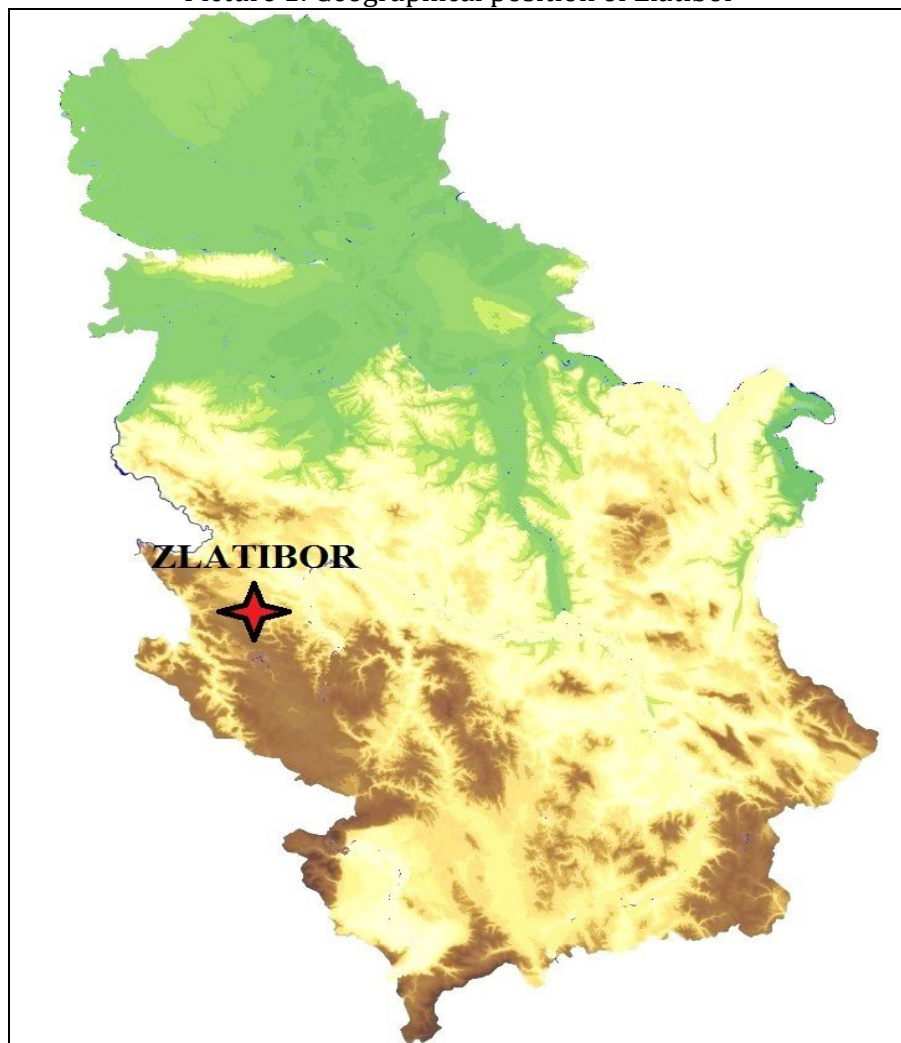
There is a well-known quote from the ancient philosopher Hippocrates, "The human organism behaves differently in certain periods of atmospheric weather. Some people tolerate winter better, others summer. Dry weather is healthier and less dangerous than rainy weather" (Cvetanović et al., 1988, p. 24). Bio-climatology actually represents the effect of a climate, through a set of weather conditions that characterize the average physical conditions of the atmosphere in a place or a wider area, on living organisms (Popović, 2007, p. 39).

Bio-climatology in Serbia began to be studied more seriously in the middle of the twentieth century, and one of the first works was the work of Pavel Vujević "Appendixes to the bioclimatology of the Kopaonik area" (Bojović, 2011, p. 49). In the later period, this area was studied sporadically. Vujević studies the area of Vrnjačka Banja, Kuršumljia, Raška and Kopaonik, giving basic thermal, pluviometric and hygric characteristics, and with complex climatic connections: temperature, wind speed and water vapor pressure, he determines equivalent temperatures, air cooling power and drying power, with special reference to geoclimatic power drying.

The year 1893 is considered the beginning of tourism on Zlatibor, since the then king Aleksandar Obrenović allowed the establishment of an air spa on Zlatibor. Numerous later studies have proven that the Zlatibor climate has very favorable effects on healthy people, but also excellent characteristics for the treatment of psychosomatic diseases, such as regulating the functioning of the thyroid gland and the like. Zlatibor Mountain is one of the most popular tourist destinations in Serbia. It is located in western Serbia, between 17° 14' and 17° 28' East Longitude and 43° 36' and 43° 48' North Latitude. It belongs to the group of medium-high mountains. The average altitude of Zlatibor is 1000 m with the peaks of Tornik (1496 m), Čigota (1422 m) and a larger number of lower peaks. The total area of this mountain is 1,000 km². It stretches from the Kremanska basin in the northwest, across the Murtenica mountain, across the Sušica and Mackatska valleys all the way to the Uvac river in the south (Novaković-Kostić, 2015, p. 49).

The climate on Zlatibor is mountainous with alpine and subalpine influences. Summers are pleasant with cool nights, while winters are long, cold and snowy. The climate of Zlatibor is monitored at the meteorological station on Palisade, which was established in 1950 (Figure 1).

Picture 1: Geographical position of Zlatibor



Source: <https://a3.geosrbija.rs/>

RESEARCH METHODOLOGY

Information about climate and bio-climate on Zlatibor is presented using PET and UTCI over a period of ten days. In this way, the obtained mean values of heat perception were analyzed. CTIS has also been used since it displays climate and bio-climatic information for tourism purposes based on threshold values of relevant parameters and their frequency. The Weather Convenience Index was also calculated because it provides synthetic information on the weather convenience for various forms of recreational and tourism activities. The obtained results were used to create a bio-climatic leaflet for Zlatibor that will allow tourists to choose the best time for their vacation depending on personal preferences and requirements.

Bio-climatic indexes

In the 1970s and 1980s, the first models were used that describe the thermal energy balance between the human body and the environment in more detail. Numerous bio-climatic indexes for heat stress and heat load, which are the main subject of study in modern human bio-climatology, were derived with the models. PET is a true climate index that describes the thermal environment according to thermal-

physiological conditions. The use of this index allows a person to experience the thermal component of the climate in his own way. It is much easier to imagine what a room air temperature of 30°C means thermally than to learn that a clear sky, moderate wind and an air temperature of 20°C are expected. Then a person can, from his own experience, determine for himself how to dress and what type of activity would be suitable for such conditions (Hoppe, 1999, p 73).

The feeling of pleasantness is determined according to the physiological equivalent temperature based on Table: 1.

Table 1. UTCI table for measure of heat stress

PET (°C)	FEELING OF PLEASANTNESS
< 4	Very cold
4 - 8	cold
8 - 13	milde
13 - 18	Pleasantly milde
18 - 23	Pleasant
23 - 29	Pleasantly warm
29 - 35	warm
35 - 41	hot
> 41	Very hot

Source: Matzarakis & Mayer, 1996. p. 8.

The universal thermal climate index UTCI is defined as the air temperature of the reference environment that causes the same model responses as real conditions. Therefore, UTCI is the air temperature that would lead to the same heat stress in the conditions of the reference environment as the actual conditions. Table 2.

Table 2. UTCI table for measure of heat stress

UTCI(°C)	Evaluation of physiological stress
bellow -40	Extremely cold stress
-40 to -27	Very strong cool stress
-27 to -13	strong cool stress
-13 to 0	medium cool stress
0 to 9	pleasant cool stress
9 to 26	Without heat stress
26 to 32	medium hot stress
23 to 29	pleasant hot stress
32 to 38	strong hot stress
38 to 46	Very strong hot stress
Higher than 46	Extremely hot stress

Source: Brode et al., 201, .p 179.

The MENEX (Man-ENVironment-heat-EXchange) model implies heat exchange between man and the environment. This model has various applications in bioclimatology (for tourism and recreation, climatotherapy, human health and urban climatology), in thermophysiological studies as well as in spatial planning (Błażejczyk, 1994, p. 37).

To calculate the PET and UTCI bioclimatic indexes, daily meteorological data for a given area were required. As there are only 4 main meteorological stations on the territory of the whole of Western Serbia, data from the climate model were also used. Reanalysis of the climate forecast system (Climate Forecast System Reanalysis-CFSR) was made initially for a period of 31 years, from 1979 to 2009. This system is built and distributed as a global, high-resolution coupled atmosphere-ocean-land model. Today, the model covers a period of 36 years, from 1979 to 2014. The spatial resolution of the model is about 38 km (Fuka et al., 2013, p. 2). Available data include temperature (T , °C), relative humidity (RH, %), precipitation (P , mm), wind (v , m/s) and solar radiation (S , MJ/m²).

The RayMan software was used to calculate the PET, while the BioKlima program was used to calculate the UTCI. RayMan is a software package developed by Professor Andreas Matzarakis (Matzarakis, Rutz & Mayer, 2007, p. 327).

Its main feature is the modeling of short and long-wave radiation. The program combines data related to the human body as well as climate parameters. The BioKlima program (Błażejczyk, 2005, p. 1) was used to calculate the UTCI index.

Based on these values, and using RayMan and BioKlima software, the PET and UTCI values corresponding to the time slots of 7, 14 and 21 hours were calculated. The mean daily values of PET and UTCI are the arithmetic mean of the values calculated in the mentioned intervals. In this way, a more detailed picture of the fluctuation of daily values of bioclimatic indices was obtained and it was possible to identify the periods and times of the day that are most favorable for certain tourist activities.

THE RESULTS

Since the climate of Zlatibor has therapeutic values, it gives it the characteristics of a climatic health resort, so the analysis of the results of the following climatic elements is very important.

Climate and bioclimate information is presented using PET and UTCI over a ten-day period. In this way, the obtained mean values of heat perception were analyzed. The Weather Convenience Index was also calculated because it provides synthetic information on the weather convenience for various forms of recreational and tourism activities.

Air temperature

The days with the highest temperatures occur in July and August, in the last decade of August. The coldest days are from October to the beginning of April. December is the month with the prevailing temperature between -10 and 0 °C. Days with a temperature of -10 °C are very rare and are most common in January.

Air humidity

RH has values that are extremely frequent. Values greater than 95% can occur from December to February, but values of 85 to 95% are dominant throughout most of the year.

Precipitation

An average of 178 days with precipitation were recorded on this mountain, of which 72 days were more than 5 mm. Periods without rain can last 187 days. The average number of days with precipitation in a year for Zlatibor in the examined period was 178. Rain of weak intensity occurs quite often, and rain of stronger intensity is mostly present in late spring and early summer.

Snow can appear in October and in the last decade of April.

Wind

Prevailing wind directions are southwest. In the middle of the day, northerly directions dominate. Wind speeds are between 1 and 3 m/s. The southwest wind blows in the afternoon, which is also characteristic of the north wind.

Bioclimatic conditions

Mean PET values on this mountain show that extreme cold stress occurs from late October to late March. Thermal comfort is better in spring and autumn. Pleasant PET values are in April, May, September and the first half of October. June, July and August have pleasant thermal conditions in the morning and late afternoon with the presence of stress during the midday. UTCI has very similar values.

Components of aesthetic weather conditions such as cloud cover, sunny days, and the number of clear and cloudy days are also presented. Thermal parameters were analyzed using PET and UTCI values by decade. The number of days with precipitation and rain are also included as are days with different snow depth classes. In addition, the leaflet also contains a wind rose drawn to show the average wind speed and wind direction throughout the year. The results of this study showed that the used climatological indices reflect the state of the climatological elements.

Zlatibor has a specific climate with characteristic air currents that cause continental and Mediterranean climates to touch. Areas under fir, pine and spruce forests, and spacious meadows, rivers and streams, with clean air and still unpolluted waters occupy large areas. The climate of Zlatibor is suitable for maintaining health, as well as for the treatment of various lung diseases, anemia, disorders of the heart and blood vessels, and especially disorders of the thyroid gland, which is why it has been declared a climatic health resort (Novaković-Kostić, 2015, p 50).

Bearing in mind that the atmospheric pressure on Zlatibor is extremely favorable, staying on this mountain has a favorable effect on the improvement of the blood count, above all on the increase in the percentage of hemoglobin in the blood and the increase in the number of red blood cells. Based on those conclusions, Zlatibor was declared a therapeutic area for all acute and chronic diseases of the respiratory organs, thyroid gland and anemia of all forms. Therefore, it is no coincidence that in 1964, the Specialized Hospital for Hyperthyroidism was founded in Zlatibor, which in 1997 grew into the Institute for the Thyroid Gland and Metabolism.

When planning the site for the Institute, many experts were consulted, especially doctors, climatologists and architects.

Obesity is a chronic disease caused by excess fat tissue that negatively affects physical and psychosocial health and well-being. Due to its high prevalence, rapid growth and association with numerous chronic diseases, obesity today represents a major public health and economic problem of global importance. According to the World Health Organization (WHO), obesity is one of the 10 main risks and one of the 5 leading health problems of today that has reached the proportions of a global epidemic.

From 1980 to 2014, the prevalence of obesity nearly doubled, and the prevalence of diabetes in 2014 was estimated at 9%. It is estimated that by 2025, approximately 2,300,000,000 adults will be overweight, while 700,000,000 will be obese. The results of research conducted by the Ministry of Health of the Republic of Serbia in 2013 indicated the trend of increasing obesity among the population of Serbia: •Increase in prevalence from 17.3% to 22.1% from 2006 to 2013 in adults •Increase in prevalence from 6.4% to 13.7% from 2006 to 2013 in children and adolescents aged 7 to 14 years (Lešović, Smiljanić & Ševkušić, 2018, p 8).

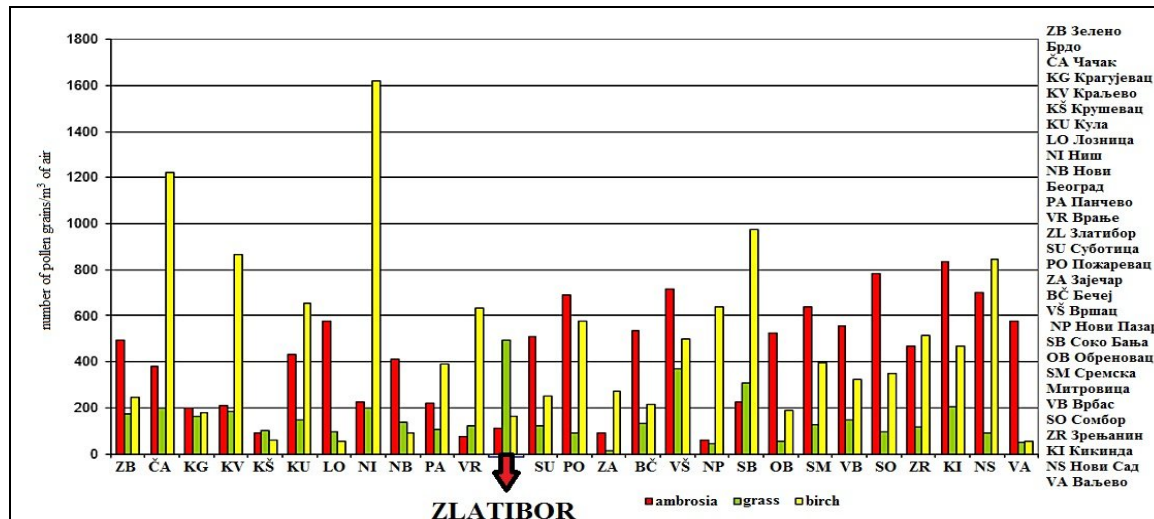
At the Čigota Center, diagnostic tests and treatment are performed, in which the following participate: a pediatric endocrinologist, a physical medicine specialist, a psychologist, a nutritionist, physical education professors, physiotherapists, nurses and animators. Once every three months, pediatrician-endocrinologist professors from Belgrade and Niš conduct consultations and visits at the Center. With expert supervision, patients receive a diet and physical activity plan depending on their age, fitness and health status, and if necessary, drug therapy is also introduced into the treatment. Hospitalization lasts 21 days, and is based on medical observation, monitoring and treatment of obesity and prevention of obesity complications. The immediate goal of treatment is to achieve a long-term - permanent reduction in body mass (Lešović, Smiljanić & Ševkušić, 2018, p 11).

In the last few decades, air pollution related to urban centers has been a big problem, as well as a large number of allergic reactions of people in areas with low altitudes.

Positive reactions to allergies are most obvious with Ambrosia, whose negative influence suddenly weakens with increasing altitude, and with clean and dry air with low pressure, as well as with annual insolation of over 2000 hours, Zlatibor becomes an ideal place to spend the summer months, with the most pronounced influence of Ambrosia, easier to overcome.

Evidence for these claims can be found in the results of the monitoring of allergenic pollen, where it is clearly seen that Zlatibor is in the rank of places where the maximum daily concentration of ambrosia pollen grains is at the lowest level in Serbia (Figure 7).

Picture 2. Maximum daily concentration of pollen grains at all stations in the Republic of Serbia in 2021.



Source: Annual Report on the state of air quality in the Republic of Serbia for 2021.
Environmental Protection Agency.

The fact of the very beneficial effect of negative ions on human health is well known. This is achieved by ionizing the air. Negative ions are most abundant in wooded areas, near waterfalls, the sea and in general near moving water.

Negative ions increase the amount of oxygen and the level of serotonin in the brain, leading to an increase in mental energy, while reducing feelings of apathy and depression, emotional instability, nervousness and stress.

Zlatibor is a place with a very large amount of negative ions.

We also know the amount of negative ions in different environments:

- near the waterfall, an average of 50,000 per cm³,
- in mountainous areas around 5,000 per cm³,
- in the countryside, an average of 1,500 per cm³,
- while in offices in urban areas, barely an average of about 50 per cm³.

These are just some of the facts that tell us about the very strong connection of bioclimatic factors with health tourism and medicine on Zlatibor.

CONCLUSION

Comparing previous research and existing medical facilities on Zlatibor, we come to the conclusion that the best results are achieved in treatment: -

Lung diseases (bronchial asthma, chronic bronchitis, emphysema, etc.)

- Diseases of the neurovegetative system (neurocirculatory asthenia, hyperthyroidism, neurasthenia).
- State of convalescence (after acute infectious diseases, tuberculosis and surgical interventions).
- General disorders (asthenia, hypochromic anemia, norochromic anemia).
- Bazed's disease.
- Stomach and intestinal digestion disorders.
- Conjunctivitis or inflammation of the mucous membranes of the eyelids and eyeballs.
- Toxemia.

The development of tourism is highly dependent on climatic conditions, especially in those destinations whose attractiveness is directly conditioned by the climate. There are users of climate information in tourism who want information about the weather for the next few days or planners in tourism who need information for the entire tourist season. A special category of users are those who need information about climate conditions for health or medical purposes. Such users have a special importance because their state of health or rehabilitation directly depends on the parameters of the climate and their movement during the year.

One of the ways to obtain such information is the presented bioclimatic brochure. It is designed to be easy to use, so that it can be easily interpreted by end users, as well as to provide climate information to tour operators.

For the territory of Serbia, the PET and UTCI calculated for the first time were used for the first time.

Based on the obtained results, the best period for visiting Zlatibor is from May to October, that period is also suitable for recreation, tourist activities in nature, swimming. Men-Kendall tests indicate the existence of a positive trend in the winter and spring seasons and a negative trend in the autumn and summer seasons.

Today, there is an increasing need for spatially and temporally detailed bioclimatic analysis. These requirements can be met by using bioclimatic maps that would show the spatial distribution of bioclimatic conditions.

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<https://a3.geosrbija.rs/>

GASTRONOMY TOURISM AND SOCIAL MEDIA: INFLUENCE, TRENDS, AND DESTINATION MARKETING STRATEGIES

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ABSTRACT

This study explores the intersection of gastronomy tourism and social media, focusing on the influence, trends, and destination marketing strategies employed in the digital realm. In January 2024, over a week-long research period conducted online via Instagram, data was collected from respondents. Descriptive statistics were used to describe and summarize data in a way that makes it easier to understand its basic characteristics. Excel 2019 was used to present the collected data. Some respondents left certain questions unanswered, resulting in a total of 123 completed responses for the study.

The findings reveal a significant reliance on social media platforms for gathering information related to gastronomy tourism, with Instagram emerging as the primary source for research, destination marketing strategies, and trend identification. The study underscores the growing importance of social media platforms such as Instagram, Facebook, and Tik-Tok in shaping travelers' perceptions, preferences, and decision-making processes within the realm of gastronomy tourism.

In conclusion, the integration of social media into gastronomy tourism has fundamentally altered the landscape of destination marketing and traveler engagement. As travelers increasingly turn to platforms like Instagram for culinary inspiration and exploration, destination marketers must adapt their strategies to leverage the power of social media in promoting gastronomic experiences and destinations effectively.

This abstract offers insights into the evolving dynamics of gastronomy tourism in the digital age, highlighting the pivotal role of social media platforms in shaping traveler behavior and destination marketing strategies.

Keywords: gastronomy tourism, social media, trends, destination, marketing strategies.

INTRODUCTION

Within the larger travel business, gastronomy tourism also referred to as culinary tourism or food tourism has grown to prominence. It entails traveling primarily for the purpose of exploring the food and beverage options, which includes dining customs, local cuisine, food festivals, and culinary experiences. Travelers can experience immersive experiences with other cultures, traditions, and flavors through food tourism, which goes beyond simple nutrition and becomes a catalyst for destination discovery and cross-cultural exchange.

In the world of food tourism, destinations are essential because they act as the hubs where food experiences are created, presented, and enjoyed. Every resort takes pride in its distinct culinary legacy, which includes anything from age-old recipes handed down through the centuries to cutting-edge cuisine inspired by international trends. Destinations provide the backdrop for unforgettable food-centric adventures, whether it's touring bustling food markets in energetic urban areas or going on culinary trails through gorgeous rural landscapes.

The manner that tourists look for, share, and engage in gastronomic adventures has changed dramatically in recent years due to the widespread use of social media platforms. Travelers now rely heavily on social media sites like Instagram, Facebook and Tik-Tok, which offer a real-time means of recording and sharing food-related information. Through visually captivating narratives, these platforms stimulate wanderlust, make it easier to find hidden culinary jewels, and connect visitors with other food fans who share their interests.

Travelers now actively contribute to developing and amplifying culinary narratives in a dynamic ecosystem of digital engagement created by the convergence of social media and food tourism. Social media platforms function as virtual centers for culinary conversation and investigation, facilitating everything from the sharing of enticing food photos to the recommendation and review exchange. Social media's instantaneous nature and interactive nature enable tourists to create customized culinary journeys, unearth undiscovered culinary treasures, and establish direct connections with local populations.

Social media and food tourism are two areas where new trends are constantly emerging as technology advances and consumer preferences change. These trends cover a broad range of phenomena, such as the emergence of food influencers, the spread of hashtags and challenges related to food, the gamification of culinary experiences via social media competitions, and the incorporation of immersive storytelling methods like augmented reality and live streaming.

It is the responsibility of destination marketing agencies to successfully use social media to promote culinary locations considering changing consumer behavior and technical improvements. Destination marketing techniques include the strategic use of social media channels, influencer collaborations, user-generated content initiatives, and data analytics to portray places as top culinary hotspots and encourage travel.

This study attempts to clarify the ways in which social media affects the dynamics of food tourism, pinpoint new developments influencing the culinary arts, and outline successful destination marketing tactics for the digital era.

LITEARATURE REVIEW

Gastronomy tourism, a niche segment within the broader tourism industry, has increasingly relied on social media platforms for destination marketing and visitor

engagement. This literature review delves into the multifaceted relationship between gastronomy tourism and social media, exploring its influence, evolving trends, and the strategic implications for destination marketers.

Influence of Social Media on Gastronomy Tourism

The pervasive influence of social media on gastronomy tourism is evident in its capacity to shape travelers' perceptions, preferences, and behaviors. Studies by Lam et al. (2020). underscore the pivotal role of user-generated content in influencing destination choices and dining experiences. Social media platforms serve as dynamic forums where travelers share their culinary adventures, seek recommendations, and contribute to destination narratives through text, images, and videos.

Furthermore, the interactive nature of social media facilitates direct engagement between tourists and destination stakeholders, fostering authentic dialogue and co-creation of experiences Melis et al. (2023). The immediacy and virality of content dissemination on platforms like Instagram and TikTok have democratized gastronomic discourse, amplifying destination visibility and shaping gastronomic identities.

Social media platforms serve as virtual bridges for fostering cross-cultural dialogue, culinary diplomacy, and international collaboration in gastronomy tourism. Culinary influencers, food bloggers, and travel vloggers transcend geographical boundaries to share diverse gastronomic experiences, promote culinary diversity, and challenge cultural stereotypes. Destination marketers leverage social media campaigns, virtual food festivals, and collaborative cooking initiatives to celebrate culinary diplomacy and position their destinations as inclusive, multicultural hubs that welcome global gastronomic exploration

Trends in Gastronomy Tourism and Social Media

The convergence of gastronomy tourism and social media has catalyzed several notable trends, reflecting evolving consumer behaviors and technological advancements. "Foodstagramming," as observed by Wong et al. (2019), underscores the visual-centric nature of gastronomic experiences, with travelers prioritizing aesthetically pleasing dishes and immersive dining settings for social media documentation. This trend not only influences individual dining choices but also informs broader destination perceptions and aspirational travel goals.

Moreover, the emergence of food influencers and digital content creators has transformed destination marketing strategies, blurring the lines between authenticity and commercialization (Cohen & Avieli, 2018). Collaborative partnerships between destinations and influencers offer opportunities for destination marketers to leverage niche audiences and co-create engaging content that resonates with target demographics. Social media activism and heightened consumer awareness have spurred demand for ethical gastronomy practices and socially responsible dining experiences. Travelers seek destinations and culinary establishments that prioritize fair trade, ethical sourcing, and sustainable food production practices. Social media platforms amplify advocacy efforts, empower conscious consumers, and hold businesses accountable for their environmental and social impact. Destination marketers leverage social media channels to communicate their sustainability initiatives, transparent supply chains, and community engagement efforts, thereby appealing to socially conscious travelers and reinforcing destination reputation

Destination Marketing Strategies

In response to the evolving landscape of gastronomy tourism and social media, destination marketers are employing innovative strategies to enhance destination

competitiveness and appeal. User-generated content campaigns, such as branded hashtags and photo contests, empower tourists to become brand advocates, fostering community engagement and authentic storytelling (Gretzel et al., 2015).

Furthermore, destinations are embracing experiential marketing approaches, curating immersive culinary events, and gastronomic festivals that celebrate local culinary heritage and foster cultural exchange Carvalho et al. (2023). These initiatives not only attract visitors seeking authentic gastronomic experiences but also position destinations as culinary hubs with distinct identities and narratives.

MATERIAL AND METHODS OF WORK

This research investigates the convergence of gastronomy tourism and social media, with a specific emphasis on examining their impact, evolving trends, and the utilization of destination marketing strategies within the digital domain. The study was conducted in January 2024, utilizing Instagram as the primary platform for data collection over the course of one week. The gathered data was presented using Excel 2019.

The data collection process yielded responses from participants, which were subsequently analyzed using descriptive statistics. These statistical methods were employed to elucidate and summarize the gathered data, facilitating a clearer understanding of its fundamental attributes. It is worth noting that incomplete responses from some participants led to a final dataset comprising 123 fully completed responses for the study.

Based on previous chapters research question were established as follows:

RQ1. Do you use social media like Instagram, Facebook and Tik-Tok to research food before visiting your tourist destination?

RQ2. Which of the platforms do you utilize the most when seeking information about the gastronomy of the country you are traveling to?

RQ3. Do you follow food and drink trends and social media recommendations when visiting a certain tourist destination?

RESULTS AND DISCUSSION

In the analysis of respondents' characteristics and behaviors related to gastronomy tourism and social media utilization, several key findings emerge:

The dataset consists of 123 respondents, comprising 51 females and 72 males. In terms of educational background, 59 respondents completed high school, 34 finished college, 20 completed a faculty program, and 10 obtained a master's degree.

Regarding the first research question (RQ 1), which investigates the preferred platforms for seeking information about the gastronomy of the country they are traveling to, the majority of respondents (62 individuals) reported utilizing Instagram, followed by 21 respondents who mentioned Facebook. Twenty individuals stated they use Tik-Tok, while an equal number of respondents indicated the use of other social platforms.

For the second research question (RQ 2) regarding the use of social media platforms like Instagram, Facebook, and Tik-Tok to research food before visiting a tourist destination, 51 respondents stated they do not use these platforms for this purpose. In contrast, 43 respondents reported using such platforms, while 29 individuals indicated occasional usage.

Regarding the third research question (RQ 3) concerning the following of food and drink trends and social media recommendations when visiting a tourist destination, 43

respondents affirmed they do follow social media recommendations, while 39 respondents stated they do not. Additionally, 41 respondents follow social media recommendations occasionally. Table 1. shows demographic characteristics of respondents.

Table 1. Gender

Gender	No	Yes	Grand Total
Female	13	38	51
Male	27	45	72
Grand Total	40	83	123

Source: Autor research

Table 2. Education of respondents

Education	N
High school	59
College	34
Faculty	20
Master	10

Source: Autor research

Table 3. Research result based on RQ1

Which of the platforms do you utilize the most when seeking information about the gastronomy of the country you are traveling to?	N
Facebook	21
Instagram	62
Tik-Tok	20
None of the above	20

Source: Autor research

Table 4. Research result based on RQ2

Do you use social media like Instagram, Facebook and Tik-Tok to research food before visiting your tourist destination?	N
No	51
Yes	43
Sometimes	29

Source: Autor research

Table 5. Research result based on RQ 3.

Do you follow food and drink trends and social media recommendations when visiting a certain tourist destination?	N
Yes I follow	43
I don't follow	39
Sometimes I follow	41

Source: Autor research

CONCLUSIONS

Research holds significant importance for the improvement of gastronomic tourism and its integration with social media. By shedding light on new possibilities, research plays a key role in shaping various aspects of the development of gastronomic tourism. Without a doubt, a significant portion of travelers' schedules and a key emphasis of destination strategy is gastronomy tourism.

Undoubtedly, a considerable portion of travelers' itineraries and a central focus of destination strategy revolve around food tourism. The culinary aspect of travel has evolved into a fundamental element of the tourism experience, with travelers increasingly seeking authentic gastronomic encounters and memorable dining experiences. As such, destination marketers and hospitality professionals recognize the profound impact of gastronomy tourism on visitor satisfaction, destination competitiveness, and economic growth. In response, destinations are strategically leveraging their culinary heritage, local ingredients, and culinary traditions to attract and delight travelers, thereby positioning themselves as gastronomic destinations of choice in a competitive tourism landscape.

However, this paper is subject to certain limitations. Firstly, it includes a small sample of respondents, which restricts the generalizability of the findings. Additionally, the short period of time allocated for research presents another limitation. Recommendations for future research include extending the time period to obtain a larger respondent pool. Furthermore, comparative analysis with similar studies could provide a broader understanding of how individuals utilize social platforms to follow trends.

The authors' research could contribute to raising awareness of the importance of social media in gastronomy tourism across its various aspects. It can be concluded that social media platforms positively influence people and play a significant role in the development of gastronomy tourism and destination marketing strategies.

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THE POSSIBILITY OF APPLICATION OF EFFECTIVE MICROORGANISMS IN THE PRODUCTION OF HEALTHY SAFE FOOD FOR THE NEEDS OF THE DEVELOPMENT OF SUSTAINABLE RURAL TOURISM

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ABSTRACT

The essence and goal of agricultural production is the provision of food, and it can be seen as one of the main factors of the sustainable regional development strategy. Modern trends in the development of agricultural production technology are related to the implementation of integral and organic production, because the set requirements are related to the preservation of the environment and the production of health-safe food. On the other hand, the increasing demand from tourists is the consumption of food with high nutritional values. The key to future agricultural production is an ecological approach in order to obtain high health-safe yields. In this regard, the application of effective microorganisms (EM) in all production systems is a new technological measure, the application of which increases the biogenicity and fertility of the soil, increases the nutrients available to plants, increases the yield of crops, reduces diseases and the unfavorable influence of climatic factors, and increases the positive effect on the environment. In this paper, different treatments of a microbiological preparation with effective microorganisms (EM Aktiv - trade name) were analyzed in order to obtain stable and high yields of vegetable crops (lettuce, beans, peppers, mushrooms) in sustainable production systems. The research described in the paper contained different variants of the treatment: control and different doses of the preparation with EM are in accordance with the set experiments. In all the results shown, the variants with the application of the EM Aktiv preparation resulted in higher yields compared to the control. The significance of the application of these methods and the obtained yields is also reflected in the safe demand for the product, and thus the increase in the number of tourists in rural areas.

Keywords: sustainable production, effective microorganisms, vegetables, rural tourism.

INTRODUCTION

Rural tourism implies sustainable, ecological, economic, economic and social development, because it represents the preservation of all those values that are for the benefit of future generations (Radović et al. 2018). An additional motivation for the development of rural tourism is the possession of various natural resources both at the local and regional level, and at the level of the entire country (Borović et al., 2021). Borto (2002) most simply defines rural tourism as a form of tourism that takes place in the countryside, while Flanigan et al. (2014) states that rural development is the result of the interaction of available resources, people and technology.

The process of modernization and globalization affects the formation of a larger number of tourists who are interested in destinations where the environment is unpolluted and where the production of health-safe food is represented (Cvijanović et al., 2022). This implies the development of new forms of sustainable and rural tourism, such as agro-tourism, gastronomic tourism and the like (Ristić et al., 2019). The importance of the mentioned directions, that is rural tourism in general, is a common feature, and that is food. Accordingly, from the aspect of tourism, tourists more often choose some type of rural tourism that offers health-safe food, while on the supply side, food production systems are used more and more where the environment is preserved. The Commission of the European Communities (1999), concludes that the quality and safety of food represents "the extent to which the product meets the needs of the user".

The increase in population leads to greater needs for the amount of food, to the reduction of arable land, intensification of agricultural production and negative impact on climatic conditions, which is reflected in the quality of produced food (Cvijanović and Žuža, 2020). The development strategy for ensuring healthy and safe food consists in the fact that until 2050, food production must increase in accordance with the estimated increase in the number of the population (FAO, 2019).

According to Zhang et al. (2022) in order to ensure a sufficient amount of safe food, it is necessary to ensure the right production technology. Accordingly, a greater number of researches related to the interactions of plants and certain groups of microorganisms with the aim of ecologically and economically profitable production. Iriti et al. (2019) state that various biostimulants, such as effective microorganisms, can positively affect changes in soil structure, nutrient solubility, stimulate plant growth and development, create symbiotic relationships, improve resistance to climatic factors and the appearance of pathogens.

The subject of research is the understanding of the concept of sustainable agriculture in rural tourism, as well as their mutual connection. The goal of the research is to show the impact of different applications of microbiological preparations with effective microorganisms in sustainable systems of agricultural plant production, with the aim of obtaining high stable yields through the possibility of quality food production.

The research methods used in the review part are the analysis of existing available literature using the desk research system, while the empirical results were performed using different methods and represent evidence of the author's long-term research.

SUSTAINABLE AGRICULTURAL SYSTEMS FOR THE PROMOTION OF RURAL TOURISM

Intensive conventional agricultural production has led to alarming negative consequences for the environment. The reason for this is the use of mechanization and the consumption of large amounts of fossil fuels, followed by uncontrolled amounts of synthetic fertilizers and plant protection agents. Awareness of the problems that have arisen has awakened the need to create new directions for the future development of agriculture, such as sustainable agriculture. Cvijanović and Ružić, (2017) state that this type of production has a positive effect on the environment, is easily applicable, and economically and socially acceptable. Sustainable agricultural and rural development is based on: an increase in agricultural production that brings food security, financial increase, as well as the possibility of employing a larger number of people, and at the same time affects the preservation of natural resources and the protection of the environment (Cvijanović i sar., 2022).

Defining sustainable agriculture is a symbiosis of tradition, innovation and science for the benefit of the environment and for everyone present in it. Many authors mention the characteristics of sustainable production, which are high ecological practices, high level of biological diversity, conservation of natural resources and application of high standards regarding animal welfare. The production method is directed towards the needs of consumers who want to consume health-safe products. Production technology is based on the use of natural components with limited or eliminated use of synthesized agents. This type of production aims to be economically profitable for the producer, and at the same time affordable for the consumer. This concept is possible and sustainable through the use of effective organisms, where production is carried out without the use of mineral fertilizers and pesticides, thus contributing to the protection and preservation of the environment.

EFFECTIVE MICROORGANISMS

In modern agricultural production, there is a need to reduce the use of mineral fertilizers and synthetic pesticides, in order to reduce their negative impact on the environment with an emphasis on reducing production costs. Application of effective microorganisms as a supplement or replacement of mineral fertilizers is an ecologically acceptable way of food production.

The application of effective microorganisms in the form of microbiological fertilizers in sustainable production systems is imperative in the production of health-safe food (Pszczółkowski et al., 2023). Abu-Qaoud et al. (2021) explained that effective microorganisms (EM) are important beneficial cultures of fungi and bacteria used as inoculants in environmentally friendly technology to improve soil quality and health, and quality crop production.

Preparations based on effective microorganisms can be of different formulations used in all branches of agricultural production (farming, vegetable growing, fruit growing, viticulture, animal husbandry, preparation of manure and compost). The application of these preparations can be by incorporation into the soil, drip irrigation system, foliar irrigation, immersing fruit seedlings, vegetable seedlings before transplanting to a permanent place, etc. The role of application and impact of beneficial microorganisms is multiple: they affect the physical, chemical and biological properties of the soil through the decomposition of organic matter, fixation of atmospheric nitrogen, increase the availability of nutrients for plants, suppress soil pathogens,

decompose toxic compounds and pesticides, synthesize antibiotics and other bioactive substances (hormones, vitamins and others), improve the structure of the soil, increase the yield and the content of nutrients in the plant, participate in the control of the occurrence of diseases and pests in plants, the control of abiotic stress factors, as well as for the treatment of waste water (Javaid, 2010; Piotrowska and Boruszeko, 2021; Aasfar et al., 2021; Zhang et al., 2022; Cvijanović et al. 2022).

Many studies confirm the positive effects of using various preparations with effective microorganisms. Ncube et al. (2017) reported an increase in yield and nutritional content in Swiss chard leaves at different doses with EM compared to the control. Sripontan et al. 2014 and Zhang et al. (2021) reported the effectiveness of EM application in lettuce and spinach. Iriti et al (2019) reported an increase in bean yield, while Dursun et al (2020) found an increase in the morphological and productive characteristics of tomato fruit.

APPLICATION OF EFFECTIVE MICROORGANISMS IN A SUSTAINABLE SYSTEM OF GROWING VEGETABLE CULTURES

In the research conducted, microbiological preparations with effective microorganisms (trade name EM Aktiv) were used. It consists of effective microorganisms (EM), a mixture of cultures of over 80 different families of beneficial microorganisms isolated from natural habitats, and the preparation belongs to the group of multiple inoculants and does not contain genetically modified microorganisms. These include: photosynthetic bacteria (*Rhodospseudomonas palustris* and *Rhodobacter sphaeroides*), milk bacteria (*Lactobacillus plantarum*, *Lactobacillus casei*, *Streptococcus lactis*), yeasts (*Saccharomyces cerevisiae*, *Candida utilis*), actinomycetes (*Streptomyces albus*, *Streptomyces griseus*) and fungi (*Aspergillus oryzae* and *Mucor hiemalis*). The exact composition of the preparation is protected by patent law and is a trade secret. It is on the list of permitted and registered means for plant nutrition and soil improvers in organic agriculture in Serbia (<http://www.minpolj.gov.rs/organska/>).

Lettuce (*Lactuca sativa* L.) is an annual vegetable crop, the advantage of which is reflected in the short vegetative period and the possibility of growing outdoors and in a closed system. It belongs to the group of the most important leafy species, which is used daily and fresh, rich in vitamins, minerals and antioxidants.

During three consecutive seasons from September 2016 to June 2017, in a closed system, the microbiological preparation EM Aktiv was applied to three different lettuce genotypes belonging to different types of green lettuce varieties (Table 1). The preparation EM Aktiv was applied by incorporation into the soil before planting and 4 times during the growing season in the recommended doses. The diameter of the rosette (head) of individual heads, which are significant as yield components from the market aspect, was examined. In all genotypes in all seasons, the preparation had a positive effect on increasing the size of the rosette (4.13-9.96%).

Table 1. The influence of the application of the microbiological preparation EM Aktiv on the diameter of the lettuce rosette (cm)

Varieties of lettuce	Method of production	Autumn	Winter	Spring	Average	Deviation (%)
Kiribati	Control	30.4	29.5	29.5	29.8	100
	EM Aktiv	33.3	31.7	33.3	32.8	9.96
Aquino	Control	22.0	27.7	22.8	27.2	100
	EM Aktiv	24.2	28.7	24.6	25.8	6.90
Aleppo	Control	25.7	28.3	30.8	28.3	100
	EM Aktiv	28.5	29.6	30.2	29.4	4.13

Source: Stojanović, 2022.

Beans (*Phaseolus vulgaris* L.) belong to the basic plant culture in human nutrition, given that it is rich in plant proteins, carbohydrates, fibers and minerals (Fe, Ca, Sn, Mo). As for vitamins, it is an excellent source of folic acid, vitamins B6, K, riboflavin (B2) and B3. In addition to seeds, green pods can also be used. Additionally, beans are used in animal feed. Also, the importance of beans is reflected as a cheap product, especially in developing countries. It belongs to the species of plants that live in symbiosis with nitrogen-fixing rhizobacteria, and is significant in reducing the application of basic fertilizers.

Research on the impact of EM Active on the yield of two different varieties of beans was carried out in 2019, in variants T1 - control, T2 - preparation applied to the soil before sowing and T3 - T2 + foliar application of the preparation twice during the growing season according to the recommended dose (Table 2). In both treatments, there was an increase in bean yield in both varieties compared to the control (34.62-61.71%).

Table 2. The influence of the application of the microbiological preparation EM Aktiv on the average yield of bean grains (kg ha⁻¹)

Varieties of beans	Method of production	Average	Deviation (%)
Zlatko	T1	1251	100
	T2	2023	61.71
	T3	1724	37.81
Maksa	T1	1730	100
	T2	2329	34.62
	T3	2514	45.32

Source: Cvijanović et al., 2022.

Pepper (*Capsicum annuum* L.) is a very intensive crop, which is grown in open and closed areas. Due to its multiple uses in nutrition, as well as in the processing industry, it is considered a highly valued vegetable. The use of pepper depends on the type and method of production. It can be used fresh or processed, and the cultivation of peppers for the production of spices is especially noteworthy. The fruit is rich in vitamins C and vitamin B complexes, as well as minerals (Ca, Fe, P, K and Zn).

The study of the influence of EM actives on pepper yield was carried out in 2023 on a micro-experiment with the Kurtovska kapija variety. A micro-experiment was set up with treatments: T1 - control, T2 - 5 foliar treatments with EM Aktiva during the growing season, T3 - T2 + seedling immersion an hour before planting, according to the recommended doses. In both variants of microbiological fertilizer application, the yield was significantly higher compared to the control, which can be seen in the deviation in Table 3.

Table 3. The influence of the application of the microbiological preparation EM Aktiv on the average yield of pepper fruit (kg)

Pepper	Method of production	Average	Deviation (%)
Kurtovska kapija	T1	0.2	100
	T2	0.47	135
	T3	0.77	285

Izvor: Authors.

Champignons (*Agaricus bisporus*) is a type of mushroom, which is mostly represented in commercial production. Due to their nutritional value, mushrooms are increasingly included in the human diet. Also, the advantage of cultivation is low production costs and capital turnover. In addition to nutrition, mushrooms are used as a dietary product, given that they contain small but useful amounts of protein, carbohydrates, fat, fiber, essential acids and various derivatives such as phenol, β -carotene and ascorbic acid. The production of champignons is manifold. For the successful production of mushrooms, strictly controlled conditions of temperature and humidity of the environment, as well as nitrogen-rich substrates, are required. Such conditions are, in addition to the production of mushrooms, important sources for the spread of pathogens. In this regard, many studies have confirmed that the application of effective microorganisms provides a supplement for increasing the beneficial microbial community in the substrate, and an additional important role is in preventing the occurrence and mitigating the development of diseases caused by various harmful microorganisms. On the other hand, the substrates after harvesting mushrooms are rich in mycelium and nutrient elements, which can then be used as a renewable resource, such as composting.

The study of the impact of EM Active on the mass of champignons was conducted in 2022 in the chambers of the company Delta Danube d.o.o. Kovin in variants: T1 - control, T2 - foliar treatment after sowing mycelium and T3 - T2 + two times spraying with water mist (Table 4). Harvesting took place in 5 stages, and during each harvest the yield was measured, and at the end all the yields were collected, in order to obtain the total yield from one production. The obtained results indicate a positive impact of the application of the microbiological preparation Em Aktiv in both variants, with the fact that the treatment T3 gave better results compared to T2.

Table 4. The influence of the application of the microbiological preparation EM Aktiv on the total yield of champignons (kg)

Pečurke	Način proizvodnje	Prosek	Odstupanje (%)
Šampinjoni	T1	7.5	100
	T2	7.6	1.3
	T3	9.1	21.3

Source: Cvijanović et al, 2023.

CONCLUSIONS

New production systems, which are based on the preservation of the environment and the production of health-safe food, imply a series of measures that must be followed. Although very demanding to that extent, it is easy to respect them on small limited holdings, which are normally most concentrated in rural areas.

The results of the presented research clearly indicate a positive correlation between the investigated parameters and the application of the microbiological preparation EM Aktiv. Also, the genotypes of the tested crop varieties, different treatments, and different cultivation systems had a positive impact.

Application of preparations with effective microorganisms, such as EM Aktiv and sustainable agriculture systems, can stimulate the development of rural households, which are involved in some forms of rural tourism. Also, promoting and developing offers and destinations is of key importance for all actors who benefit from rural tourism.

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LEADER APPROACH TO TOURISM DEVELOPMENT IN RURAL AREAS: A CASE STUDY OF CAHUL DISTRICT, REPUBLIC OF MOLDOVA

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ABSTRACT

Republic of Moldova is part of the LEADER Programme since 2016. The LEADER approach at the EU level has been extended under the broader term - Community-Led Local Development (CLLD). At the national level, the LEADER approach has been implemented with the support of the EU countries, esp. Poland, Romania, Czech Republic, Estonia, but USA through USAID programme also has had a large contribution to. Nowadays 50% of rural areas from the whole country are involved in the Local Action Groups (LAGs) as the main tool of LEADER implementation: 754 rural localities from 33 districts within 48 LAGs. Comparing with EU coverage which has been involved aprox. 60% of rural population in LAGs, Moldova has a lower percentage of coverage. The results of the research shows that Cahul district is one the most active in this regard, so being selected as study area for this paper. 41 rural localities and 5 LAGs are registered within the Cahul district: Cismeaua Sudului LAG, Eco Duz Ialpușel LAG, Jemciujina Yuga LAG, Lunca Prutului de Jos LAG and Valea Halmagiei LAG. The development strategies and implemented projects of those 5 LAGs were analyzed and the conclusion is that in all five the tourism was identified as one of the priority sectors for the local rural development. In the paper the implemented tourism projects are analyzed and highlighted the benefits for the local communities in terms of sustainable local development. The social, economic and environmental impacts are defined.

Keywords: LEADER, rural development, sustainable tourism, Local Action Groups, local community, projects.

INTRODUCTION

Republic of Moldova is part of the LEADER initiative since 2016; LEADER is an acronym from French language – Liaison entre actions de développement de l'économie rurale. The LEADER approach at the EU level since 2014 has been extended under the broader term - Community-Led Local Development (CLLD). The role of LEADER is “to engage local actors in the design and delivery of strategies, decision-making and resource allocation for the development of their rural areas” (https://ec.europa.eu/enrd/leader-clld_en.html); the main tool used for it is Local Action Group (LAG). Firstly, the initiative was launched in EU member states countries in 1991, the last available data on the LAG database is that at EU level there are around 3134 LAGS registered (https://ec.europa.eu/enrd/lag_en.html), that covers more than 60% of EU rural areas. In the Republic of Moldova around 754 rural localities from 33 districts are part of the LEADER initiative, that means 50 % of coverage at the national level (<https://leaderin.md/gal-moldova/>). According to the national LEADER portal there are 48 LAGs which are divided in senior and junior LAGs, meaning that the junior ones are at their first experience in implementing projects. The added value of the LEADER programme was demonstrated in time so from 2022, 5% from the National Fund for the Development of Agriculture and the Rural Environment are allocated to support LAGs activities, beside the support provided by the development partners – EU through different programmes or some individual programmes of countries – Poland (e.g. Solidarity Fund PL), USA (USAID), Austria (ADA), Switzerland (SDC), Germany (GIZ), Romaia, etc. Republic of Moldova is, so far, the only country in the non-EU space that implements the LEADER approach as a public policy tool. All these actions being a part of public and private support for the sustainable economic development with a focus on the local level – from local to national approach.

In the Republic of Moldova services sector has the larger contribution to the development according to the data provided by National Bureau of Statistics (share of 58,37% in 2022, <https://statistica.gov.md/en/statistical-databank-78.html>), even the tourism sector has a minor contribution, it constantly growing. In 2022 the accommodation and food services sector contributed with 1,3% at national GDP, a percentual growth of +0,3% comparing to 2021 year. Another sector that could be considered as part of tourism industry is art, recreation and leisure activities that in 2022 contributed with another 0,9% to GDP. In general, at the national level, in 2019 were identified some priority sectors, tourism being one of them along others as ICT, the textile industry, wine production and commercialization; all of them with no so many contributions to GDP, but with potential for generating more added value (European Training Foundation, 2019). So, the tourism sector remains one of the priority areas for the development of the local economy, and the LEADER initiative is a sustainable tool for tourism development in the Republic of Moldova (Capatina, 2020, p. 257-262; Capatina, 2021, p. 12-15). The role of the tourism for the economic growth was highlighted as well in the Country Development Cooperation Strategy for 2020-2025 period as a support for country sustainable development; a Strategy which was developed with the support of the USAID Programme (USAID, 2018)

MATERIALS AND METHODS

The data used for the research was collected from www.leaderin.md official portal and from the database provided by the National Bureau of Statistics of the Republic of Moldova, so as the research method the analysis from the secondary sources was applied. The analysis tool was used for collecting data from media sources (including social media) available for each LAG in part – all 5 LAGs which were analyzed as case studies have official pages on the facebook, but 4 out of 5 update regularly their pages and are publicly available. One of the LAG - Jemciujina Yuga LAG – doesn't maintain viable the fb page.

RESULTS AND DISCUSSIONS

As was stated above, the LEADER programme has an estimated coverage of 50% at the national level. Comparing with 2021 when were registered 32 LAGs with a total coverage of 35%, in 2024 already exists 48 LAGs and some more in the process of registration as legal entities. In 2024 the spatial distribution is more or less uniform at least one village from all 33 districts is included in the LAG; the districts from the left side of the river Dniester and Bender municipality are not part of the study. 754 rural localities are part of the 48 LAGs that represents aprox. 50% from the whole territory of the Republic of Moldova. Based on the data available on the leaderin.md digital platform the top 3 most involved districts are – Cahul, Drochia and Glodeni (<https://leaderin.md/gal-moldova/>, tab. 1).

Table 1. Top 3 districts involved in the LEADER programme

<i>Name of the district</i>	<i>Nr of LAGs</i>	<i>Nr. of villages</i>	<i>Population number (aprox.)</i>
1. Cahul	5	41	63.000
2. Drochia	3	28	54.000
3. Glodeni	2	35	51.000
Total	10	104	168.000

The top districts represent around 6% of the total number of LAGs, but involved 14% of villages that are part of the LEADER national network. Even the Territorial Administrative Unit Gagauzia has a high level of involvement in the LEADER programme (8 LAGs with 82.000 people), it was not taken in consideration in this study. The level of involvement was defined through the number of LAGs in which the villages from the districts are involved and the total number of population. Based on the results of the most involved districts, Cahul district was selected as case study for the current research. In the study area exists 5 very active LAGs; 2 of them includes only the villages from Cahul districts, other 3 additionally includes some villages from the neighboring districts – tab. 2. In the table 1 and figure 1 are highlighted only the villages that are part of the Cahul district.



Figure 1. LAGs from Cahul district on the <https://leaderin.md/gal-moldova/> platform

Source: <https://leaderin.md/gal-moldova/>

As a general conclusion the 5 LAGs in total offers a support for development for 66 villages, 41 of them being part of the Cahul district, others are part of other administrative units – Cantemir, Taraclia etc.

Table 2. General overview of LAGs from Cahul district

r.	Name of the LAG	Nr. of villages		Link on the fb page
		Cahul district	outside the Cahul district	
.	Cismeaua Sudului	1	5	https://www.facebook.com/gal.cismeauasudului
.	Eco Duz Ialpușel	2	4	https://www.facebook.com/eco.duz.ialpușel
.	Jemciujina Yuga	3	16	https://leadermoldova.eu/ru/lag-zhemchuzhina-juga.html
.	Lunca Prutului de Jos	4	0	https://www.facebook.com/GALLPdJ
.	Valea Halmagiei	1	0	https://www.facebook.com/people/Grup-de-Ac%C8%9Biune-Local%C4%83-Valea-Halmagei-/100064926360093/
	Total	4	25	
		1		

Each LAG in part is actively involved in the Calls of the project proposal announced by the LEADER national chapter located in Chisinau, capital city of Republic of Moldova. Cismeaua Sudului, Eco Duz Ialpușel, Jemciujina Yuga (original name – “Жемчужина Юра”), Lunca Prutului de Jos and Valea Halmagiei LAGs are registered as legal entities, have their own Statute and develop and implement their own strategies of development. All 5 LAGs identified the local tourism development as one of the priorities in their strategies. During the active calls the local community can apply with their own proposal in order to be financed and contribute to the tourism development. From the available sources were analysed the implemented projects and identified

those that are focused on tourism. As a result, it was noticed that some of them are focused on infrastructure development, other on services. The proposal of the study is to identify the impact of the projects at the local community and classify as social, economic and/or environmental impact.

Cismeaua Sudului LAG. Cismeaua Sudului LAG has started the active involvement from 2023, so with no many results achieved but set up ambitious goals. The main focus of the LAG is on (1) development of entrepreneurship, economic infrastructure and stimulation of investments; (2) creating the local tourist identity, promoting cultural heritage and local traditions; and (3) efficient management of public spaces and community interest.

In 2019-2020 the projects implemented in the LAG have had a high impact through creation new jobs, supporting new businesses, but lack of knowledge and passive involvement from management point of view in the recent years, lack of human resources, it was “abandoned” for a while. Even though, the support offered for a business of rabbit farm (as an attraction for tourists.) and the construction of a mini-farm of ostriches for tourists in Cismichioi cillage remains the outcomes and investments of LEADER programme. Another initiatives that were implemented is the development of a tourist route in the region by capitalizing the place where the skeleton of *Dinoterium giganteum* was discovered (nowadays being the “must visit” attraction at the National Museum of Ethnography and Natural History in Chisinau); the construction of a lookout tower in Cismichioi village and in good weather conditions could be seen the Dobrogea mountains from Romania.

Starting from 2023 the LAG was revitalized and won a general project LAG “CIȘMEAUA SUDULUI” - for local development” which runs on-going 19 initiatives, 3 of them are related directly to the local tourism development esp. Under the LAG project were supported 19 initiatives from different local communities – namely:

1. “From the heart to the traditions - the popular costumes and song”,
2. “Creation of the “Valea Gavanoasei” recreation area” and
3. “Renovation of traditions and customs in Gavanoasa village”.

As all these projects just started in 2024 there are no impacts to analyse, but social impact and cultural impact on the community level is very well highlighted in the projects number one and three as the promotion and conservation of local traditions has a very important impact on the society level. The environment impact is presented in the second project as the area will be created and designed and managed accordingly; in terms of economic impact - some local businesses will be developed for the services provided.

Eco Duz Ialpușel LAG. Eco Duz Ialpușel LAG is going to (1) support small and medium entrepreneurship, (2) modernize the cultural and educational infrastructure, and (3) develop and support culture and rural tourism. Not very active in the initiative proposal, but the first steps were done through implementing two major projects with social impact – “Women engaged in economic activity at home” and “Together we develop the villages!” – both implemented in 2021. The villages, part of the Cahul district are not involved actively in the projects, otherwise the Congaz local community part of the LAG is one of the most active at the national level – being recognized and spread as success story for the LEADER initiative in Moldova – Gagauz Sofrasi Ethno Village (Capatina, 2020; <https://www.gagauzsofrasi.com/>). Otherwise, all LAG members were active in 2023- 2024 by participating at different exhibitions and cultural events for promotion their cultural heritage and natural resources – e.g. Tourism, Leisure and Hotel International Exhibition in Chisinau, Europe Day 2023,

study visits in other LAGs from Moldova and Romania – all these activities could play an important role for the future development of the local communities from Eco Duz Ialpușel LAG

Jemciujina Yuga LAG. Original name of the LAG is “Жемчужина Юга” and is the least active community in the LAG development comparing with other 4, but at the local level it means a lot for the local community. As recommendation for the future development is to share among the LAG the good practices and lessons learnt from other LAGs in order to motivate. The LAG in general is oriented to support the ideas for the communities’ development, and social impact projects are most common. Three projects were selected for analysis:

Terrace for everyone in Karbalia village, project implemented in 2020 – this is the only area that the local people can enjoy and socialize with each other so the terrace of 51 m² were designed, tables and chairs, 2 refrigerators were procured as well. The role of the project was to extend the accessibility of the local community to social services and improvement the work conditions for employees. In 2020, the second project was implemented, but in Moscovei village – “Step to health and longevity” Project - a recreation area development for residents of the Moskovei village”, followed by the third one, oriented to social part - “Social laundry Project - “Caring for people” (2021) – were purchased and installed 5 washing machines for the local community; the idea was implemented by Karabetskaya Tatiana in cooperation with Local Public Authority of Vinogradovka village.

Lunca Prutului de Jos LAG. One of the most active LAGs at the national level – have been implemented around 85 initiatives and projects – a part of them is focused directly on the tourism sector, others have had an indirect contribution (e.g. street lighting). The main goals of the “Lunca Prutului de Jos” LAG is to improve ecological safety and sustainable exploitation of natural resources from the region and to develop and promote the local products, traditional, natural and cultural resources.

The most recent projects were focused on promotion of their local products at national and international level as tourism is one of the focus areas. The support offered by the LEADER programme helped the tourism stakeholders to participate at different exhibition even the major ones - ITB 2024, TT Warsaw 2023, TT Bucharest– Valeni village, member of the LAG was the winner of Best Tourism Villages 2023 contest.

The social impact was also noticed during the analysing implemented project through the empathy to the refugees from Ukraine, in 2023 couple of projects were focused on organizing master classes for refugees – for example those provided at the Valentina Grigoriță folk crafts Workshop or Gheorghe Burcă leather workshop, and in the Crihana Veche Museum (figure 2).



Figure 2. Master class with Ukrainian refugees

Source: <https://www.facebook.com/GALLPdJ>

The social and economic impact is also highlighted in the project that was focused in starting to run a business in the rural tourism sector – by transforming the parents house in the guesthouse – La Bunica Clava Guesthouse which means “at the grandmother Clava” – the sustainable approach is that firstly in 2021 the project proposal was addressed on the financial support to equip and develop facilities for the tourists inside the house (which is deesigned in the style of '60-'70s of the XXth century), and in 2023 another support was offered to renovate the fence and the gate, but still in the old style, so that to be compatible with the house (figure 3).



Figure 3. “La Bunica Clava” Guesthouse, “Lunca Prutului de Jos” LAG

Source: <https://www.facebook.com/GALLPdJ>

The experience in how a tourism destination should look like – some of the projects were oriented on local community capacity building in the hospitality,

animation sector through organizing or participating in different training with theoretical and practical parts. In 2023 the LAG members participated in the training focused on the legal operational framework in the field of tourism. The LAG members were trained about the structure of the tourism industry in the Republic of Moldova (as in the last years a lot of reforms has been implemented), institutional framework in tourism, general framework for starting and running a business in tourism etc.

The high interest in the LAG is demonstrated through community activism, in March 2024 the GAL launched a Call for the involvement in the general Project called “A clean environment - developed tourism” with a general goal - support for local communities’ development and in total were received 14 applications and the results should be announced in May 2024.

Valea Halmagiei LAG. Valea Halmagiei LAG has the main interest for application in the field of (1) modernizing the agricultural and agri-food sector, (2) capitalizing and promotion of the cultural heritage and local attractions and (3) local public infrastructure improvement and environmental protection.

Local businesses are supported as far they demonstrates continuity and interest in their future development with an impact at least at local level. One of these projects that could be part of good practices is on beekeeping or apiculture, an agriculture sector wide spread in Moldova. In 2019 Curjos Mihai from Larga Nouă village proposed a start-up to be financed by LEADER programme, esp. with the focus on the equipment procurement for apiary, at that moment 3 new jobs were created. In 2021 the owner decided to extend his business – from agriculture activities to tourism part – to create a wax processing workshop oriented on making beeswax sheets that are used in systematized beekeeping, and as a secondary activity, the workshop will be pouring decorative natural wax candles. So, increasing his business from start – up to a real business registered legally as “Bee Pro” LLC (in 2022), from agriculture sector to services sector.

The promotion of the cultural heritage as part of the community with the community involvement is analysed in the 3 projects proposal that were supported in their ideas by the LEADER programme. One of the projects implemented in Cucoara village was about the procurement of a loom that was installed in the Cucoara museum and the idea is to promote this handicraft to all the community representatives interested in. The generic name was - “The past full of life”. For this purpose, the meetings are periodically organized (in Romanian language called “șezătoare”) to teach the traditional technics. As raw materials is used the material from clothes that are not used anymore, named - “cordelitul”, the cordite of the cloths (figure 4). This type of thread is prepared in a specific way which is time consuming and the community involvement is needed. The result – carpet and other goods may be commercialized and to obtain the financial resources for further development of these community initiative.

The second project with local involvement at all phases is the playground development in the Andrușul de Jos village and the third one (2021) – where the community stands as beneficiary is about the extension of the public lighting Badicul Moldovenesc village, project proposed by Local Public Authority.

Valea Halmagiei LAG is an example of good practices that confirm the local community and Local Public Authority may have very important results acting together, promoting the same idea and working on the same outcomes.



Figure 4. "Cordelitul" as traditional activity, Cucoara village

Source: <https://www.facebook.com/people/Grup-de-Ac%C8%9Biune-Local%C4%83-Valea-Halmagei-/100064926360093/>

All the example presented above demonstrates that the partnership (between local communities, private and public sector, local and national authorities etc.) is mandatory for the sustainable development and economic growth of rural communities. Experiences and successful practices implemented at the local level are not less important as many communities may face the same challenges – for example for the involvement in support of refugees from Ukraine etc.

CONCLUSIONS

The development strategies and implemented projects of those 5 LAGS were analyzed and the conclusion is that in all five the tourism was identified as one of the priority sectors for the local rural development. LEADER initiative uses LAGs as an efficient cooperation and fundraising tool to ensure continuous local development.

The recent call of projects proposals in Moldova was launched under the Rural Development Fund LEADER – EU 3.0 „EU4Moldova: Local Communities” supported by EU, Germany, Austria and Poland and implemented by GIZ, ADA and Solidarity Fund PL. So, the interest for such a way of development is increasing and the main beneficiary is local community; the only fact is to convince the local community to be involved more actively and to share their ideas through start-ups or small projects that might be financed by the donors. The final result is to improve the quality of life of local communities based on a sustainable approach, from local to national impact, and in the end win-win approach.

Economic, social or environment impacts can be noticed at the local level, and the local community positive feedback is the most valuable results that a project can achieve. And the good practices sharing remain one of the motivational tools to a more active involvement.

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Education and knowledge – inclusion

AGRICULTURE AS AN OPPORTUNITY FOR EMPLOYMENT OF PERSONS WITH DISABILITIES

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ABSTRACT

The integration of persons with disabilities in the sphere of employment is one of the most important issues when it comes to human rights, which brings with it economic, social and psychological benefits. The laws of the Republic of Serbia promote equal employment rights for persons with disabilities, and one of the umbrella laws is the Law on professional rehabilitation and employment of persons with disabilities.

It should be emphasized that there are far-reaching benefits of manual work for the psychophysical improvement of people with disabilities, especially mental ones, and one of them is engagement in agricultural production, which is particularly suitable due to contact with the ground, which has been scientifically proven to have a positive effect on improving health condition. Examples of adapted manual work were developed through professional rehabilitation programs at the Enterprise for professional rehabilitation and employment of persons with disabilities Avlija održivog razvoja in Bogatić, through which employment opportunities were provided for persons with disabilities. Professional rehabilitation programs are based on the acquisition of basic knowledge of agricultural production and the learning of work skills through which persons with disabilities will acquire competences for work.

The aim of this paper is to present legal frameworks and professional rehabilitation programs based on agricultural production as a type of employment opportunity for people with disabilities, which contributes to the complete work and social integration necessary for inclusion in community life.

Keywords: agriculture, people with disability, professional rehabilitation and employment, social inclusion.

INTRODUCTION

The Constitution and laws of the Republic of Serbia promote equal rights for inclusion in the labor market for all persons equally, without discrimination, and the right to work is guaranteed in this way for persons with disabilities. The reduction of the unemployment rate for persons with disabilities, as one of the most vulnerable social groups, is made possible thanks primarily to the Law on Professional Rehabilitation and Employment of Persons with Disabilities, which is an umbrella law in the field of professional rehabilitation and employment of persons with disabilities. It completes the employment process, predicting, for the first time in our country, the employment of persons with disabilities outside of protected business conditions, that is, on the open labor market. In addition, as its name suggests, it also prescribes professional rehabilitation measures for persons with disabilities as one of the most effective mechanisms of inclusion in work processes, enabling them to be fully integrated into the work environment.

People with disabilities clearly have big problems when hiring, integrating into the working environment and keeping their jobs, regardless of what type of disability it is, but it can be said that they are one of the most vulnerable people with mental disorders. The negative attitudes of society, which bring with them negative behavior or the absence of adequate behavior, create social obstacles that undoubtedly affect many aspects of the life of people with disabilities, among which is certainly the possibility of employment and, consequently, the very quality of life of a person.

Work is important for every person and brings with it financial but also other benefits, such as social and psychological, that is, it leads to personal and professional fulfillment of each of us, and therefore to a sense of belonging and independence. It represents a part of social integration, overcoming obstacles created by society's stereotypes, reduces the feeling of inferiority, which has an added value for people with disabilities (Koritnik, 2019). For this reason, as well as due to compliance with legal norms, it is necessary to develop our society in a direction that will enable as many people from marginalized groups as possible to obtain employment and support them in keeping it.

The legal regulations state that every citizen has the same right to work as well as the choice of occupation, including every person with a disability who is given the opportunity for training and employment that is in accordance with the remaining abilities, knowledge and affinities. Thus, people with disabilities can be engaged in any jobs. One of the sectors in which people with different types of disabilities, especially mental ones, can find employment and achieve professional success is agriculture. This is also evidenced by the Company for professional rehabilitation and employment of persons with disabilities *Avlija održivog razvoja* (Avlija sustainable development) d.o.o. Bogatić, which developed three programs for professional training based on the acquisition of basic competencies in the field of agriculture. After training, people with disabilities are able to get involved in the work process, with adequate support, and the end product of manual work and being in nature is their psychophysical improvement.

NORMATIVE FRAMEWORK OF THE REPUBLIC OF SERBIA AND EMPLOYMENT OF PERSONS WITH DISABILITIES

Although today there is a lot of talk about the inclusion of people with disabilities in regular social flows and the sphere of employment, it was not always like that. The attitude towards persons with disabilities and their inclusion in the labor market has changed throughout history from the assumption of responsibility and care by society, through the selective protection of persons with disabilities to their imprisonment and social exclusion. Another turning point occurred during the 20th century, when society again began to fight for the visibility of people with disabilities and the opportunity to use their capacities and potentials.

The turning point was an initiative for the professional rehabilitation of disabled people after the First World War. Programs were designed to help war veterans and retraining programs for people with disabilities, while laws in most European countries required employers to employ a certain number of people with disabilities (Petrović, 2012). Then there is a strengthening of the civil sector and, as was said earlier, a change in the view on disability, and therefore the problem of unemployment of persons with disabilities stood out as one of the leading ones to solve.

Guided by these influences, the state had to take a leading role and adopt a series of measures that will facilitate employment and create equal working conditions for people with disabilities. The measures called "positive discrimination" are designed with a reason to favor vulnerable groups who find it difficult to find employment, in order to create the greatest possible equal opportunities. The biggest legal changes that have been made regarding the employment and integration of persons with disabilities in the world of work came about under the influence of the civil non-governmental sector (Lončar et al., 2011). As in the whole of Europe and the world, this topic has been legalized in Serbia as well. The legal censuses of the Republic of Serbia, which prohibit any form of discriminatory behavior towards persons with disabilities in terms of labor rights, encourage their employment and promote inclusion in regular social processes, which will be discussed briefly in the rest of the paper.

Constitution of the Republic of Serbia

As the highest legal act, the Constitution emphasizes that "any discrimination, direct or indirect, on any basis, especially on the basis of race, sex, national affiliation, social origin, birth, religion, political or other belief, property status, culture is prohibited, language, age and mental or physical disability" (Article 21). Therefore, before the Constitution and the Law, everyone is equal, protected from discrimination on any basis. Additionally protecting persons with disabilities, the Constitution in Article 60 guarantees the right to free choice of work, under equal conditions, availability of all jobs, and also guarantees the right to safe and healthy work. It especially emphasizes that "women, youth and the disabled are provided with special protection at work and special working conditions, in accordance with the law" (Constitution of the Republic of Serbia, Article 60).

Labor law

Apart from the Constitution of the Republic of Serbia, the rights of persons with disabilities are also sought to be protected by laws. When it comes to the area of employment and work, there is definitely the Labor Law. Article 12 specifically emphasizes the protection of persons with disabilities: "...an employed person with

disabilities has the right to special protection, in accordance with the law" (Labour Law, Article 12). The same article provides for rights regarding safety and health at work, health care, protection of personal integrity, personal dignity and other rights in case of illness, reduction or loss of working capacity (Ibid, Article 12). This Law also prohibits any form of discrimination against persons seeking employment, emphasizing in particular persons with disabilities (Ibid, Article 18). In the separate part concerning the protection of persons with disabilities and employees with health disorders, it is emphasized that the employer is obliged to enable a person with disabilities to perform work according to his working abilities (Ibid, Article 101).

Law on Prohibition of Discrimination

When it comes to discrimination of persons with disabilities, it is important to mention two laws of the Republic of Serbia, which, similar to previous legal acts, mandate the protection of rights and protect persons with disabilities. The first is the Law on Prohibition of Discrimination, which in Article 3 prescribes that "everyone has the right to be effectively protected by the competent courts and other public authorities of the Republic of Serbia against all forms of discrimination" and recognizes as a serious form of discrimination "causing and inciting inequality, hatred and intolerance against on the basis of national, racial or religious affiliation, language, political orientation, sex, gender identity, sexual orientation and disability and age" (Article 13, paragraph 1, point 1). Article 26 of this Law talks specifically about discrimination of persons with disabilities and states that "discrimination exists if one acts contrary to the principle of respect for equal rights and freedoms of persons with disabilities in political, economic, cultural and other aspects of public, professional, private and family life", as well as that "the manner of exercising and protecting the rights of persons with disabilities shall be regulated by a separate law" (Article 26).

Law on Prevention of Discrimination of Persons with Disabilities

The above-mentioned Law is the Law on Prevention of Discrimination of Persons with Disabilities, which in a separate part, through 6 articles (Articles 21 to 26), talks about discrimination in connection with employment and employment. When it comes to discrimination in the field of employment, the Law prohibits discrimination due to disability in employment and the exercise of rights from an employment relationship against a person with a disability who is seeking employment and/or his companion, as well as against an employed person with a disability and/or his companion (Law on preventing discrimination of persons with disabilities, Article 21). Discrimination due to disability in employment is considered to be: not hiring a person with a disability or their companion due to a disability; setting special health conditions for employment; prior checking of psychophysical abilities that are not directly related to the jobs for which the employment relationship is based; refusal to carry out technical adaptation of the workplace that enables the efficient work of a person with a disability (Law on Prevention of Discrimination of Persons with Disabilities, Article 22). Here, it is important to point out Article 26 of the Law, which singles out "harassment, insult and belittling of an employee with a disability by the employer, i.e. a direct superior in the work process, because of his disability" as a particularly serious form of discrimination.

Law on Professional Rehabilitation and Employment of Persons with Disabilities

Another Law that is important to mention when we talk about the employment of persons with disabilities is the Law on Professional Rehabilitation and Employment

of Persons with Disabilities. It was adopted in 2009 and is the umbrella law when we talk about this area. He brought news regarding employment on the open labor market; assessments of working abilities; professional rehabilitation; obligation to employ persons with disabilities; conditions for establishing and performing the activities of companies for professional rehabilitation and employment of persons with disabilities and other special forms of employment and employment of persons with disabilities (MINRZS, 2021). This Law for the first time provided the possibility of employment of persons with disabilities on the open labor market, but the forms of employment under protected conditions are retained, namely in companies for professional rehabilitation and employment of persons with disabilities; work centers and social enterprises and organizations (Article 34).

The law also gives the possibility of determining disability through the process of assessment of work ability to persons whose disability has not been determined according to the previous regulations on pension and disability insurance or the protection of military invalids. This gives the opportunity to be included in the work process and use the rights prescribed by the Law (Article 2). After the evaluation by the expert body of the Republic Fund for Pension and Disability Insurance, a person can be classified in one of 4 levels (zero level, first, second or third) (Law on Professional Rehabilitation and Employment of Persons with Disabilities, Article 16). After that, persons who are categorized under the 1st and 2nd degree can be included in the work process, with or without support, that is, employed under general or special conditions. According to this Law, employment of persons with disabilities under general conditions is considered employment by an employer without adjustment of jobs, workplace or jobs and workplace, while employment of persons with disabilities under special conditions is considered employment by an employer with adjustment of jobs, workplace or jobs and workplace (Article 23).

Adjusting jobs means adjusting the work process and work tasks. Adapting the workplace means technical and technological equipping of the workplace, means of work, space and equipment - in accordance with the capabilities and needs of a person with disabilities. By adapting, professional assistance can be provided, as support for a person with a disability during the introduction to work or at the workplace, through counseling, training, assistance services and support at the workplace, monitoring at work, development of personal work methods and evaluation of efficiency (Article 23).

Adaptation of workplaces and jobs to persons with disabilities and inclusion of experts is foreseen for persons with an estimated 2nd degree of disability, both on the open labor market and in companies for professional rehabilitation and employment of persons with disabilities.

BENEFITS OF MANUAL WORK FOR PERSONS WITH DISABILITIES

The benefits of manual work performed by people with disabilities, especially mental disabilities, have been recognized since ancient times due to the positive impact on the psychophysical condition of the affected persons. Work as a form of treatment was used even during the time of Greek mythology, and the preserved data tell about the God Zeus who created blacksmithing for the needs of the work of his lame son Hephes. The goal of the blacksmith trade was manual employment in order to divert his son's thoughts from his disability (Savković, 2016). Manual work, in addition to physical activation in order to preserve motor skills and develop new ones, also brings with it a significant psycho-social component through inclusion in the work team. This is also

evidenced by the earliest research of Celsius from Rome, who treated mental illnesses with conversation, socializing and travel (Quiroga Virginia, 1995).

A similar approach was applied in England during the 18th century by William Tuke, who used manual work and activities in the treatment of disabled people, wanting to improve the functioning of the sick people (Savković, 2016).

During the 19th century, the idea of employing people with disabilities entered America. G. E. Barton, an architect with chronic illnesses, were considered the founders of work integration at the time; W. R. Dunton – psychiatrist; Eleanor Clarke – social worker who worked with people with schizophrenia; Thomas Kinder – architect and special adviser to the USA on rehabilitation issues; Susan Tracy – a nurse who conducted vocational courses for people with disabilities. Their joint work contributed to the creation of the National Association for the Promotion of Occupational Therapy, which later grew into the American Association of Occupational Therapists, and through its action they further shaped the profession itself. One of the aforementioned founders, Dunton, emphasizes that an occupation or activity must have a purpose in order to be an effective tool in the treatment of mental and physical disorders. What he particularly emphasized was that the work must be interesting and have an end product (Savković, 2016).

The very process of deinstitutionalization, the prevention of institutional placement of persons with mental disorders, which gradually took place in the 20th century, gave opportunities for wider work and inclusion in the community as equal members of society. In the 80s and 90s, the focus of occupational therapy was on the quality of life of the mentally ill, and therefore the goal of the practice was prevention, quality of work and increasing independence. Today, the focus of occupational therapy work is on individuals and their needs, to which all activities in the environment, including employment, are adjusted (Savković, 2016).

The view of occupational therapy of the 21st century goes beyond the concept of handicap and is based on the basics of a dignified life of a person with disabilities in their environment. This type of occupational therapy is based on restoring, maintaining or preventing the deterioration of functions due to acquired disability or disability caused by trauma, which prevents a person from functioning independently (Savković, 2016).

PROFESSIONAL REHABILITATION OF PERSONS WITH DISABILITIES

When we talk about the employment of people with disabilities, professional rehabilitation plays the most important role in such a process. Employment represents the fourth phase of professional rehabilitation and its most important part (Odović, 2008). The term vocational rehabilitation "refers to that part of a continuous coordinated rehabilitation process that includes the provision of occupation-related services, namely: vocational orientation, vocational education and selective employment, which enables a disabled person to secure and retain suitable employment" (ILO, R 99, 1955).

The goal of professional rehabilitation is to achieve the maximum when it comes to physical, social, emotional, educational, work opportunities, taking into account the limits that represent the limitations of people with disabilities. Emphasis in rehabilitation is placed on remaining capacities, not on incapacity (Law on Professional Rehabilitation and Employment of Persons with Disabilities, Art. 17). Professional rehabilitation is a multidisciplinary field consisting of a series of activities aimed at

"professional and work training, employment and work of persons with disabilities" (Koritnik, 2019: 20).

The previous experience of the author of the paper shows that with the professional support of the team for professional training, people with disabilities can very well be involved in work processes and master manual tasks. In order for persons with disabilities to be included in the process of work training, the existence of a professional rehabilitation program is necessary.

VOCATIONAL REHABILITATION PROGRAMS – AVLIJA ODRŽIVOG RAZVOJA AS AN EXAMPLE OF GOOD PRACTICE

Avlija sustainable development (Avlija održivog razvoja) is registered as a company that employs people with disabilities and deals with their professional rehabilitation. The beginnings of Avlija's sustainable development were born in 2014 by the implementation of work-occupational therapies for the users of the day care service of Caritas Šabac, who is also the founder of the company. A plum orchard in Badovinci, raspberry, blackberry, cherry plantations in Vukošić, a property in Bogatić are just the beginning. On the estates, users acquire their first work skills, develop capacities, gain independence and readiness for the labor market. Realizing the effectiveness and improvement of manual work through work-occupational therapy, the idea of social entrepreneurship is born. The first employment of persons with disabilities on agricultural estates is the beginning of the social economy.

The courtyard of sustainable development extends over a property of about 1 hectare and is located in Bogatić, which geographically represents the center of Mačva. For this reason, one of the activities of the company is primary agriculture, i.e. growing fruit in orchards, as well as vegetables in greenhouses on the property. The second segment, which consequently and logically follows on from the first, is secondary agricultural production, i.e. the processing of produced fruits and vegetables into juices, sweets, jams and ajvar.

The previous chapters described the advantages of doing manual work for people with disabilities, as well as the need for their professional training in order to join the world of work. Professional rehabilitation programs in the Court of Sustainable Development, related to agricultural production, were created on these bases. The very contact with nature, working outdoors has its benefits for psychophysical health. In the Court of Sustainable Development, people with disabilities are trained through three professional rehabilitation programs: Maintenance and care of lawns, Care and cultivation of fruits and vegetables, Processing of fruits and vegetables and production of winter crops.

The professional team that carries out professional rehabilitation introduces a person with a disability to the work and social process and provides continuous support (Pantelić, 2022).

Professional rehabilitation programs are based on the acquisition of basic knowledge in agricultural production. Training is adapted to their abilities and capacities. After completing work training programs, people with disabilities acquire competences in handling tools and machinery, prepare soil for planting, plant and grow fruits and vegetables, and also acquire knowledge in maintenance of grass areas and processing of fruits and vegetables.

The goal of these programs is to give people with disabilities the opportunity to gain employment through mastering skills related to agricultural production.

The experience of the author of the work in the field of professional rehabilitation shows that manual work and employment, support during work, and the end product resulting from work together make success in the inclusion of people with disabilities and their psychophysical well-being.

CONCLUSION

Employment of persons with disabilities as one of the vulnerable groups has long been a topic in our legislative framework. In the Republic of Serbia, as we had the opportunity to see, the right to work is guaranteed by the Constitution of the Republic of Serbia and applies to the entire population, including persons with disabilities. One of the basic human rights is the right to work, which is important for every individual since it does not only represent economic independence, but is a key factor for self-actualization, increasing self-confidence and is the most powerful means of complete integration into society and social flows. Consequently, the international community as well as the Republic of Serbia have taken initiatives and adopted legal regulations that will protect people with disabilities from all forms of discrimination regarding labor rights. In the Republic of Serbia, the most significant is the Law on Professional Rehabilitation and Employment of Persons with Disabilities, which, with its publication, leads to a reduction in the unemployment rate of this vulnerable population category.

The term professional rehabilitation includes programs of measures and activities that aim to train a person with a disability for a suitable job, get a job, keep an existing job, progress in it, or retrain for another suitable job. An example of good practice in the field of professional rehabilitation is precisely Avlija Sustainable Development, which, through developed professional training programs based on agricultural production, completes the work integration of people with disabilities and shows that the agricultural sector can provide opportunities for their employment.

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CHALLENGES OF TEACHING ENGLISH FOR SPECIFIC PURPOSES TO SPEAKERS OF OTHER LANGUAGES

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ABSTRACT

The current global trends in prosperous as well as in developing or even struggling economies have seen an increased demand of professionals who, alongside high-quality skills in their field, must also be proficient in English as a tool for communication. Hence, English for Specific Purposes (ESP) has been extensively promoted for the purpose of acting as a Lingua Franca in specialized fields and it plays a crucial role in training professionals that can meet the requirements of a fast-changing labour market.

In the present article we describe and discuss challenges of teaching ESP to speakers of other languages, emphasizing on the need to identify effective teaching-learning approaches that would produce the best educational outcomes. Major difficulties related to miscellaneous factors like teacher qualifications, student motivation and engagement and teaching materials are analyzed and suggestions of potential improvement are made.

Keywords: approaches, challenges, deciding factors, English for Specific Purposes, outcomes.

INTRODUCTION AND RATIONALE FOR THE PAPER

We are constantly eye-witnessing an incredibly fast changing global landscape, tremendously impacted by a whole array of transformative processes and trends, occurring at all levels of modern society. The tightly interwoven elements of the world we live in are undergoing interdependent, rapid transformations, inevitably producing a domino effect. The field of language education has most certainly been massively affected by all these societal changes, prompted largely by globalization phenomena. It is not an exaggeration to state that under these conditions, the demand for English language proficiency has never been greater, with all its afferent dimensions being targeted: business, technology, medicine and academia.

The intensified mobility of individuals for educational, professional or personal reasons has led to a substantial increase in the demand for high quality skills in English so that its user could function efficiently and effectively in a variety of contexts and settings.

English continues to solidify its status as the lingua franca of international communication and the field of teaching English for Specific Purposes (ESP) has undergone remarkable evolution to meet the increasingly diverse needs of learners from various domains. ESP emerged due to the increasing demands of the changing world and its main objective is to prepare learners for their professional responsibilities in the context of rapidly growing international trade, multinational companies, worldwide spread businesses, etc.

In this article, we are attempting to highlight the trends in shaping the practice of ESP instruction in the 21st century. We will expand on innovative approaches, pedagogical strategies and technological advancements that are reshaping the ways in which ESP is taught, and most importantly, on the challenges and difficulties that ESP teachers constantly face.

ESP DEFINITION, CONCEPTUALIZATION AND EVOLUTION TRENDS

Prior to exploring the pedagogical implications of ESP in more detail, we suggest examining several definitions of the concept of English as a Second Language in order to gain deeper insights of what dimensions it encompasses and its scope in the wider tapestry of language education.

Laurence A. (2018, pp.10-11) defines ESP as **an approach to language teaching** that targets the current and/or future academic or occupational needs of learners, focuses on the necessary language, genres and skills to address these needs, and assists learners in meeting these needs through the use of general and/or discipline-specific teaching materials and methods.

This definition presents ESP as an approach to language teaching and encompasses two main branches: academic and occupational. Much as most modern language education, ESP is essentially “an eclectic approach that incorporates elements from various other approaches and takes the most useful, successful, and valid ideas from other theories and practices, combining them into a consistent whole” (Laurence A. 2018, p. 9).

Learner-centered, just like most modern-day approaches, ESP still has its uniqueness, which resides in the connection with specialist subjects and the extensive use of authentic materials. Despite the never-ending debates, misinterpretations and ambiguous conceptualizations, one aspect stands out and confirms the status of ESP: it is not a field in itself as there are no solid theoretical developments to prove it: ESP, according to Mohammad Ali (2020, p. 252), is “just the practical application of language to a specific ‘use’ context, but not a self-sustained autonomous type of language in and

of itself". ESP has been around for over fifty years: initially it was an integral dimension of English Language Teaching, but it gradually developed into a subfield of Applied Linguistics and enjoys some autonomy.

Though there are numerous contradictions concerning the status of ESP and its connections to other branches of English Language Teaching/Learning, one thing is irrefutable: it cannot be entirely independent from English for General Purposes and there is a consistent overlapping of the two in the sense that everyone who knows English will be able to use it for specific purposes, with some effort to learn the ABCs of the particular field. They just need to learn some specific terminology, genres, not a completely new language (Lawrence, A. 2018).

With regards to the origins of ESP, Hutchinson and Waters, posit that "as with the most developments in human activity, ESP was not a planned and coherent movement, but rather a phenomenon that grew out of a number of converging trends" (Hutchinson & Waters, 1991, p. 6). In a world dominated by technology and commerce that started flourishing after World War II, there was an impressive, unprecedented expansion in science, technology, and economy worldwide which in turn prompted a demand for an international language. Hence, the emergence of an increasing number of people wanting to learn English not just for prestige, but because English opened new opportunities to them and access to international markets. Thus, a new generation of learners appeared - they knew specifically why they were learning English! These were businessmen and businesswomen who wanted to sell their products, mechanics who had to read instruction manuals, doctors who needed to keep up with the developments in their fields..." (Hutchinson & Waters, 1991, p. 7).

The realization that people learn differently, in accordance with their interests and needs, was another factor contributing to the rise of ESP by emphasizing the need to use materials that would match their professional preferences to study English (Laurence A., 2018, p. 21; Selcuk, K., 2014, p.593).

In the five decades that ESP has been part of English Teaching/Learning, it has primarily been approached from pedagogical perspectives and educators' main concerns have essentially been about materials and teaching methodology (Ali Salmani-Nodoushan, M. 2020, p. 249).

Since experts in the field have failed to put forward reliable, comprehensive theoretical developments that would assure ESP full autonomy as a field, the major advancements that have been made, as it has already been highlighted, deal with methodological aspects. Hence, ESP as a dimension of Language education has been marked by three major approaches: 1) - **Content-based Instruction**; 2) - **Content and Language Integrated Learning** and 3) - **Genre-based Instruction**. (Task-based Instruction is also sometimes referred to as an approach in use in ESP) (Laurence A. 2018, pp. 42-44)

T. Hutchinson and A. Waters (1991), postulate that "ESP, like any form of language teaching, is primarily concerned with learning. But, they add, "in its development up to now, ESP has paid scant attention to the question of how people learn, focusing instead on the question of what people learn" (p.18). Conducting literature review, we found that even though the field of ESP is not quite new, there is a shortage of studies that thoroughly investigate the challenges both ESP teachers and learners face. In general, most papers focus primarily on the status and the evolution of ESP and describe the pedagogical dimensions that contributed to its success.

METHODOLOGY

This article is primarily descriptive and encompasses a series of generalizations based on data collected in 2022-2023, when the author taught two different sets of ESP courses at the Police Academy “Stefan cel Mare” in Chisinau. The first course, the most challenging and demanding one, dealt with teaching English to Customs Police and the second one was dedicated to English for Forensics. More data were collected from teachers of an ESP course (English for Psychologists) at “Ion Creanga” State Pedagogical University of Chisinau, Moldova during the first semester of the 2023-2024 academic year.

The necessity to delve deeper into the peculiarities of such courses was prompted by the manifold intricacies and difficulties we were facing on a regular basis, particularly due to the fact that the classes appeared more like delivering dry sets of lexical items and reading materials that did not seem to have any effect on the students and their motivation to participate in class.

To clarify the underlying reasons and causes for such a situation, regular observations and reflective journals were carried out, followed by an unstructured interview involving 11 ESP and 5 FSP (French for Specific Purposes) teachers at the same institution and 3 teachers from “Ion Creanga” State Pedagogical University. The participants had extensive experience as teachers of foreign languages and less experience as teachers of a foreign language for specific purposes. The questions they were asked were focusing on various aspects of teaching a foreign language for specific purposes and involved dimensions like grammar, language skills development, cultural elements, intercultural communication, teachers’ knowledge of the subject, where to find appropriate materials, how to adapt them, when and where to look for specialized help, and so forth. Answers to various burning questions were collected at different times during the academic year and later on these were classified and interpreted. The major challenges described below are the ones the majority of the participants identified in their teaching practice. At times, students were also asked to put forward their perceptions, views and opinions about the course and about what would make their classes more engaging and attractive, and their responses were also analyzed and taken into consideration.

Some of the teachers also came forward with their own approaches that helped improve the situation, whereas some others appeared to comply with the reality and take it for granted.

CHALLENGES AND DIFFICULTIES IN TEACHING ESP. POTENTIAL SOLUTIONS

Teaching ESP to speakers of other languages presents a unique set of challenges that educators must navigate. One significant obstacle is tailoring the language instruction to meet the specific needs and goals of diverse learner groups. Unlike general English language instruction, ESP requires a deep understanding of the learners' professional or academic context, which can vary widely across disciplines such as medicine, engineering, or business. Designing materials and activities that are both linguistically challenging and contextually relevant demands extensive research and expertise. Additionally, addressing the language needs of learners with varying proficiency levels within the same specialized field can be daunting. Furthermore, incorporating authentic materials and real-world tasks into the curriculum poses challenges in terms of accessibility and appropriateness. Effective ESP instruction also necessitates collaboration with industry professionals to ensure the relevance and accuracy of content. Moreover, motivating learners who may perceive English as a

means to an end rather than an end in itself can be a persistent challenge.

Another significant difficulty and challenge for ESP teachers in the case of foreign language learners refers to the fact that they must teach concepts and topics that even native speakers of English may not understand as these are primarily subject-specific. Teaching ESP for business, IT or aviation engineering, for instance, requires deep understanding and quite extensive knowledge of the field. It is quite frequent for ESP teachers to have a confusing feeling about what they are teaching: English or a specific subject in English?

When teaching ESP, educators often encounter a dilemma regarding the focus of their teaching. On one hand, they aim to improve language skills and proficiency in English. On the other hand, they are tasked with teaching content related to a specific subject area, such as business, medicine, or engineering, ecology of green agriculture. This dilemma can lead to a confusing feeling among ESP teachers about whether they are primarily teaching the English language itself or using English as a medium to teach subject-specific content. A few reasons why this confusion may appear are described below:

- **Language Skills vs. Content Knowledge:** ESP teachers must balance between developing students' language skills (e.g., reading, writing, speaking, listening) and imparting knowledge related to the specialized field. They may question whether their primary goal is to enhance language proficiency or to ensure understanding of the subject matter.
- **Student Needs and Expectations:** ESP courses are generally designed to meet the specific needs of students in a particular field or profession. Teachers may grapple with aligning their teaching priorities with the expectations and requirements of their students. This can lead to uncertainty about whether they should prioritize language instruction or content delivery.
- **Integration of Language and Content:** Effective ESP instruction involves integrating language learning with subject-specific content. Teachers may struggle to strike the right balance between teaching language skills and incorporating relevant content.
- **Professional Identity:** ESP teachers to speakers of other languages, as a rule, come from diverse educational backgrounds, with the majority having expertise in language teaching and very few are experts in the specialized field they are teaching. This can contribute to diverging perspectives on the role of language versus content in ESP instruction.

Apart from what has been mentioned above, the success of ESP classes/ courses is also determined by the learners' knowledge of the subject matter, their interest in the field fueling their active participation in English classes (Falaus, A. 2017, p.2). When referring to ESP courses taught to university students, who have reached upper levels of cognitive maturity, we might have higher expectations, alongside integrating materials of different levels of complexity. These beneficiaries acknowledge what and why they want to do certain things in relation to their future careers. On the other hand, if ESP courses are delivered to vocational school students, the challenges are manifold for the educator. First and foremost, their level of general English proficiency may be significantly lower which means the educator may have to dedicate more of the instruction time to developing their basic language skills: reading, writing, speaking and listening. Additionally, students may experience various difficulties when dealing with essential subject related concepts and ESP educators are expected to establish how to differentiate tasks and contents so that they grapple with the new material in the most

effective way. To navigate this challenge of dealing with related concepts, ESP teachers often benefit from clarifying their teaching objectives, establishing clear learning outcomes for both language proficiency and subject knowledge, and adopting instructional approaches that effectively integrate language and content. To fully recognize the interconnectedness of language and subject matter in ESP instruction, teachers need extensive support and specialized training so that they can create a more cohesive and effective learning experience for their students.

The Problem of Developing Intercultural Competence within ESP courses

A pivotal dimension of ESP that still raises a significant number of issues deals with the recognition of the importance of intercultural competence and communicative skills. The need for solid communicative competences in a variety of contexts has increased awareness of the necessity to incorporate intercultural competence in ESP classes as the mere immersion in specialized, authentic materials failed to achieve this objective. It is extremely difficult to identify relevant authentic materials that would effectively tap into these subtle and delicate matters and this is one of the most challenging aspects of ESP courses. As professionals interact in diverse multicultural settings, the ability to navigate cultural nuances and communicate effectively across borders has become indispensable and ESP teachers face the daunting task of skillfully integrating materials and activities that promote not just the linguistic dimension of the course, but also cultural awareness, empathy and intercultural communicative competence. This is a strong argument for us to contend that ESP teachers are educators, not simply instructors, as they are expected to go much beyond in order to achieve the objectives of their courses, in contrast with specialized courses teachers. Their task as educators is multifaceted and multidimensional as, apart from developing language skills and imparting subject-specific knowledge, they have to be able to expertly guide the learners when dealing with:

Misunderstandings in Cross-Cultural Communication. In our diverse world, students come from different cultural and social backgrounds and misunderstandings can occur due to differences in communication styles, non-verbal cues, and cultural norms. As a result, this can impede effective collaboration and comprehension of subject-specific content can be affected.

Difficulty in Negotiating Meaning: Effective communication in ESP requires the ability to negotiate meaning collaboratively, especially when discussing complex or technical topics. Limited intercultural competence may hinder students' ability to engage in productive communication, leading to ambiguity and confusion.

Barriers to Collaboration: In ESP courses that involve group work or collaborative projects, students need to navigate cultural differences to work effectively as a team. Challenges such as differing communication preferences, decision-making styles, and conflict resolution approaches can hinder collaboration and project outcomes.

Cultural Sensitivity in Language Use: ESP teachers and students must be aware of cultural nuances in language use to avoid unintentional offense or misunderstanding. Lack of intercultural competence may result in inappropriate language choices or insensitive communication, leading to tension or breakdowns in communication.

Impact on Professional Relationships: In professional contexts, effective communication is crucial for building relationships and networking. Limited intercultural competence and communicative skills in ESP may hinder students' ability to establish rapport with colleagues, clients, or stakeholders from diverse cultural backgrounds, impacting their professional success.

Impediments to Cross-Cultural Adaptation: ESP students often need to adapt to new cultural environments, especially if they plan to work or study in international settings. Challenges related to intercultural competence and communicative skills can make it difficult for students to navigate cultural differences and adjust to unfamiliar contexts.

The need for pedagogical intervention in this regard is evident and essential. However, in the context of ESP courses, the very subtle and sensitive cultural underpinnings of international communication are quite neglected, namely because of the risk of generating misunderstandings and, eventually, conflicts or because the ESP educator does not have the proper skills or even the methodology to approach them effectively. It is a well-known fact that language skills (reading, writing, speaking, listening) are easier to develop, compared to multidimensional, culture-bound competences.

Addressing these challenges requires a holistic approach that integrates intercultural competence development with communicative skill-building in ESP instruction. Strategies may include incorporating cross-cultural communication activities, providing explicit instruction on cultural norms and expectations, fostering opportunities for authentic language use in diverse contexts, and promoting reflection on the role of culture in communication. By actively addressing these challenges, ESP educators can better prepare students for success in their academic and professional endeavors.

NEEDS ANALYSIS - AN EFFECTIVE APPROACH TO OVERCOME MAJOR HURDLES IN ESP

In line with A. Robinson (1991) who suggests that an ESP course should be based on a Needs Analysis (NA), it is essential to note that NA is paramount, or the cornerstone of ESP courses and it should be at the heart of all the other endeavors that follow (Selcuk, K, 2014, p.597). The study conducted by Selcuk, K. revealed that 80% of ESP teachers indicate that lack of NA is their main challenge when designing an ESP course syllabus, selecting the suitable materials and teaching it. Any ESP course must be tailored in accordance with beneficiaries' level of language proficiency, goals, professional objectives and potential contexts (Selcuk, K, 2014, p. 596). For this reason, ESP teachers need specialized professional development courses in the field especially since what they teach is usually more complex and demanding and multi-faceted, compared to English for General Purposes. Firstly, as ESP teachers, they are expected to know the major aspects of the specialized subject very well. About 89% of the respondents who participated in S. Koran's study emphasized that they need extensive training in specialized terminology and only a small number mentioned the need for training in teaching methodology - 5% (Selcuk, K. 2014, p.596). Having sound subject knowledge will definitely provide ESP teachers with the possibility to use it efficiently for real communication and to design relevant activities on the basis of authentic materials which are extensively recommended in ESP courses. Unquestionably, this can be achieved by reading specialized articles, examining the findings of studies in the field or by consulting subject teachers. However, ESP teachers could and should benefit from close collaboration with subject teachers, which, as a rule, does not happen too often.

Regretfully, in foreign language teaching contexts, ESP teachers are left to themselves and they are striving all alone to design the course syllabus, to find the right materials and to identify and apply the appropriate methodology, which sometimes may differ from the straightforward methodology used in teaching general English

(Salazar, E.U, 2017). Apart from this, in most ESP educational contexts, teachers simply do not have the suitable context and conditions to carry out proper, relevant needs analysis prior to course inception. Such a possibility would be facilitative in many ways. First, they would get relevant insights into the learners' general level of language proficiency and, absolutely important, what the main reasons for them to study English are. With this information missing, the materials that they choose to tailor their ESP course may be either too complex or too easy, both complexity levels having their associated risks. Having the possibility to adopt a needs-based approach well in advance may help teachers better address the unique language requirements and professional objectives of their students, thus fostering motivation, engagement and higher success rates of the ESP courses (Salazar, 2017, pp.199-200). Despite these drawbacks, it should be noted that in most cases ESP educators are skillful and flexible enough and can reshape the trajectory of their teaching practice to meet the needs of their students on the run.

PEDAGOGICAL APPROACHES TO HONE IN ESP

Though the challenges, difficulties and dilemmas in the field of ESP are numerous, there are many achievements in the efforts to make it more effective, relevant and attractive to the learners. In this sense, it is worthwhile referring to a range of pedagogical approaches, strategies and techniques that have been tailored and developed to meet the language learning needs of learners in specific professional or academic contexts. In what follows we will look briefly into some of the most effective pedagogical approaches:

- Integrating authentic materials, such as texts, documents, and multimedia resources from real-world contexts, enhances the relevance and authenticity of ESP instruction. Authentic materials expose learners to the language and discourse conventions prevalent in their target professional domains, facilitating meaningful language acquisition and promoting transferable skills.
- Emphasizing task-based learning engages learners in purposeful, communicative activities that simulate real-life language use within their professional contexts. By focusing on the completion of tasks, such as problem-solving, negotiations, or presentations, learners develop language proficiency while acquiring essential workplace skills, such as collaboration, critical thinking, and decision-making.
- Analyzing the discourse patterns and rhetorical conventions specific to learners' professional fields enables educators to teach language in context. By examining authentic texts and genres characteristic of their disciplines, learners gain insights into the structure, style, and communicative strategies necessary for effective communication within their respective fields.
- Leveraging technology tools and digital resources enhances the effectiveness and efficiency of ESP instruction. Interactive multimedia platforms, virtual simulations, online databases, and communication tools facilitate authentic language practice, collaboration, and access to real-time information, extending learning beyond the confines of the classroom.
- Collaborating with professionals and experts from learners' target fields promotes authentic language learning experiences and fosters interdisciplinary connections. Guest lectures, industry partnerships, and collaborative projects provide learners with opportunities to interact with authentic language users, gain insights into professional practices, and develop relevant language skills and cultural competencies.

- Feedback and assessment: Providing timely and constructive feedback on language performance is essential for learners' progress and motivation. Formative assessment techniques, such as peer review, self-assessment, and instructor feedback, enable learners to reflect on their language development, identify areas for improvement, and set achievable goals for language proficiency within their professional contexts.
- Recognizing the importance of cultural competence in effective communication, ESP instruction emphasizes the development of intercultural awareness and sensitivity. By exploring cultural values, norms, and communication styles prevalent in their target professional contexts, learners acquire the skills to navigate cultural differences, build rapport, and establish effective cross-cultural communication.
- Continuous Professional Development: Engaging in continual professional development ensures that ESP educators remain abreast of evolving language trends, pedagogical approaches, and technological advancements relevant to their fields. Participation in conferences, workshops, and professional networks enables educators to exchange ideas, share best practices, and enhance their instructional expertise to better meet the evolving needs of learners.
- Flexibility and adaptability: Recognizing the dynamic nature of professional contexts, effective ESP instruction embraces flexibility and adaptability. Educators continually assess and adjust instructional strategies, materials, and activities to accommodate changes in learners' needs, technological innovations, and industry trends, ensuring the relevance and effectiveness of ESP instruction over time.

By implementing these effective practices, ESP educators can create engaging, relevant, and empowering learning experiences that equip learners with the language skills, cultural competence, and professional competencies necessary for success in their respective fields.

DISCUSSION

As a result of personal experience with ESP and analyzing minutely the responses generated by colleagues during several series of unstructured interviews alongside those of ESP students, it is worthwhile pinpointing that the field of ESP is still characterized by the presence of multiple challenges and impediments. The array of challenges and difficulties identified are the most commonly referred to and they indicate that ESP educators need extensive support and assistance in both designing and delivering high quality courses. A potential solution consists in having the possibility to carry out comprehensive NA which would provide valuable insights about the trajectory to follow.

Among the numerous challenges listed, developing students' Intercultural Communicative Competence appears to be the most difficult to tackle in an ESP setting with educators feeling disconcerted by the multitude of aspects to be properly integrated and approached. This is a crossroads aspect that still needs in-depth investigation for lucrative solutions to be identified. In this sense, the integration of authentic materials, task-based learning and the incorporation of online tools are just some of the practices that are extensively used to achieve the best educational outcomes, however some more comprehensive approaches are needed.

The data obtained reveal that both short term and long term, these challenges put significant pressure on ESP teachers, particularly in the context of the never-ending changes on the labor market. Professionals in different fields are expected to be highly

proficient in both general and specialized English and ESP teachers have to be able to identify the problems, and the solutions to these problems in order to equip students with the skills they need to function effectively in various contexts. ESP teachers continue to strive in order to elaborate approaches that would improve the situation in their particular educational context. They upgrade their skills and adapt their practices to enhance the relevance and the effectiveness of ESP instruction.

CONCLUSION

The critical analysis of the current situation in the field of ESP leads to the conclusion that it is still characterized by discordance, fallacies and deficiencies that affect the attainment of an ESP course objectives. Its multi-faceted character requires judicious, complex, multi-dimensional approaches and well-informed pedagogical intervention. Therefore, ESP educators need ongoing professional development and support that would enable them to achieve their professional objectives. It has been shown that navigating the realm of ESP presents a multitude of challenges from tailoring appropriate content to diverse audiences/beneficiaries to constantly addressing the needs of an ever-evolving labour market, heavily marked by global phenomena like migration, internationalization trends etc.

However, despite the impediments, ESP educators continually innovate teaching strategies and methodologies to enhance the learning experiences and empower learners to succeed in their specific professional or academic contexts. They acknowledge that a complex, proactive approach, leveraging technology, fostering collaboration between educators and specialization professional can help transform the various hurdles into opportunities for professional growth and enhanced, effective communication.

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Promotion and preservation of human health

HEALTH-RELATED PROBLEMS AND DAILY THERAPY IN THE POPULATION OF PROFESSIONAL DRIVERS

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ABSTRACT

Introduction: The drivers' health condition can affect driving ability and be one of the determinants of participation in traffic accidents, as well as use of some medicines, whether they are taken alone or in combination with other psychoactive substances such as alcohol. The aim of this study was to examine health-related problems and daily therapy in the population of professional drivers in Serbia and Bosnia and Herzegovina. **Methods:** The research was conducted as a multicenter cross-sectional study. The study population was consisted of 221 professional drivers, both genders, aged from 20 to 65, with a minimum of 2 years driving experience. Participants were employed in taxi associations, transport organizations, delivery services, auto-traffic companies, or they spend most of their working time to operate the machinery, such as industrial workers, workers who handle cranes, forklifts and agricultural machinery. During the study data about the health-related problems of participants and their daily therapy, especially driving impairing medicines, were collected as independent variables. **Results:** The average age of the participants was 42.82 years. From some chronic disease suffer 20.36% respondents, while 18.10% of them used the prescribed therapy daily. One chronic medical condition had 9.50% respondents, 6.78% had two, while 4.07% had three or more. Driving impairing medicines were used by 9.95% of participants. More over the half (55.00%) among drivers who used prescribed therapy on daily basis have at least one, while 4 of them used three or more of these medicines. Of the other drugs used by respondents on a daily basis, antihypertensive and medications for diabetes treatment were the most common. **Conclusions:** This study showed a better health status of professional drivers compared to other drivers. The use of driving impairing medicines in the studied population is high.

Keywords: professional drivers, health-related problems, chronic diseases, medicines, daily therapy.

INTRODUCTION

Commercial transport is significant from the aspect of socio-economic development of every country, especially the type that is involved in the transport of passengers and goods (Okafor et al. 2017). Professional drivers have a great responsibility in terms of traffic safety and require a greater degree of attention, optimal working ability and constant concentration. The training and selection processes of the professional drivers include necessary professional knowledge and skills, as well as psychological preparation (Zaranka et al. 2021). According to the Law about Traffic Safety on the Roads of the Republic of Serbia, professional drivers are persons whose main occupation is driving a vehicle or performing public transport. The same Law defines that every legal entity and entrepreneur who is the owner or user of a vehicle is obliged to ensure that its vehicles in road traffic are technically correct and that the drivers of their vehicles meet health and other conditions for safe driving. More than half (54.3%) of commercial drivers have poor knowledge of driving ability (Yan et al. 2021).

Professional drivers should maintain their mental and physical health, in order to perform their duties safely and without risk to themselves and other road users. As in other industries with a high risk of occupational injuries, such as construction or agriculture, it is possible that pharmacological treatments or undiagnosed or poorly controlled medical conditions may contribute to an increased risk of occupational injuries, particularly from traffic accidents (Riva et al. 2018). The health condition of the driver can affect the driving ability and be one of the determinants of participation in traffic accidents (McGwin et al. 2000). It has been found that there is a significant discrepancy between the perception and behavior of drivers regarding the impact of health conditions on the risk of accidents and there is a growing need to raise people's awareness of this fact. A large number of drivers continue to drive even when they are unfit to do so, which is clearly a risky behavior (Alonso et al. 2016). Several medical conditions are associated with traffic accidents due to impaired sensory, cognitive and motor functions: neurological diseases (epilepsy, Parkinson's disease, dementia), psychiatric diseases (anxiety, depression, schizophrenia), addiction and abuse of psychoactive substances, diabetes, cardiovascular diseases, diseases locomotor tract (arthritis), vision and hearing disorders, sleep apnea (Rudisil et al. 2016; Skyving et al. 2021). The responsibility for maintaining fitness to drive is shared by drivers, health professionals and government licensing authorities. For drivers this means maintaining their own health, following medical advice regarding relevant driving conditions, seeking medical advice for a condition they suspect may affect their ability to drive safely (Ryan et al. 2020). Most doctors agree that they should be legally responsible for reporting unsafe drivers to licensing authorities (Yang et al. 2007) but feel that there should be reference guides for assessing drivers' driving abilities (Sebo, 2020).

It has been known for many years that the consumption of some psychotropic medicines has a negative effect on the ability to drive. Whether taken alone or in combination with other substances such as alcohol, these medicines increase the risk of traffic accidents (Legrand et al. 2012; Duquet, 2013) and have a negative impact on clinical outcome in trauma patients (Torp et al. 2021). Drivers who took medicines that potentially interfere with driving were 1.2-7.5 times more likely to be involved in a traffic accident (Ivers and White, 2016). Therefore, the influence of medicines on driving is an important factor in creating a treatment regimen (Hetland and Carr, 2014).

Prescription medicines abuse is a danger, particularly in relation to opioid-related deaths (Parekh, 2019). The unrestricted availability of drugs that negatively affect psychophysical abilities is also a problem (Chowanec et al. 2005).

The aim of this study was to examine health-related problems and daily therapy in the population of professional drivers in Serbia and Bosnia and Herzegovina.

MATERIAL AND METHODS

The study was conducted as a multicenter, cross sectional study in 6 cities of Serbia (Šabac, Belgrade and Vranje) and Bosnia and Herzegovina (Brod, Derventa and Brčko), in the period from 2017-2022, after obtaining the approval of the Ethics Committee of the Faculty of Medical Sciences, University of Kragujevac, according to the standards of Good Clinical Practice (GCP), respecting all recommendations of ethical documents (Helsinki declaration), and obtaining a written informed consent of the participants.

The study participants were approached through the transport companies where they were employed. The research population was consisted of 221 professional drivers, both genders, aged from 20 to 65, with a minimum of 2 years driving experience. Participants were employed in taxi associations, transport organizations, delivery services, auto-traffic companies where they drive car/truck/van/bus, or they spend most of their working time to operate the machinery, such as industrial workers, workers who handle cranes, forklifts and agricultural machinery. Professional drivers who didn't operate motor vehicles or machinery and didn't have a driver's license at the time of the survey, due to health problems or traffic violations, were excluded from the study, as well as those who didn't show the willingness to comply with the study protocol. Respondents who met the inclusion criteria and who signed a written informed consent were surveyed. The questionnaires were filled by the researchers who interviewed the participants. The researchers recorded a response rate.

During the study data about the health-related problems of participants and their daily therapy, especially driving impairing medicines, were collected as independent variables.

All calculations in this study were performed by SPSS software, version 20. Before performing statistical analysis, the normality of the data distribution was examined by Kolmogorov-Smirnoff test. Data about the basic characteristics of the respondents were processed using descriptive statistics. Statistically significant results were those in which the probability of null hypothesis was less than 5% ($p < 0.05$).

RESULTS AND DISCUSSION

From 235 respondents at the beginning, 221 finished the study, so response rate in the study was 94.01%. The average age of the participants was 42.82 years (ranging from 21 to 65, standard deviation 11.26). Male sex was 216 (97.74%) of respondents, and only 5 (2.26%) were females. From Serbia 168 (76.02%) professional drivers were participated and 53 (23.98%) from Bosnia and Herzegovina, based on availability of participants for the study. The characteristics of the respondents are given in Table 1.

Table 1: The main characteristics of the respondents

		Freq uency	Perce ntage
Gender	Male	216	97.74
	Female	5	2.26
Education level	Unfinished primary school	5	2.26
	Primary school	41	18.55
	High school	122	55.20
	Higher school	38	17.19
	Faculty	15	6.79
Living area	Urban	97	43.89
	Suburban	48	21.72
	Rural	76	34.39
Country	Serbia	168	76.02
	Bosnia and Herzegovina	53	23.98
City	Šabac	120	54.30
	Belgrade	19	8.60
	Vranje	29	13.12
	Brod	16	7.24
	Derventa	15	6.79
	Brčko	22	9.95

From some chronic disease suffer 45 respondents (20.36%), while 40 of them (18.10%) used the prescribed therapy daily. One chronic medical condition had 21 respondents (9.50%), 15 respondents (6.78%) had two, while 9 (4.07%) had three or more. The subjects' chronic medical conditions are shown in Table 2.

Table 2: Chronic medical conditions of the respondents

	Medical conditions	Frequency	Percentage (all respondents)	Percentages (respondents who use therapy daily)
Cardiovascular diseases	Hypertension	36	16.29	80.00
	Arrhythmias	3	1.36	6.67
	Angina pectoris	2	0.90	4.44
	Varicose veins	1	0.45	2.22
Metabolic and endocrine diseases	Diabetes mellitus	7	3.17	15.56
	Hyperlipoproteinemia	3	1.36	6.67
	Hypothyroidism	2	0.90	4.44
Psychiatric diseases	Depression	4	1.81	8.89
	Anxiety	2	0.90	4.44
Urogenital diseases	Benign prostate hypertrophy	5	2.26	11.11
	Renal insufficiency	1	0.45	2.22
Respiratory diseases	Allergies	3	1.36	6.67
	Asthma	2	0.90	4.44
Neurological diseases	Migraine	3	1.36	6.67
Gastrointestinal diseases	Peptic ulcer	3	1.36	6.67
Musculoskeletal diseases	Lumbar pain	2	0.90	4.44
	Osteoarthritis	1	0.45	2.22
Hematological diseases	Anemia	1	0.45	2.22

Driving impairing medicines were used by 9.95% of participants. More over the half (55.00%) among drivers who used prescribed therapy on daily basis have at least one, while 4 of them used three or more of these medicines. Benzodiazepines were used in daily therapy by 52.50% of the participants, mostly anxiolytic benzodiazepines 45.00%. More detailed results of driving impairing medicines in daily therapy of study participants are given in the Table 3.

Table 3: Drugs that may impair driving in daily therapy of the respondents

GROUP	INN	Frequency	Percentage (all participants)	Percentage (participants who use daily therapy)
Anxiolytics	alprazolam	8	3.62	20.00
	bromazepam	5	2.26	12.50
	diazepam	4	1.81	10.00
	prazepam	1	0.45	2.50
Antiepileptics	clonazepam	2	0.90	5.00
Hypnotics	midazolam	1	0.45	2.50
	zolpidem	1	0.45	2.50
Antidepressants	sertraline	2	0.90	5.00
	venlafaxine	2	0.90	5.00
	maprotiline	1	0.45	2.50
	paroxetine	1	0.45	2.50
	amitriptyline	1	0.45	2.50
Antimigranics	sumatriptan	2	0.90	5.00
Propulsives	metoclopramide	1	0.45	2.50
Central antihypertensive	methyldopa	1	0.45	2.50

Of the other drugs used by respondents who use prescribed therapy on a daily basis, antihypertensive medicines (angiotensin-converting enzyme inhibitors (ACE inhibitors), beta blockers, diuretics and statins) and medications for diabetes treatment were the most common. A detailed presentation of the subjects' therapy by pharmacological groups is shown in Table 4.

Table 4: Other drugs in the daily therapy of the respondents

Group	Frequency	Percentage (all participant s)	Percentage (participant s who use daily therapy)
ACE inhibitors	23	10.41	57.50
β blockers	19	8.60	47.50
Diuretics	19	8.60	47.50
Calcium blockers	6	2.71	15.00
Statins	6	2.71	15.00
Oral hypoglycemic medicines	6	2.71	15.00
Platelet aggregation inhibitors	5	2.26	12.50
Medicines in the treatment of benign prostatic hypertrophy	3	1.36	7.50
Fibrates	2	0.90	5.00
Angiotensin receptor blockers	2	0.90	5.00
Antiaesthetics	2	0.90	5.00
Nonsteroidal anti-inflammatory drugs	2	0.90	5.00
Thyroid hormones	2	0.90	5.00
Insulins	1	0.45	2.50
Anticoagulants	1	0.45	2.50
Antiarrhythmics	1	0.45	2.50
Muscle relaxants	1	0.45	2.50

The results of this study are supported by a high response rate of 94.04%, which is significantly higher compared to similar studies conducted with drivers, such as the study in Tanzania (Kagashe and Seleman, 2009), where the response rate was 78.91%, especially in compared to the study in European Union (Monteiro et al. 2012), where the response rate was only 18.00%.

The majority of respondents in our study were males, 97.74%, typically for professional drivers. The average age was 42.82 years (21-65 years). Other demographic characteristics of the respondents are similar to the results of the studies carried out so far (Pourabdian et al. 2021; Dini et al. 2019; Yosef et al. 2021).

At least one chronic disease had 20.36% of professional drivers, while 18.10% used daily prescribed therapy, which is contrary to the results of the study by Giroto et al. (Giroto et al. 2016), where 63.30% reported some health problem. In the research conducted in Serbia (Antonić et al. 2012), in the general population of drivers, 50.00% of respondents had some chronic disease and used therapy daily, which suggests that professional drivers are healthier than the general population of drivers. The results of the study by Okafor et al. (Okafor et al. 2018) indicated that around 80% of commercial drivers were unfit to drive because they were either unaware of it or had a wrong perception of what mean adequate driving ability. In a study in Pakistan (Mir et al. 2013), even physical limitations to safe driving were found, such as impaired vision. Almost a quarter of respondents, truck and bus drivers, reported some degree of visual impairment, although a visual assessment is a mandatory part of the procedures for obtaining driver's licenses.

Among the drivers who use prescribed therapy daily in our study, 55.00% used at least one drug with a negative effect on driving ability, while 17.50% used two or more of these medicines, which can negatively contribute to traffic safety, as well as use of alcohol and other psychoactive substances. The above data supports the fact that drivers are not sufficiently familiar with the influence of medicines on their ability to drive. In a study with professional drivers (Giroto et al. 2016), 72.90% and 18.60% used one and two medicines with a negative effect on driving, respectively. In a study in Japan (Okamura et al. 2018), drivers reported using 2.7 sedative medications in the past two years, noted few adverse drug effects on driving, and generally did not adhere to warnings about medication effects on driving. The presence of driving impairing medications in therapy was associated with participation in traffic accidents and a higher frequency of committing traffic violations (Okamura et al. 2018). In a study by Smyth et al. (Smyth et al. 2013) 73.20% of respondents used some of the drugs with negative effects on driving, and 56.1% used them in the previous year, while in the study of Kelley-Baker et al. (Kelley-Baker et al. 2017) nearly 20% of subjects had used at least one medication with a negative effect on driving in the previous two days, with increased use in older age in the general driver population. A study in Spain (Alonso et al. 2014), shows that 15.00% of drivers permanently consumed psychotropic medicines, 2.50% of drivers used antidepressants, 2.60% of anxiolytics, and 3.70% of hypnotics and sedatives, while 8.30% of drivers occasionally used some type of psychotropic medication. In a study by Veldhuijzen et al. (Veldhuijzen et al. 2006), it was found that despite warning labels on the packaging that these drugs may impair the ability to drive, the majority (71.00%) of users continued to drive. The fact that 40.00% of these users stated that they were not more careful in traffic after taking psychotropic medications is worrying.

A study by Del Rio and Alvarez (Del Rio and Alvarez, 2003) confirmed that among drivers who chronically consume driving impairing medicines, 65.80% are considered fully fit for driving, 27.30% fit with certain restrictions. In France, with an estimated 3.30% of road accidents attributable to prescription medicines, 27.00% of drivers were exposed to at least one prescribed medicine on the day of the accident (Orriols et al. 2010). Even if they notice a negative effect of medication on driving, 20.90% would drive when they think traffic is less heavy, and 37.70% would change their medication regimen to be able to drive normally (Smyth et al. 2013). In a study conducted in Japan (Okamura et al. 2018), 20–28% of subjects reported being unaware of important facts such as the potential for an increased risk of crashes at the start of drug treatment, increased risk of accidents when taking higher than prescribed doses and reduced performance driving due to combining more than one medicines or drinking alcohol while taking these medicines.

Of the other drugs in the daily therapy of the respondents, the most represented are cardiovascular drugs and drugs for diabetes therapy, which is in accordance with the study by Girotto et al. (Girotto et al. 2016) where the prevalence of the use of these drugs is higher than in our respondents.

However, research highlights less risky behaviors observed among professional drivers (Mirzaei et al. 2014), for whom professional ethics, internal regulations and safety management procedures are effective ways to prevent the use of alcohol and psychoactive substances while driving. This is probably less true for medicines, which are less in focus for the preventive occupational medicine. However, the likelihood of being employed as a professional driver is certainly lower for those with poor health, thereby reducing medication use in this population (Lu et al. 2020). Regardless of these facts, professional drivers can represent a risky group in road traffic (Mirzaei et al. 2014).

CONCLUSIONS

This study showed a better health status of professional drivers compared to other drivers. However, the presence of some chronic medical conditions can have a negative impact on the ability to drive safely. The most common chronic diseases in the studied population are cardiovascular and metabolic and endocrine diseases. Psychiatric diseases, such as depression and anxiety, were present among the respondents, which may be associated with traffic accidents due to impaired sensory, cognitive and motor functions.

The use of driving impairing medicines in the studied population is high, which makes this group of drivers as risky population, with a negative impact on traffic safety. Benzodiazepines were used in more than half of the participants who used prescribed therapy on daily basis, mostly anxiolytic benzodiazepines. The presence of driving impairing medications in therapy may be related with participation in traffic accidents and a higher frequency of committing traffic violations. The results of this study support the fact that drivers are not sufficiently familiar with the influence of medicines on their ability to drive.

Of the other drugs used by respondents who use prescribed therapy on a daily basis, antihypertensive medicines (angiotensin-converting enzyme inhibitors (ACE inhibitors), beta blockers, diuretics and statins) and medications for diabetes treatment were the most common.

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SAFETY FIRST: A COMPREHENSIVE APPROACH TO FOOD ALLERGY MANAGEMENT IN RURAL TOURISM

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ABSTRACT

Introduction: Amidst the global variability in food allergy prevalence, this study underscores the critical role of labeling regulations, especially within the realm of hospitality. It emphasizes the individual responsibility to prevent inadvertent allergen ingestion, a pivotal consideration in the context of severe allergies during travel and the imperative for effective risk management in the burgeoning field of rural tourism. **Methods:** Employing a comprehensive literature review, this study delves into the challenges associated with food allergies in the context of rural tourism. **Results:** Within the hospitality industry, where food safety reigns supreme, the management of allergens emerges as a critical concern. The rising popularity of rural tourism, fueled by the quest for unique local cuisine, presents both opportunities and challenges. While contributing to economic development, the culinary focus of rural tourism poses obstacles for individuals with food allergies due to limited services. To address this, rural tourism establishments must prioritize guests' needs, ensuring staff education and adherence to allergen safety standards based on Hazard Analysis Critical Control Points principles. Strategic measures such as detailed menu information, staff training, and alternative menus are essential. **Conclusions:** Enhancing guest satisfaction and reinforcing the reputation of rural tourism as a destination prioritizing individual needs can be achieved through the provision of safe and customized options. The intersection of rural tourism and food allergies emphasizes the significance of informed practices, staff training, and proactive measures to ensure a positive and secure visitor experience.

Keywords: Food allergy, rural tourism, management, education, communication.

INTRODUCTION

Every living being must eat to survive. However, because there is such a wide variety and availability of food accessible in the market, eating is not only a necessary part of existence for humans, but it is also a pleasant experience. The human population is greatly impacted by the many food sectors that provide a variety of food items. Consequently, eating a variety of foods led to the development of food sensitivities. Lucretius said centuries ago that a person's food may be deadly to another. In the 20th century, the first patient with a food allergy was documented. Many of these food allergies were formerly disregarded by the medical establishment, but today allergies are widely acknowledged in North America, Europe, Japan, and Australia (Gupta et al., 2019).

The definition of a food allergy is "An adverse health effect arising from a specific immune response that occurs reproducibly on exposure to a given food", and this reaction can result in a wide range of symptoms and illnesses. The frequency of food allergies and their effects on people living in different regions of the world are little understood. Some people, nevertheless, are more vulnerable to food allergies than others. Occasionally, these allergies cause more severe and fatal implications for those who are impacted; as a result, authorities should look into food allergies more. This potentially fatal and expensive ailment is becoming more and more of a global issue (Mazzocchi et al., 2017). Even when precautions are taken to avoid a known food allergy, unintentional responses might still happen. Due in part to variations in dietary consumption, food allergy responses vary in frequency and cause depending on where in the globe one lives (Gupta et al., 2019).

According to current estimates 25% of the population, may suffer from a food allergy (Wen et al., 2020). In Western nations, 1%–3% of adults and 3%–8% of babies suffer from food allergies. The estimated prevalence of allergies to specific foods, split down by location, was revealed in a recent systematic analysis that examined worldwide trends in food-induced anaphylaxis. The most common food allergies among children in Europe are shellfish (0.11%), peanuts (0.42%), cow's milk (0.35%), hen's egg (0.32%), hazelnut (0.28%), wheat (0.16%), and walnut (0.12%). Hazelnut (0.86%), shellfish (0.41%), peanut (0.35%), walnut (0.3%), cow's milk (0.16%), fish (0.14%), and hen's egg (0.08%) had the highest incidence among adult Europeans. These estimations covered the following European nations: Iceland, The Netherlands, Poland, Greece, Bulgaria, Spain, and Switzerland (Gupta et al., 2019; Rotella & Oriel, 2022).

Food sensitivity is an abnormal reaction to a certain food (Gupta et al., 2019). Toxic and nontoxic food reactions are the two groups into which these negative reactions are divided. Both immune- and nonimmune-mediated pathogenic processes are included in the nontoxic responses. Food intolerance, or non-immune mediated processes, can be caused by irritants, psychosomatic reactions, pharmaceuticals, enzymes, and other unexplained factors. In contrast, immune-mediated food allergies include immunological reactions. Food-related difficulties harm travelers' quality of life, and issues with these limitations are becoming more common in many tourism-related settings. Three categories of food-related obstacles exist: dietary intolerances, food allergies, and healthy lifestyles. Finding the right food products for their vacations frustrates travelers with similar illnesses or habits (Birch & Memery, 2020).

This literature review aims to comprehensively explore current research, public health implications, and challenges in rural tourism related to food allergies, providing a holistic understanding of this critical health issue.

COMPLEXITY OF FOOD ALLERGIES AND RELATED ISSUES

The complexity of food allergies extends across different age groups, with a higher prevalence observed in infants and children compared to adults, manifesting diverse symptoms affecting the skin, mucosa, respiratory tract, and digestive tract. Vague symptoms, including nausea, vomiting, diarrhea, and constipation, can also be associated with food allergies. Cross-contamination, particularly related to pollen allergies, contributes to allergic responses to specific foods. For example, individuals with pollen allergies may experience hypersensitivity and anaphylaxis upon consuming mango (Gupta et al., 2019).

The mucosa of the digestive tract plays a crucial role in immune defense mechanisms, responding to various food antigens and gut bacteria. Factors such as altered dietary habits, medication use, and changes in hygiene practices have contributed to the increased prevalence of food allergies. The modern trend toward a longer and more sanitized lifestyle, especially in Western societies, has been linked to higher susceptibility to immunological abnormalities in newborns. Research emphasizes the significance of early-life exposure to a microbially rich environment in reducing the likelihood of allergic reactions (Huang et al., 2017; Sbihi et al., 2019). Understanding host-microbe interactions is crucial for unraveling the complexities of immune-mediated allergic responses. Ongoing clinical investigations, supported by human samples, contribute to advancements in food allergy therapy. However, fundamental research often relies on animal studies to explore the external factors influencing allergic reactions and develop effective precautions against food allergies.

EMERGING ISSUES CONCERNING FOOD ALLERGIES

Emerging issues related to food allergies encompass a broad spectrum of food items, with a focus on common allergens like wheat, eggs, fish, crabs, peanuts, soybeans, and seafood, among others. While there is an extensive list of over 170 foods capable of causing allergies, packaged meals typically provide clear ingredient lists to alert individuals with allergies before consumption (Gupta et al., 2019).

The Codex Committee, recognizing the significance of food allergies, has advised listing common allergens on food labels since 1993. The Codex Alimentarius Commission has mandated the inclusion of a list of allergen-linked foods and components on labels. Foods exceeding a concentration of 10 mg/kg, including gluten-containing cereals, crustaceans, eggs, fish, peanuts, soybeans, tree nuts, and milk derivatives containing lactose, are required to be listed. In addition to these allergens warning labels and allergic reactions to commercially sold genetically modified foods have also emerged (Codex Alimentarius Commission, 2023). Global organizations like the World Trade Organization and the World Health Organization, alongside individual governments, play a crucial role in emphasizing the prevalence of food allergies and intolerances, recognizing their substantial impact on public health (WHO, n.d.; WTO, n.d.). Regulatory bodies must ensure that food labels contain sufficient information for allergic individuals, emphasizing the importance of monitoring the labeling of packaged food items. It is essential to strike a balance, acknowledging that highly refined peanut and soybean oils, lacking sufficient protein to trigger allergic responses, need not be listed on labels. Continuous adherence to guidelines are imperative to address the evolving landscape of food allergies and ensure the safety of the affected population.

MATERIAL AND METHODS OF WORK

In conducting this study we employed a literature review method to analyze existing knowledge in this field. The approach involved identifying relevant scholarly articles and research through searches in recognized databases and academic journals. By focusing on key terms such as "food allergies," "rural tourism," "food safety," and "traveler dietary needs," we categorized and synthesized information to gain a comprehensive understanding of how food allergies influence tourist experiences in rural settings. The methodological approach provides foundation for further research and the development of guidelines to enhance practices in rural tourism, making it more inclusive and responsive to the needs of guests with food allergies.

CONDITIONS ASSOCIATED WITH FOOD ALLERGIES

Various health conditions can arise in connection with food allergies, encompassing gastrointestinal, cutaneous, and respiratory reactions, each presenting distinct syndromes and symptoms.

Gastrointestinal food-allergic conditions

Gastrointestinal food allergies are the cause of many illnesses that are brought on by unfavorable immune reactions to dietary antigens. Even though there is a lot of overlap between these illnesses, the following distinct syndromes have been identified.

Immediate gastrointestinal hypersensitivity

Immediate gastrointestinal hypersensitivity, falling under IgE-mediated allergic reactions, exhibits symptoms of upper gastrointestinal distress within minutes and lower GI distress several hours later. The most frequent IgE-mediated reaction is acute, spontaneous vomiting.

Eosinophilic esophagitis

Eosinophilic Esophagitis is characterized by localized eosinophilic esophageal inflammation. Symptoms range from feeding difficulties, reflux, vomiting, and stomach discomfort in children to dysphagia and esophageal food impaction-type symptoms in adolescence and adulthood.

Food protein-induced enterocolitis syndrome

Food protein-induced enterocolitis syndrome, a non-IgE-mediated illness, presents in early babies with prolonged emesis and diarrhea after food allergen exposure. Milk and soy protein are primary triggers and similar occurrences have been documented in adults, often linked to crustacean shellfish consumption.

Oral allergy syndrome

Oral allergy syndrome a localized, IgE-mediated allergy, is triggered by raw fruits or vegetables. Individuals sensitive to pollens often exhibit oral allergy syndrome signs, such as itching of the lips, tongue, roof of the mouth, and throat, with or without swelling.

Cutaneous reactions

Food allergies frequently result in cutaneous responses, which can be classified as IgE-mediated (urticaria, angioedema, flushing, pruritus), cell-mediated (contact dermatitis, dermatitis herpetiformis), or combined cell-mediated and IgE reactions. The sections that follow provide descriptions of them.

Acute urticaria

Food allergies frequently lead to cutaneous responses, including acute urticaria characterized by IgE-mediated symptoms like hives, angioedema, flushing, and pruritus.

Angioedema

An IgE-mediated food allergy, angioedema, manifests as nonpruritic, nonpitting, clear edematous swelling in various body parts. Laryngeal angioedema, a medical emergency, can occur, necessitating immediate evaluation.

Atopic dermatitis

Atopic dermatitis is a skin condition resulting from a combination of environmental factors, including allergens, irritants, and microorganisms, coupled with skin barrier malfunction (Lack, 2008). It leads to red, swollen, cracked, and itchy skin, with affected areas often releasing clear liquid that thickens over time. Typically manifesting in childhood and worsening with age, atopic dermatitis has been associated with null mutations of the skin barrier protein filaggrin. These mutations increase the risk of transcutaneous allergen sensitization and the development of food allergies in response to atopic dermatitis.

Allergic contact dermatitis

Allergic contact dermatitis clinically presents with vesicles, edema, erythema, papules, and severe pruritus. This form of eczema arises from a cell-mediated allergic reaction to haptens, which can either naturally occur in foods like mangos or be present as food additives.

Respiratory reactions

Respiratory reactions in food allergies are primarily IgE-mediated and occur during a systemic allergic response, often considered a key marker of severe anaphylaxis. Heiner Syndrome is a pulmonary condition affecting newborns and young children, triggered by hypersensitive foods such as cow's milk. This rare condition is characterized by upper respiratory tract symptoms, gastrointestinal issues, pulmonary infiltrates, and iron deficiency anemia. Chronic or recurrent lower respiratory symptoms, coupled with gastrointestinal and pulmonary infiltrates, upper respiratory tract infections, and iron deficiency anemia, mark the presentation of this illness. Precipitating antibodies to milk protein fractions, resulting from a non-IgE-mediated immune response, cause Heiner Syndrome. Lung biopsies swiftly identify iron insufficiency, peripheral eosinophilia, antibody deposition, and C3 protein deposition. Symptom alleviation is rapid upon removing milk from the diet, with lung infiltrates disappearing within a week (Gupta et al., 2019).

These conditions underscore the intricate interplay between immune responses, environmental factors, and genetic predispositions in the manifestation of diverse allergic reactions related to food allergies. Understanding these conditions aids in precise diagnosis and effective management.

MEDICATION ALLERGY PRECAUTIONS

Taking proactive measures and precautions is essential when dealing with medication allergies, and adherence to specific guidelines can significantly contribute to the well-being of individuals susceptible to adverse drug reactions.

Ignore the offending food for a minimum of three months

In the absence of advanced blood tests for various reactive foods, abstaining from allergens for up to two weeks proves beneficial in identifying the source of discomfort. A detailed log or documentation of meals along with observed symptoms aids in pinpointing reactive foods. Positive responses or a preference for specific foods may indicate an allergy. The reintroduction of suspicious foods into the diet, following a maximum of two weeks of elimination, allows for monitoring adverse reactions. Reintroducing a meal helps assess if allergic responses persist, indicating a potential allergy to that specific food (Mazzocchi et al., 2017).

Enzymes and nutrients for digestive system healing

A leaky gut, characterized by the passage of undigested food particles into the bloodstream, is a significant factor in food allergies. The insufficient release of digestive enzymes, including proteolytic enzymes like papain, bromelain, and protease, often contributes to the persistence of undigested particles. These enzymes play a crucial role in breaking down food into simple, usable components for easy absorption. Moreover, they support immune system health by fostering the growth of beneficial gut flora (Mazzocchi et al., 2017).

Vitamins and minerals

In addition to enzymes, vitamins, and minerals play a crucial role in the recovery of a leaky gut. These nutrients are essential for the optimal functioning of enzymes, and their deficiency can lead to various health issues, ranging from allergies to cancer. Vitamin A regulates the release of prostaglandins during allergic responses and acts as an antioxidant, eliminating free radicals. Vitamin B6 contributes to the management of conditions such as depression, attention deficit hyperactivity disorder, and migraines triggered by food allergies. Zinc enhances digestive capacity by stimulating the production of hydrochloric acid in the stomach. Magnesium alleviates symptoms associated with depression, asthma, and migraines. Vitamin C, known for its antioxidant properties, is particularly produced during food allergies (Mazzocchi et al., 2017). These nutrients collectively support the thymus gland, a crucial immune organ. Substances like methylsulfonylmethane, quercetin, and omega-3 fatty acids, known for their anti-inflammatory properties, contribute to reversing a leaky gut. Additionally, glutamate and probiotics play a role in strengthening the immune system and promoting the repair of a leaky gut (Mazzocchi et al., 2017).

Acupressure

Acupressure serves as an alternative method for addressing stress and emotional issues associated with various illnesses, including cancer, heart disease, hypertension, and allergies. This technique involves applying physical pressure to specific acupuncture points using the hand, elbow, or specialized tools. By exerting pressure on specific points, acupressure provides immediate relief, targeting both the physical symptoms and emotional roots of the ailment. This alternative approach is believed to contribute to restoring the body's balance and overall well-being (Leone et al., 2023).

Adopting a holistic approach that combines nutritional support, acupuncture, and other complementary strategies can aid in managing food allergies.

DETECTION OF FOOD ALLERGENS

The introduction of precise diagnostic methods, such as skin prick tests and blood examinations, empowers specialists to accurately identify food allergy triggers, thereby enhancing the diagnosis and treatment processes.

Skin prick tests

To assess potential food allergies, skin prick tests measure Immunoglobulin IgE levels. This cost-effective test provides rapid results, as an allergist applies a drop of food allergen solution to the patient's back or forearm using a needle or plastic probe. The test, known for its simplicity, causes no pain or bleeding.

Results, visible approximately thirty minutes later, reveal a wheal—a raised white lump surrounded by red, itchy skin—confirming a positive outcome. While larger wheals are often associated with positive results, size does not necessarily correlate with accuracy (Leone et al., 2023).

Blood examinations

Blood tests, also known as radioallergosorbent tests, evaluate the presence of IgE antibodies in response to specific foods. Modern techniques no longer involve radioactivity, and various laboratories may use different test "brands" with unique scoring systems or units to present results (Leone et al., 2023).

Oral food challenge

In cases where blood and skin prick tests yield inconclusive results, an oral food challenge may be recommended. Allergists guide patients to ingest increasing dosages of potentially reactive foods in a controlled setting. The challenge starts with minimal amounts, and patients are monitored for any signs or symptoms throughout. If no symptoms arise, higher doses are administered, with the challenge ending at the first sign of any reaction. Severe reactions are rare, and minor side effects, such as flushing or hives, can be managed with antihistamines (Leone et al., 2023).

Food elimination diet

Temporarily removing suspected foods from the diet aids in the easier diagnosis of food allergies. When coupled with blood or skin tests, this approach is effective in diagnosing conditions like gut-associated allergies and IgE-mediated food allergies. Typically lasting two to four weeks, individuals abstain from questionable foods during this period while physicians closely monitor symptoms. At the end of the test, symptoms associated with any food linked to an allergic response should subside (Leone et al., 2023). The combination of oral challenges and elimination diets provides a holistic approach to diagnosing food allergies, enabling the effective identification and management of these health challenges.

LABELING OF FOOD

In addition to safeguarding allergic individuals, food labeling serves as a pivotal tool in influencing consumer behavior and shaping various aspects of food production. By offering information on health, environmental impact, cultural relevance, and social well-being, food labeling establishes a vital link between conscientious consumers and

specific food products (Mazzocchi et al., 2017).

With a dual purpose of consumer protection and ensuring fair marketing practices, food labeling operates within the dynamics of the market. While not impeding the market presence of food products, labeling empowers consumers to make informed choices, providing a mechanism for the market to respond to preferences and concerns (Gupta et al., 2019). Moreover, the proposition of labeling genetically modified foods exemplifies how food labeling can be a platform for public expression and opinion on emerging technologies, further underlining its role in facilitating transparency and consumer engagement (Leone et al., 2023).

ADDRESSING FOOD ALLERGIES IN RURAL TOURISM

Travelers with food allergies encounter unique challenges in rural tourism, where local cuisine is a central attraction. As the significance of food in tourism grows, it becomes essential for rural destinations to accommodate the needs of visitors with food allergies. Tourism managers can try to elevate local cuisine from a necessary but utilitarian component of a trip to a focal point of a desired experience and a component of the region's image. A growing number of tourist locations are drawing visitors with local cuisine and culinary-themed activities (Hsu & Scott, 2020).

Gastronomy tourism and allergies

A key factor in the socio-cultural rebirth and economic growth of a place is gastronomy tourism (Yong et al., 2022). Food accounts for one-third of a traveler's expenses, making it an essential component of tourism. Although food's significance in travel and the experiences of those with special dietary demands resulting from cultural or religious obligations have been explored in literature, little has been written about food allergies and how those who suffer from them act in a tourist setting. Even though the needs of people with food allergies and those whose culture or religion forbids certain foods may overlap when they travel, the actual experiences of both groups may differ due to the negative effects on one's physical and general health that can arise from erroneously consuming certain foods while experiencing a food allergy (Lewis & Mehmet, 2021). Such allergies have been linked to the social stigma of being "picky," as well as an increased feeling of insecurity and loneliness.

Culinary tourism and food heritagization

The main way that rural communities draw tourists is through their unique cuisine, and local food production locations-like farms, dairy farms, cheese dairies, vineyards, and breweries-are further marketed as tourist destinations to bring in more money (Vuksanović et al., 2024). The packaging and replication of traditional cuisine, or "food heritagization," has been envisioned and advocated as a viable local development strategy due to the rising significance of food in rural tourism. It's frequently asserted that supporting rural communities in general and rural tourism in particular would benefit from local cuisine that is seen as genuine and connected to the region's history and culture (Guan et al., 2019) (Figure 1). Food heritagization, however, is a disputed and controlled social process in which different actors attempt to define particular meals as a legacy for their purposes rather than a process of technological advancement (Sidali et al., 2015).

Figure 1. Sample of Serbian local cuisine



Source: <https://belquest.rs/en/category/around-serbia/rural-tourism/>

Throughout the last several years, individuals have been progressively complaining about their troubles when ingesting particular meals owing to their hurried lifestyle and stress. They are increasingly choosing what and where to eat, who will cook for them, and making sure they are consuming healthful meals to protect themselves. They aim for a healthy lifestyle and nutritious eating, that is, health comes first. As a result, catering businesses frequently use healthy meal preparation techniques and purchase high-quality produce from nearby farms (Svržnjak et al., 2022).

Those looking for a traditional, healthful, and less processed gastronomic experience are usually drawn to rural locations. However, guests may not have many options to fulfill their food allergy because of the small quantity of food services. Food experiences influence destination image and place attachment; hence, a bad meal might harm a location's reputation. Traveling to new areas might make food restrictions more difficult, especially if the destination has different eating customs, culture, or lifestyle from the traveler's home country. Large restaurant chains can help by accommodating food allergies, but their standardized menus seldom offer a truly local experience, and only a small portion of the money spent stays in the rural community.

Food allergy labeling regulations

Both the frequency of food allergies and the labeling of food allergens differ from nation to nation. While national regulations governing labeling may differ, most adhere to the Codex Alimentarius. Though highly developed nations typically impose stricter labeling regulations to protect their citizens and visitors, even developing nations have some degree of guidelines for labeling food allergies. Food Allergy Research and Education is one of the many local and international organizations that works to enhance food allergy labeling regulations worldwide. The majority of nations mandate that the key food groups- milk, eggs, soy, wheat, peanuts, tree nuts, fish, and shellfish included on food labels. Individual differences exist between locations based on the staple foods in each diet (Popov-Raljić et al., 2016). Allergens must be highlighted in the ingredient list so that customers may quickly identify them, according to EU regulations. Germany, France, Italy, Sweden, Poland, Spain, Ireland, Romania, Netherlands, Denmark, Bulgaria, Belgium, Croatia, Portugal, Austria, Greece, Czech Republic, Hungary, Finland,

Luxembourg, Malta, Lithuania, Republic of Cyprus, Slovenia, Slovakia, Estonia, and Latvia are among the 27 members of the European Union as of March 2022. The EU gives producers leeway in choosing how to highlight the allergies. An EU notice regarding Annex II of Regulation (EU) No 1169/2011 states that the allergen is the only word that needs to be highlighted when a substance has multiple words (Commission Notice, n.d.). For instance, if there is an egg in the mayonnaise on a sandwich, the word "egg" has to be highlighted.

There is a need for legislative action to guarantee that persons with food allergies may purchase and eat foods more safely, as the prevalence of food allergies is rising globally. Until then, it is mostly the responsibility of the individual to prevent unintentional ingestions and anaphylaxis; they must become knowledgeable about labeling regulations and take other preventative precautions (Chang et al., 2023). In Serbia, 14 food ingredients can result in allergic reactions or intolerances, according to the Regulation on declaration, labeling, and advertising of food (Pravilnik o deklarisanju, označavanju i reklamiranju hrane, n.d.). For 11 of the aforementioned ingredients, there are also suggested reference doses.

By implementing fundamental food safety management principles in the hospitality industry, which are based on knowledge of nutritive allergies and food production processes, a system that can support the production of food that contains and does not contain a particular allergen in circumstances where the risk to the consumer is minimized can be developed. In the hospitality industry, the current approach to managing food safety is frequently predicated on the need to identify potential risks early on and mitigate them to a manageable level before they materialize. One of the safety concerns that are frequently taken into account in the food business is allergies and intolerances to food components that are present in ingestion goods (Popov-Raljić et al., 2016).

Severe allergy sufferers run the danger of health problems and safety hazards when traveling, and foreign travel exposes passengers to a variety of potential allergens. Any dietary or environmental allergy can compromise the enjoyment or success of a trip, but severe responses have the potential to be fatal (CDC, n.d.). The knowledge, actions, and attitudes of staff members and management on the significance of allergenic food ingredients and risk management have a big impact on how allergic reactions turn out in hospitality settings.

In particular, workers at hospitality establishments play a vital role in mitigating the adverse effects of food components that cause allergies, and their work necessitates a specific understanding of risk management and the use of allergen safety standards based on HACCP principles (Popov-Raljić et al., 2016).

Challenges and strategies in rural tourism

In rural tourism, where local and traditional dishes often take center stage, it becomes crucial to pay special attention to guests' needs regarding food allergies. Food allergies are a serious matter that can have significant health consequences for individuals, making it essential to provide proper information and procedures to ensure a safe and enjoyable visit.

Knowledge about food allergies plays a pivotal role in delivering a quality experience to tourists. Rural hosts and staff in tourism establishments need to be educated about common allergens and understand how to handle special guest requests adequately. The diversity of allergies may include gluten, nuts, milk, eggs, and other ingredients, making it important to be informed about the composition of the food

offered. Furthermore, promoting awareness about allergies among the local population is also crucial. Education on safe food handling, clear labeling of ingredients in traditional dishes, and open dialogue with guests can contribute to creating a secure environment for all visitors (Fuentes-Moraleda et al., 2021; Lewis & Mehmet, 2021). In line with this, rural tourism can develop strategies that involve:

- Providing detailed information about ingredients in the menu items can help guests make informed decisions about the food they consume;
- Staff in rural establishments should undergo training on food allergies, recognizing symptoms, and proper procedures in emergencies;
- Active communication with guests before arrival and during their stay can enable timely responses to special requests and provide guests with a sense of security;
- Considering the possibility of offering alternative menus for guests with allergies, allowing them to enjoy local cuisine without risking their health;
- Clearly labeling allergens in traditional dishes will help guests quickly identify potential hazards.

Implementing food safety management principles in the hospitality industry is crucial to minimizing risks associated with food allergies. Staff education on allergens, risk management, and adherence to safety standards are essential to create a safe environment for guests. Importantly, providing safe and customized options for guests with allergies not only contributes to their satisfaction but also enhances the reputation of rural tourism as a destination that cares about the individual needs of every guest.

CONCLUSIONS

Globally, people are adopting healthier diets, and they have high standards for food. Modern customers anticipate food to enhance their quality of life and prevent or mitigate diet-related illnesses, rather than just satiating their hunger and providing the required nutrients. Ensuring the safety and satisfaction of travelers with food allergies is not only a responsibility but also an opportunity for rural tourism to enhance its reputation as a destination that cares about the individual needs of every guest. Awareness of the effects of food on health, customized nutrition, preserving food authenticity, eating food grown organically, and structuring the tourism value chain generally in line with sustainable development principles has all increased noticeably. By embracing these strategies, rural tourism can create a welcoming environment for all visitors.

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COMMUNICATION AND EMPATHY IN MEDICINE AND NURSING

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ABSTRACT

Introduction: Throughout history, nursing has been recognized as a compassionate profession primarily focused on aiding and caring for the sick. In the healthcare system, nurses bear significant responsibilities that rely heavily on effective communication. Their daily interactions with patients, their families, and fellow healthcare professionals necessitate strong communication skills. Alongside their adept manual abilities, nurses must also demonstrate empathy and understanding in their communication. Without these essential skills, the fulfillment of nursing duties becomes markedly challenging. Contemporary lifestyles, alongside the emergence of new global diseases and the adoption of advanced medical technologies, also necessitate specific nursing skills. **The aim of the paper:** This paper indicates the importance of communication and empathy in nursing, without which it is almost impossible to carry out daily activities in the relationship with the patient, his family and other healthcare workers. **Methods:** Review of available literature. **Discussion:** Nursing is a profession reliant on strong communication skills and empathy to establish trust with patients and effectively meet healthcare needs. Without these fundamental abilities, the integrity of the nursing profession is compromised. **Conclusion:** The education of nurses in communication skills is of paramount importance. Nurses equipped with strong communication and empathy skills navigate their daily duties with greater ease, leading to enhanced productivity and job commitment. These factors contribute to expedited patient recovery, improved health outcomes, and foster mutual respect and appreciation.

Keywords: communication; nursing; medicine, patient, empathy.

INTRODUCTION

Communication, the ability to effectively convey ideas and emotions from one person to another, is an inseparable element of human interaction, playing a crucial role in daily functioning. Scholars approach this concept from various angles, recognizing it as a functionally necessary and fundamental social process (Marojević et al., 2019). Its significance extends beyond social interactions, as it holds paramount importance in the healthcare system (Marojević et al., 2019). Over time, the importance of communication has evolved, emphasizing the need for both verbal and non-verbal communication to cultivate trust and build relationships. Research underscores its profound impact on treatment outcomes and patient satisfaction. Particularly in challenging circumstances, such as with children, the elderly, and patients in intensive care units, effective communication becomes even more crucial (Kelemić et al., 2016).

Ensuring quality healthcare also relies on clear and accurate interpersonal communication, which helps prevent misunderstandings, whether verbal or non-verbal (Kočić, Knežević, 2023). Non-verbal communication, characterized by sincerity and often operating unconsciously, includes expressions like smiles, energy, and emotional cues, which effectively convey para-verbal messages and signals (Petrov et al., 2018). Even when communication lacks explicit verbal expression, it can still persist as a continuous and uninterrupted process, subject to subjective interpretation based on individuals' moods. Ultimately, communication embodies interaction. While historical communication research predominantly focused on verbal expression, its significance lies in its role as a fundamental skill for healthcare professionals, underlining its critical importance in delivering quality healthcare (Dartiguelongue et al., 2021).

METHODS

The research was conducted as a descriptive study, utilizing a review of existing literature and documentation analysis. This review was performed electronically using various databases, with keywords including nursing, medicine, communication, patient, and empathy.

COMMUNICATION

Communication involves distinct elements: the sender, the receiver, and the message. In healthcare, these elements correspond to the healthcare professional, the patient, and clear, fact-based professional information provided by the healthcare professional. The manner in which the message is conveyed significantly impacts the success of communication, although external environmental factors can also influence it. Communication often occurs in stressful situations and under time constraints. Therefore, understanding the components of the communication process becomes crucial for effective interaction (Marojević et al., 2019).

It is worth noting the concept of medicine in ancient civilizations, which emphasized a holistic approach to understanding a person's health and illness as a whole (Kelemić et al., 2016). Healthcare workers operate as a team with interdependent tasks and a shared goal, highlighting the necessity for them to possess good communication skills. Implementing various strategies can enhance communication and reduce inefficiencies (Dartiguelongue et al., 2021).

COMMUNICATION IN HEALTH CARE

The World Health Organization recognizes communication as one of the five essential skills for leading a healthy life. In various work environments, both formal and informal communication play critical roles. The communication process encompasses a broad spectrum of forms, expressions, types, and variations. Formal communication adheres to established rules, standards, and regulations, whereas informal communication is spontaneous and unpredictable (Marković et al., 2015).

Within healthcare institutions, communication often occurs in a hierarchical manner, characterized by specific patterns. Emphasizing teamwork is crucial, as it leverages diverse behaviors and perspectives, proving to be the most effective approach to work (Radić et al., 2021).

In Western countries, communication skills in medicine are typically acquired during academic studies and further refined through various forms of post-graduate education. Consequently, extensive research has led to the establishment of major organizations dedicated specifically to communication in medicine (Đorđević et al., 2011).

COMMUNICATION IN NURSING

Virginia Henderson, along with communication, included basic human needs in the context of expressing the patient's feelings and needs. The reciprocal relationship between nurses/technicians and patients forms the foundation of the nursing profession, encompassing the development of manual skills, which also entails honing communication skills (Krešić, 2013). In their daily responsibilities, nurses engage with patients from initial assessment to the completion of treatment. Given the considerable time spent with patients, their task is to establish warm, confidential, and respectful relationships. Patient satisfaction is closely linked to effective communication (Starc, 2016). Despite advancements, the nursing profession grapples with evolving perceptions and stereotypes, emphasizing the need to address the evolving needs of those served (Gusar et al., 2019).

Communication is a skill that enhances our work and reduces stress and dissatisfaction. Patients vary in education, religion, culture, and social status, influencing mutual communication. Nurses/technicians are pivotal in healthcare delivery (Marojević et al., 2019). In today's digital age, patients are often well-informed through the internet, necessitating equitable and two-way communication (Radić et al., 2021). Nurses/technicians must tailor information to patients' understanding and involve their families. Establishing contact, accepting emotional reactions, and adapting communication methods are crucial tasks (Marojević et al., 2019). Each patient should be individually attended to by nurses/technicians. Communication also adheres to ethical principles, respecting patients' individuality, age, and disabilities. Active listening is paramount. Through various skills, nurses can elucidate problems and resolutions, potentially averting conflicts (Starc, 2016). Healthcare activities revolve around fourteen basic human needs:

- Breathing
- food and liquid intake
- elimination of harmful products
- movement and appropriate body positions
- rest and sleep
- Clothing

- maintenance of normal body temperature
- maintenance of personal hygiene
- avoiding harmful environmental influences
- communication with other people
- religious needs, work, reaction, learning
- research and satisfying curiosity (Krešić, 2013).

Many patients lack knowledge about health behavior and healthcare, which can lead to anxiety, reduced self-care, and reluctance to cooperate. Providing accessible information is crucial to enhance communication with patients and their families (Kičić, 2014). Patients base decisions regarding proposed measures, diagnostic and therapeutic procedures on information received from the healthcare team, with nurses/technicians often being the first point of contact for sharing fears and seeking answers (Karabatić et al., 2018). However, some patients require special consideration due to barriers arising from the nature of their illness.

Elderly patients, for instance, experience physical, cognitive, and psychological changes typical of aging, often suffering from multiple diseases requiring diverse therapies (Kelemić, 2016). In intensive care units, every word spoken to a patient influences their feelings, especially feelings of loneliness and abandonment. Addressing patients by their names helps combat anonymity and fosters a sense of recognition (Brkljačić, 2013). Nurses/technicians, as executors of doctors' orders and integral members of the care team, play a pivotal role in patient treatment, often being the first to notice any health changes (Radić et al., 2021).

The initial conversation with a patient is crucial, with a quality approach involving patience, friendliness, and clear communication of professional terms. This fosters understanding, trust, and a sense of security for the patient (Marković et al., 2015). The nursing process, a problem-solving method in nursing, employs a scientific approach to achieve specific outcomes, promoting patient independence and quality of life (Kičić, 2014). During conversations, health workers should listen actively without giving orders or moral admonitions, facilitating diagnosis and treatment (Marković et al., 2015). Healthcare institutions with frequent changes in healthcare teams and shift work greatly hinder patients' orientation. Patients benefit from familiar faces and explanations of procedures to alleviate fears and misunderstandings (Brkljačić, 2013). Over time, nurses/technicians develop familiarity with patients, aiming to improve health outcomes and patient satisfaction (Marojević et al., 2019).

EMPATHY IN COMMUNICATION

Communication in healthcare is essential for effective healthcare delivery. In addition to communication skills, experience, and other factors such as working conditions, understanding patients' perspectives and the ability to empathize are crucial. Empathy involves the capacity to comprehend the emotions and feelings of patients, which is considered indispensable in nursing as it fosters mutual understanding and positive therapeutic outcomes (Bitunjac et al.,). Certain standards have been established for nurses'/technicians' communication, encompassing verbal and non-verbal communication, written communication, and the use of new technologies, while also respecting and safeguarding patients' personal data (Starc, 2016). Furthermore, regardless of experience and education, workplace conditions should nurture quality interpersonal relationships and foster positive attitudes towards healthcare and patient care among all healthcare professionals. Thus, education through

various avenues such as congresses, symposiums, magazines, and books is crucial for promoting successful communication and treatment (Brkljačić, 2013). In addition to communication, empathy enhances patient satisfaction and yields positive treatment and healthcare outcomes (Bitunjac et al., 2022).

DISCUSSION AND RESULTS

Numerous studies indicate that people spend 75% of their time communicating throughout their lives (Marojević et al., 2019). In the 1970s, communication between doctors and patients, as well as among other healthcare team members, was recognized as crucial for the quality of healthcare and treatment outcomes. Since then, numerous research efforts have focused on improving communication skills (Kelmić, 2016). However, literature suggests a frequent disparity between verbal and non-verbal communication in doctor-patient relationships, with many individuals unaware of the importance of non-verbal cues (Petrov et al., 2018).

Surveys conducted among nurses/technicians regarding communication reveal that the majority of respondents interact with nurses several times a year. Most consider communication highly important, citing respect, kindness, trust, and empathy as essential for successful communication (Starc, 2016). Additionally, patients in another study report familiarity with the roles and activities of nurses/technicians, with most expressing positive experiences with nurses. This research focused on public perception of the nursing profession (Gusar et al., 2019).

Research findings on successful communication highlight the significance of active listening and trust between patients and nurses/technicians for improved healthcare delivery. However, criticisms and dissatisfaction often stem from inadequate communication practices, such as nurses/technicians not listening to patients, interrupting them, or limiting time with individual patients. It's crucial for healthcare workers to recognize that any breakdown in communication affects treatment outcomes (Starc, 2016).

Only a small portion of our communication with others is conveyed through words. Verbal communication typically accounts for 7-35% of everyday communication, underscoring the importance of non-verbal cues (Marković et al., 2015). Research underscores the importance of continuous education in communication skills to foster stable, respectful, and professional relationships among all healthcare workers, thereby ensuring patient security amidst changing social dynamics and interpersonal relations in medicine (Krešić, 2013).

Furthermore, research emphasizes the importance of uninterrupted communication between nurses/technicians and patients during conversations. This facilitates patients' understanding of their illnesses and their ability to cope, embodying the essence of effective communication in healthcare (Starc, 2016). Studies examining empathy among nurses/technicians reveal a generally high level of empathy. Interestingly, women tend to exhibit higher empathy levels compared to men, who often maintain a more neutral stance, while younger individuals typically display lower empathy compared to older counterparts (Bitunjac et al., 2022).

CONCLUSION

Effective communication and empathy are fundamental in both medical and nursing practices, shaping the treatment and care provided to patients and ultimately influencing their quality of life. Nurses and technicians, given the nature of their work, often spend significant time with patients, initiating the process of successful

communication. Education plays a crucial role in establishing communication and empathy among all healthcare professionals, patients, and their families. Without strong communication and empathy, adequate treatment and healthcare are compromised.

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NURSES' INTERVENTIONS FOR THE PREVENTION OF FALLS AMONG THE ELDERLY IN SERBIA

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ABSTRACT

Introduction: Falls represent the primary factor of morbidity and mortality among the elderly demographic, prompting a substantial public health concern. In Serbia, a deficiency exists in the provision of comprehensive practice guidelines and preventative promotional initiatives targeting falls prevention among the elderly, notably those involving highly trained nursing professionals **Objective:** To show the effect and importance of the introduction of interventions by nurses with higher education in the prevention of falls among the elderly in Serbia. **Material and methods:** Systematic search across pertinent databases employing relevant keywords to procure data pertinent to the research subject matter. (PubMed, Ref List, PsycINFO, Kobson, Scindeks). **Result and discussion:** Serbia is facing a serious increase in the elderly population on one hand and the migration of nurses to EU countries on the other. The introduction of an electronic form in primary health care was supposed to make it easier for doctors to see patients, but despite this, doctors are not fully focused on addressing the serious problems they face when it comes to the elderly population. Guides of good practice, as well as preventive promotional programs for the prevention of falls among the elderly in primary health care do not exist in Serbia. Research has shown that the elderly in Serbia have experienced more than three falls in the past 12 months and that women are at increased risk of falling. The involvement of nurses in fall prevention in the elderly varies from country to country and depends on staff education and management decisions, but in general their involvement is based on complete documentation of screening assessment of patients at risk of falls and specific practice fall prevention programs for patients. The health care process for fall prevention in the elderly includes all steps to ensure the assessment of patients at risk of falls and the evaluation of the benefits of adequate individual plans for the prevention of falls in the elderly. **Conclusion:** Creating good practice guides and preventive promotion programs for the prevention of falls among the elderly in primary health care with the intervention of nurses with higher education is a priority in Serbia.

Key words: elderly, fall, nurses, interventions, prevention.

INTRODUCTION

It has been known since ancient times that it is better to prevent than to cure. When it comes to the elderly population, fall prevention is of particular importance, because they are at increased risk of falling and the consequences of falling can range from scratches to serious fractures and death. Hospitalization, fracture treatment, and subsequent rehabilitation can be physically and emotionally demanding, primarily for the elderly patient and secondarily for their family members, placing strain on both parties and the healthcare system. The process of recovery and healthcare serves as a sensitive indicator, significantly influencing the outcome of care, which, in turn, is determined by both the quality and quantity of care provided (Ojo, E., O., Thiamwong, 2022).

The planning, organization, implementation, and evaluation of preventive promotion programs aimed at reducing falls in the elderly are within the domain of primary healthcare responsibility. Nurses with an academic education are experts who can face the increase in the elderly population and, within the framework of research in the elderly population, can significantly contribute to fall prevention programs from the perspective of primary health care and clinical practice. However, regardless of the serious increase of the elderly in the general population, there are a limited number of nurses everywhere who are involved in research in the elderly population, and in Serbia they almost do not exist. In the literature, it is advised that research focusing on the elderly should prioritize their present needs (Thiamwong, 2022). Additionally, it is crucial to plan, implement, and evaluate diverse interventions (Ojo, E., O., Thiamwong, 2022) to facilitate the application of suitable measures aimed at mitigating health inequalities and promoting independence (Thiamwong, 2022).

In Serbia, until now, all research related to falls in the elderly population was focused on determining risk factors for falls (Ivanović, et al., 2018), risk groups (Ivanović, et al., 2021) and consequences of falls (Ivanović, S., Trgovčević, 2018), while in other countries the focus was on fall prevention education, on fall prevention guidelines with strategies, but not on the involvement of nurses (Ojo, E., O., Thiamwong, 2022). Of all studies reviewed, only 33% (n = 2) involved nurses in the delivery of interventions (Ojo, E., O., Thiamwong, 2022).

An interdisciplinary team of health workers is needed for promotional and preventive fall prevention programs. As nurses are the largest group of health workers, they have an important role in implementing fall prevention programs (Ojo, E., O., Thiamwong, 2022). Hence, this paper aims to elucidate the impact and significance of implementing interventions by highly educated nurses in preventing falls among the elderly population in Serbia.

METHODS

This study adopts an observational descriptive approach, analyzing professional literature that primarily underscores the effectiveness and significance of interventions by highly educated nurses in preventing falls among the elderly.

The utilization of the descriptive method is aligned with our objective, aiming to effectively demonstrate the impact and importance of these interventions in addressing fall prevention among the elderly population in Serbia.

Professional papers were mostly found electronically, by searching through various databases (PubMed, Kobson, Scindeks, Hrčak srce...), in English, Serbian and Croatian. Also, publications published on the websites of sister associations (ICN, EFN,

NANDA...). All relevant facts, as well as their alignment with the standards and criteria established by the WHO for developing guidelines on best practices in fall prevention, were compared with those of highly educated nursing personnel using a comparative method. The inductive-deductive method was used for the purpose of explaining facts as well as for proving stated theses and predicting future events. The population sample of this research consisted of elderly people and nurses with higher education in Serbia. Research on this topic in the form of data collection started much earlier, due to problems that are current and critical in the elderly population for a long period of time, and for the purposes of this work, a selection of the most relevant academic research was made.

RESULTS AND DISCUSSION

ETIOLOGY

The reason why there are more frequent fall situations in the elderly can be found in the explanation that, with age, there is a decline in the functions that affect normal walking, resulting from the coordination of the following neural components:

- a) the brainstem system of the basal ganglia,
- b) regulated muscle tone and
- c) functional processing of sensory information (sight, hearing and proprioception) (Appeadu, M., K, Bordoni, (2023).

With age, the risk of associated comorbidities increases, which are more common in older people and are treated with the use of more than three drugs, prescribed by experts specializing in these conditions. Additionally, the walking pattern, speed, and distance covered undergo changes. In addition to internal factors, an elderly person is also threatened by external fall risk factors that are in their environment, and their interaction is most often the result of an event such as a fall. Therefore, falls are described by the World Health Organization (WHO) as incidents causing an individual to inadvertently come to rest on the ground, floor, or another lower level (Salari et al., 2022). A fall for an elderly person, in addition to causing injuries, can also end in death. Fall injuries can require hospitalization, surgical intervention, rehabilitation, and seriously affect quality of life and increase health care costs. As the number of the elderly population increases, the health effects and costs of falls increase worldwide, as well as in the Republic of Serbia.

Based on the strength of the evidence, the following risk factors for falls are mentioned in the literature:

- a) positive history of falls,
- b) balance and gait disorder,
- c) decrease in muscle strength,
- d) vision problems,
- e) polypharmacy (use of four or more drugs),
- f) depression,
- g) orthostasis or dizziness,
- h) functional dependence,
- i) age over 80 years,
- j) female sex,
- k) incontinence,
- l) cognitive difficulties,
- m) arthritis,
- n) diabetes and

o) pain (Appeadu, M., K, Bordoni, (2023).

In the elderly population, due to the possibility of falling and injuries due to falling, another risk factor for falling often develops, which is the fear of falling, as a phobic reaction to standing or moving "ptophobia". For the elderly, the consequence of this condition is reflected in the loss of independence, freedom from activity limitations, higher risk of recurring falls, reduced social activity and lower quality of life (MacKay, et al., 2021). Due to its frequency and great consequences, it is also necessary to identify risk factors for the emergence of fear of falling. All in all, falls are a serious problem not only for the elderly but also for the entire society and represent a real challenge for modern society due to the increased risk of falls with aging and the possibility of falls with injuries.

The abundance of risk factors for falls among the elderly, coupled with the absence of fall prevention programs or barriers to their establishment and execution, underscores the urgent need for a comprehensive solution to address this critical issue. It is imperative that nurses responsible for patient care receive training and actively participate in assessing the fall risk of older individuals, determining the severity of the risk, and developing and implementing tailored care plans to address their needs. Finally, an evaluation will assess the impact of these interventions and identify any necessary adjustments to the organization and implementation of the care plan.

ELDERLY IN RESIDENTIAL CARE, HOSPITALS AND COMMUNITY

As individuals age, they experience not only changes in their functional status and health condition but also in their financial situation, which can be concerning for many elderly people. Their realized pension often falls short of covering the expenses advised and necessary for their everyday life and active aging. The government provides certain concessions to the elderly, including healthcare, as well as social protection aimed at prioritizing social services to support and enhance the quality of life for older individuals. Social protection should offer social benefits to ensure a dignified life, including financial assistance for families with disabled members, enabling the elderly to remain in their communities for as long as possible. When necessary, specialized institutions dedicated to elderly care should be available as an option (Babović et al., 2018). Based on all this, we can say that elderly people want to stay as long as possible in their home, in their environment in the general population or, when they are not able to take care of themselves, they become functionally dependent, then the solution is to place them in one of the institutions for housing the elderly. This division is necessary because fall prevention programs also differ.

Homes for the elderly can be described as institutions with different levels of health and psychosocial support aimed at improving the quality of life of the elderly. Also, different institutions can be declared as homes for the elderly, apart from the state there are also private (profit and non-profit), social or health agencies (Villar, et al., 2022). Most of the users of homes for the elderly are in contact with family members, but regardless of everything, there is a lack of research on user satisfaction with these services, as well as evidence of whether users receive all services. Also, from conversations with the elderly, during the project (Babović et al., 2018), differences were determined regarding familiarity with existing social services.

Accommodation in institutions for the elderly can be understood as social exclusion, as a separation of individuals and groups from the mainstream of society, and it is considered that life in these institutions obviously includes challenges related to the lack of opportunities to participate in key activities inside and outside the institution. In

this sense, nursing homes can be institutions where people are isolated from the wider environment communities and lead a closed and regulated life that is formally monitored and controlled by professionals (Villar, et al., 2022).

This means that older people are excluded from community participation, which is considered an essential component of healthy aging. In addition to meeting with family or friends, which the elderly in the homes achieve, this participation also includes participation in recreational activities, volunteering, and cultural or social activities. These activities mean that the older person is provided with interaction with others in the society or community, because they have a lower risk of functional disability and thereby increase the quality of life (Gough, et al., 2021).

THE ROLE OF NURSES IN FALL PREVENTION IN THE ELDERLY

In hospital settings, nurses maintain continuous contact and provide round-the-clock patient care, including monitoring for any changes. Due to this constant presence and responsibility, they are rightfully regarded as primarily responsible for minimizing patient falls. In addition, one of the indicators for assessing the quality of work of nurses, the American Nurses Association (The American Nurses Association) and the National Quality Forum (the National Quality Forum) also use falls, which puts the responsibility for patients directly on the nursing staff. Therefore, due to the responsibility they have, every patient's fall is a stressful situation for nurses, which manifests itself in increased nervousness, anxiety, guilt, concern and doubt about the quality of care they provide, not to mention sanctions and punishments (King, et al ., 2018). Hence the need for the well-being of patients and their safety, it is suggested that nurses be educated and involved in fall risk assessment, because they are in a position to do this during the hospitalization of patients (Montejano-Lozoya, et, al., 2020). The greatest responsibility lies with nurses in primary health care because they deal with prevention. In this case, the responsibility would be within the patrol service and home care within the visits they make on an annual basis. The researcher's recommendation refers to the inclusion of nurse researchers, with academic training, who can significantly contribute to research on the elderly population and benefit clinical practice. Also, it is emphasized that despite constant indications that the elderly population is increasing and that it will be a global problem, there are limits to the number of nurse researchers trained for the elderly (Thiamwong, 2022). The essence of working with the elderly is based on preserving their independence, active aging and improving the quality of life. Hence the need for future research in the elderly to be based on their needs, the identification of potential risk factors for the elderly (Ivanović, et al., 2018).

Aging is no longer unattainable, but it is accompanied by the complexity of health problems, which are possible in this population, and therefore it is the responsibility of academic nurses to find the best possible ways to meet the needs of the elderly, prevent chronic diseases, take advantage of technological opportunities, promote independence and ensure active aging. for all the elderly. Setting such a challenge for academic nurses and researchers, as well as its realization through the assessment and monitoring of the functional status and health of the elderly, stems from the global burden of the increase in the elderly population, the costs of treatment and disability of this population, and that it is inevitable to reduce the costs of health care (Thiamwong , 2022). Also, for the prevention of falls in the elderly, it is necessary to form a multidisciplinary team, which includes doctors, nurses, physiotherapists and pharmacists.

Pharmacists are considered to be of particular importance when it comes to polypharmacy, on the basis of which they can identify people who are at risk of falling due to taking medications that increase the risk of falling (Gemmeke, et al., 2022).

For nurses in acquiring new knowledge in the process of health care for the elderly, researchers and nurses with academic education lead their multidisciplinary teams, in order to find new ideas and appropriate research approaches, which later direct them to successful projects for funding by the state and the ministry. Therefore, it is necessary to organize programs aimed at training or mentoring nurse researchers who are dedicated to the care of the elderly and whose goal would be to advocate and spread all that is new, good for the care of the elderly in order to maximize the independence of the elderly (Thiamwong, 2022).

NURSING INTERVENTIONS

Research has shown that elderly people living in the general population have more activities and social interactions outside the home than elderly people who are placed in institutional settings. Also, for the elderly, activities outside the home and social interaction are very important for their normal daily functioning, for maintaining motivation, cognitive functions and healthy aging. The problem with the elderly in the general population is generally that their usual activities are related to the activities they perform between meals and are mostly sedentary (more than 10 hours), while those desirable activities, which are mostly related to a greater number of trips outside the home, walks around the neighborhood, parks, activities that contribute to increasing the level of physical activity of the elderly are mostly ignored. People with a greater number of health problems are particularly at risk here, and that they participate much less in the community, which would be a priority in the nursing prevention of falls (Gough, et al., 2021).

It is paramount for older adults to sustain physical activity for as long as feasible; nevertheless, it's crucial to recognize that physical activity can act as both a risk and protective factor concerning falls and fractures, which remain the primary contributors to mortality and disability among the elderly. While physical activity yields beneficial effects by enhancing muscle activity and bone density in older individuals, it concurrently heightens exposure to circumstances predisposing them to falls and fractures. This presents a paradoxical situation wherein reduced physical activity, stemming from illness or disability linked to conditions associated with falls, chronic ailments, and diminished quality of life, can exacerbate the risk of such incidents (van Gameren et al., 2022).

Because of all the above, the first step of nurses in the prevention of falls in the elderly would be a nursing assessment, with the help of which the nurse obtains the following information about:

- physical
- psychosocial
- emotional and
- diagnostic condition of patients

Assessments recommended for nurses by researchers are as follows:

1. Assessment of the general health condition of patients.

This pertains to the documentation of acute or chronic patient conditions by the nurse. Usually, detailed records are kept for each patient, covering factors pertinent to the risk of falls in the elderly. These records often contain information about specific conditions

that could contribute to falls, such as the use of a hearing aid, wearing glasses, or being prescribed multiple medications (typically ranging from 3 to 4) (Wagner, Lukey, 2024).

2. Assessment of muscle strength, coordination and use of aids.

Trained nurses can assess balance and gait using tests. Additionally, they can review records of recent surgical interventions, injuries, and incidents of falls (Ivanović et al., 2018).

3. Use of scales to assess the elderly at risk of falling.

In hospital conditions, for the identification of persons at risk of falling, the Morse fall scale is recommended, for the reason that it enables a quick assessment of the probability of patients at risk of falling, where "0" is no risk of falling, and a score above 45 indicates a high risk of falling (Wagner, Lukey, 2024). In the general population, the proposal is based on the recommendation of Lawson, which relies on two instruments that are based on the anamnestic data provided by the respondents and on the basis of which they are grouped into those without risk (or at low risk) of falling in the general population and those with (moderate or high) risk of falling:

- The Elderly Fall Screening Test (EFST), developed by Cwikel and colleagues, is used to detect the level of fall risk. It consists of five items related to previous falls, consequences of falls, near-fall experiences, and current gait function.
- Multifactor Falls Questionnaire-MFQ. The MFQ consists of general questions related to falls as well as the consequences of those falls. There are 10 specific groups of factors that represent the risk of falling. (Ivanović, et al., 2018). Assessing a patient's fall risk using a fall risk assessment screening should include three parts: a fall risk status, a risk factor checklist, and an action plan.
- Part 1: Fall risk status includes data on the patient's history of recent falls, medications, psychological and cognitive status.
- Part 2: Checklist of risk factors includes vision, mobility, transfers, behaviors, activities of daily living (ADL), environment, nutrition, continence, and more.
- Part 3: The Action Plan incorporates clinical judgment and expertise when selecting key interventions to protect patients from falls, including individualized care plans based on actual fall and injury risk factors (Wayne, 2024).

4. Assessment of mental status.

Mental status assessment by nurses can be conducted to identify patients who show signs of being confused, sedated, or hallucinating and may overestimate their physical abilities or forget their physical limitations (Wagner, Lukey, 2024).

5. Evaluation of the use of auxiliary means.

The nurse assesses whether an elderly person requires mobility aids such as a walker, cane, or a mobile bedside commode, as well as whether the elderly individual is capable of using these assistive devices or comprehends how to use them properly (Wagner, Lukey, 2024).

Health care is a separate scientific discipline that belongs to nurses and in which they are independent in making nursing diagnoses. One of those diagnoses according to the NANDA classification of nursing diagnoses is Risk of falling, defined as an increased susceptibility to falling, which can lead to physical damage and endanger health. Making this diagnosis requires nurses to identify specific risk factors, at-risk populations, and associated conditions (Moreira, et. al., 2022). In this sense, interventions for the prevention of falls in the elderly should be aimed at reducing or eliminating fall risk factors, especially those that interact with associated factors.

In fact, effective interventions would not only reduce falls, but also result in a reduction in fractures and other fall-related injuries (Guirguis-Blake, et al. 2018).

CONCLUSION

By incorporating this group of professionals, along with their leaders, into a culture of responsibility and enhancing their training in preventive programs, we can achieve highly favorable outcomes.

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STRATEGIC PROSTATE CANCER PREVENTION PROGRAMS

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ABSTRACT

Introduction: Prostate cancer represents a significant public health issue worldwide. As the most cost-effective and long-term strategy among all programs aimed at reducing the incidence and prevalence of malignant diseases, prevention is a key component. **Objective:** To identify opportunities for early screening of prostate cancer with the aim of reducing the incidence rate and prevalence of prostate cancer. **Methodology:** The systematic review method was applied, presenting research findings from other researchers that align with the research objective. The investigation of key aspects of strategic prostate cancer prevention programs will be based on the use of the analytical-synthetic method. **Results and Discussion:** From the available literature, primary prevention programs for prostate cancer have not been proven to be effective. Therefore, it is crucial to redirect all potentials towards secondary prevention of prostate cancer, specifically focusing on screening methods. These methods include a combination of prostate-specific antigen (PSA) from serum, digital rectal examination, and transrectal ultrasound. None of these methods is entirely foolproof, but for early prostate cancer screening, the determination of serum PSA undoubtedly holds the greatest importance. Prostate cancer prevention has significant public health potential, and if well-organized and targeted, it represents an effective approach in controlling malignant diseases. **Conclusion:** Early detection allows for early diagnosis and the initiation of prompt treatment. Prostate cancer prevention, through screening, should encompass asymptomatic men aged forty-five and above. It is essential for them to be adequately informed about the importance of screening, with primary healthcare workers playing a crucial role. To raise awareness about the significance of prostate cancer screening, participation in promotional activities should be carried out collaboratively with the local community.

Keywords: prostate cancer, prevention, screening.

INTRODUCTION

Prostate cancer represents a health problem worldwide, especially in developed countries where the population is aging and the incidence of this disease continues to rise. Prostate cancer is the second most commonly diagnosed malignancy among men globally, and the fifth leading cause of death (Bray et al, 2018). Data from the Institute of Public Health of Serbia "Dr. Milan Jovanović Batut" from 2019 show that prostate cancer is the third most common cancer among men in the Republic of Serbia, and it ranks third in terms of the number of deaths among the male population.

Prevention is a key component and the most cost-effective and long-term strategy of all programs aimed at reducing the incidence (occurrence and prevalence) of malignant diseases (Subotić, Anđelski & Subotić, 2015). Prevention means eliminating or minimizing exposure to cancer-causing agents, and includes reducing individual susceptibility to the effects of such agents. This approach offers the greatest potential for public health and the most cost-effective long-term cancer control (WHO, 2020).

Early detection involves early diagnosis in symptomatic populations and screening in asymptomatic but at-risk populations. Increasing awareness of the signs and symptoms of cancer contributes to detecting the disease in less advanced stages. Where cancer tests are available at specific locations, and facilities are appropriate, screening seemingly healthy individuals can detect cancer at early stages when treatment may be most effective. Early detection is successful only when linked to effective treatment (WHO, 2020). Prostate cancer screening is conducted through a combination of transrectal ultrasound (TRUS), digital rectal examination, and prostate-specific antigen (PSA) testing.

Prostate cancer represents a highly heterogeneous disease, ranging from clinically insignificant to highly aggressive tumors resistant to orchiectomy (Kucera, 2020). Clinicians have different opinions on methods of prostate cancer early detection, but all imply regular and systematic monitoring of healthy men. Therefore, the aim of the study is to identify possibilities for prevention, as well as early screening of prostate cancer to reduce its incidence and prevalence.

Prevention of prostate cancer is a crucial component in reducing its incidence and improving the quality of life for affected individuals. Primary prevention strategies aim to reduce the occurrence of the disease by addressing risk factors such as diet, physical activity, alcohol consumption, sexual activity, hormonal balance, and lifestyle habits. However, factors like age, race, and genetics also play significant roles, with older age being the most significant risk factor. Epidemiological studies show a progressive increase in prostate cancer incidence with age, with about 85% of cases diagnosed after the age of 65. Ethnic differences also contribute, with higher incidence rates observed among African-American men compared to Caucasians, leading to increased mortality rates primarily due to more aggressive disease. Positive family history is associated with a doubled risk of developing prostate cancer, with the number of affected family members correlating with increased risk. While modifiable risk factors can influence the risk of developing and dying from prostate cancer, evidence supporting clear prevention strategies beyond early diagnosis for reducing prostate cancer mortality is limited. Secondary prevention involves early detection through screening methods such as transrectal ultrasound, digital rectal examination, and prostate-specific antigen testing in at-risk populations. Tertiary prevention focuses on treating and managing the disease in diagnosed patients to reduce disease progression or recurrence, often involving lifestyle interventions like diet and physical activity modifications.

Prostate-specific antigen (PSA) is a glycoprotein secreted by prostate epithelial cells, and its discovery in the 1970s revolutionized early detection methods for prostate cancer. Initially introduced into clinical practice in the 1980s, PSA testing gained FDA approval in 1986 to monitor disease progression in diagnosed patients. Subsequently, in 1994, it was approved for asymptomatic prostate cancer screening in combination with digital rectal examination. The introduction of PSA testing enabled the diagnosis of prostate cancer in its early stages, regardless of the patient's age. PSA levels vary depending on age, race, and prostate volume, with significant increases observed in individuals with benign prostatic hyperplasia, particularly between the sixth and seventh decades of life. While there is no precise PSA level range defined, most urologists consider optimal serum PSA levels to be between 0.1 and 4 ng/ml. Increased PSA levels in circulation result from basal membrane damage and increased vascularity of prostate tissue, indicating prostate pathology even before clinical symptoms manifest.

Prostate Cancer Prevention

Prevention represents a key component and the most cost-effective and long-term strategy of programs aimed at reducing the incidence and prevalence of malignant diseases. Adequately designing and implementing cancer control programs can lower the incidence of malignancies and improve the quality of life of patients, even in underdeveloped countries (Subotić, Anđelski & Subotić, 2015). Prostate cancer prevention aims to limit costs and prevent morbidities associated with diagnosis and treatment. Prevention strategies target all phases of the disease process. Interventions aimed at primary prevention of prostate cancer aim to prevent disease incidence (Ballon-Landa & Parsons, 2018), achieved by removing risk factors. For prostate cancer, this involves adequate nutrition, physical activity, reducing alcohol intake, sexual activity, hormonal balance, and lifestyle habits. However, besides the mentioned factors, there are also factors that are more difficult to address, such as race, age, and heredity (Radovanović, 2004).

Age is the most significant risk factor for prostate cancer development. Epidemiological studies indicate that its incidence progressively increases with age, becoming clinically manifest. Prostate cancer has a low overall incidence in men under 50, representing less than 0.1% of all diagnosed patients. Studies show that prostate cancer is diagnosed after the age of 65 in about 85% of cases (Patel & Klein, 2009). With aging, the percentage of prostate cancer linearly increases, with it being present in as many as three-quarters of cases in the eighth decade (Yin, Bastacky, Chandran, Becich & Dhir, 2008).

The significance of racial belonging on prostate cancer development is best seen in the differences in incidence rates among different ethnic groups. Incidence rates are 60% higher in African American men compared to Caucasians, and the African American race is associated with increased mortality, primarily due to a more aggressive disease (Sathianathan, Konety, Crook, Saad & Lawrentschuk, 2018).

The impact of positive family history on the risk of prostate cancer is shown in a study where men whose father or brother had the disease were twice as likely to develop prostate cancer as those without a positive family history. However, the study also showed that an increased number of affected family members was associated with an increased risk of developing prostate cancer (Sathianathan, Konety, Crook, Saad & Lawrentschuk, 2018). When it comes to hereditary carcinomas, studies show that they occur on average 6 to 7 years earlier compared to non-hereditary carcinomas. However,

there is no significant difference in aggressiveness and survival between these two groups of prostate cancers (Hemminki, 2012).

Positive family history, race, and heredity are well-established risk factors for prostate cancer. Modifiable risk factors can influence the risk of developing and dying from prostate cancer, but studies show little evidence for any clear indications for prevention other than early diagnosis to reduce prostate cancer mortality (Gandaglia et al, 2021).

Secondary prevention involves detecting disease in its early stage, when treatment is significantly more successful. Early detection is part of the preventive strategy, involving diagnosis, treatment, and disease monitoring (Radovanović, 2004). Secondary prevention includes screening for preclinical diseases in at-risk populations.

Prostate cancer screening is achieved through the combination of transrectal ultrasound (TRUS), digital rectal examination (DRE), and serum prostate-specific antigen (PSA) (Ballon-Landa & Parsons, 2018).

Tertiary prevention aims to reduce disease progression or recurrence in patients with known diseases. It involves therapy and procedures aimed at bringing the patient to optimal health. Many primary and tertiary prevention interventions focus on modifiable disease risk factors, including nutrition, physical activity, and lifestyle (Ballon-Landa & Parsons, 2018).

Prostate Cancer Screening

Through various screening tests, prostate cancer can be diagnosed in its early stages when no symptoms of the disease are present in men. Diagnosing prostate cancer in its early stage offers a broader range of treatment options and a higher success rate in curing the disease. Literature data suggests that screening tests should begin around the age of forty-five. Men with an increased risk of developing prostate cancer (positive family history, i.e., a father, uncle, or brother with prostate cancer, and if family members on the maternal side have had breast cancer) should start screening for prostate cancer around their forties. In primary prevention of prostate cancer, factors that can be influenced include medication, proper nutrition, and regular physical activity (Subotić, Anđelski & Subotić, 2015).

Since primary prevention of prostate cancer is not effective, the focus is on the possibilities of secondary prevention. The goal of screening is to detect prostate cancer in its early stage, when curative treatment is still possible. Screening should include asymptomatic men at increased risk of developing prostate cancer. Early detection enables the early diagnosis of prostate cancer and the initiation of earlier treatment (Subotić, Anđelski & Subotić, 2015).

Prostate-Specific Antigen (PSA)

Localized prostate cancer is asymptomatic. By the time symptoms appear, the disease has progressed too far to be curable. The concept of screening for prostate cancer is highly beneficial as it provides an opportunity to identify the disease in a curable phase. Research into tests that could detect prostate cancer earlier led to the discovery of the prostate-specific antigen (PSA) blood test, first isolated and defined in the 1970s (Carlsson & Vickers, 2020). The introduction of the PSA test into clinical practice allowed for the diagnosis of prostate cancer in its early stage regardless of the patient's age. PSA values in men without prostate cancer vary depending on age, race, and prostate volume (Mijović et al, 2017). For men without benign prostatic hyperplasia, changes in PSA levels of 0.04 ng/ml per year have been observed. On the

other hand, a significantly higher increase in PSA has been noted in men with benign prostatic hyperplasia, ranging from 0.07 to 0.27 ng/ml per year. PSA levels also increase with age, particularly between the sixth and seventh decades of life. While there is no defined exact range of PSA levels in the blood, most urologists consider optimal PSA values in serum to range from 0.1 to 4 ng/ml (Subotić, Anđelski & Subotić, 2015).

The increase in PSA levels in circulation occurs due to damage to the basal membranes of the glands and increased vascularization of prostate tissue, so the increase is not solely conditioned by increased activity of secretory cells. As a result of these changes, PSA appears in the extracellular space of glandular tissue and then enters the bloodstream via lymph, hence the increase is not solely conditioned by increased activity of secretory cells. As a consequence of these changes, PSA appears in the extracellular space of glandular tissue and then enters the bloodstream via lymph, hence the increase is not solely conditioned by increased activity of secretory cells (Cerović, 2009, pp.8).

An elevated PSA value in the serum is a biochemical indicator of trauma, but also prostate disease (prostatitis, benign prostatic hyperplasia, prostate cancer). There are many factors that can cause an increased PSA level in the blood. Serum PSA values are also affected by manipulations on the prostate, such as touching the prostate during a rectal examination, when it is possible for PSA values to increase by a factor of two. Prostate biopsy, as well as prostate surgical interventions (transurethral resection of the prostate), when PSA values can increase up to 60 times compared to the reference value, also affect PSA values (Stamey et al, 1987). Prostate biopsy, as well as prostate surgical interventions (transurethral resection of the prostate), when PSA values can increase up to 60 times compared to the reference value, also affect PSA values (Stamey et al, 1987). An elevated level of PSA in the serum has also been observed with urinary retention, stress and excessive physical activity (long-term cycling can increase the concentration of PSA in the serum by up to 10%) (Mejak, Bayliss & Hanks, 2013). Despite the fact that research shows that an increase in the serum value of PSA is not specific only to prostate cancer, its determination still represents the gold standard both in the diagnosis and in monitoring the progression of prostate cancer (Zhang et al, 2004).

In their study, Katalona et al. concluded that using only digital rectal examination and/or ultrasonography as a screening method for prostate cancer, prostate cancer was not diagnosed in 32–43%, but was detected by the PSA test. Data from the Prostate Cancer Prevention Study showed that there is a significant number of high-grade cancers in men with $PSA \leq 4.0$ ng/ml, which is considered a normal level, and for this reason they suggested that the reference value for PSA indicating the presence of prostate cancer should be reduced (Catalona et al, 2017).

However, this suggestion has not been widely accepted and remains controversial, with neither European nor American guidelines recommending specific cut-off PSA levels to indicate the necessity of a biopsy, but rather advocating an individual risk-based approach (Mottet et al, 2017). . On the other hand, the National Comprehensive Cancer Network guidelines recommend that men with $PSA > 3$ ng/ml should undergo a prostate biopsy (Sathianathen, Konety, Crook, Saad & Lawrentschuk, 2018).

In order to achieve greater specificity of PSA in the detection of prostate cancer, various indexes have been developed: age-specific PSA (age-specific PSA ratio of total PSA to prostate volume (PSA density-PSAD), PSA growth dynamics as a function of time (PSA velocity), transitional density zone PSA (transition zone PSA density), percentage ratio of free to total PSA (%f PSA).

Regarding age-related initiation of screening, it has been shown that at age 45 it is possible to identify a subgroup of men who are at significant risk of developing or dying from prostate cancer within 10 years. Research shows that very few younger men have elevated PSA levels in their blood, and scientists have therefore suggested that screening should start at age 50, based on the lower age limit for men included in the European Randomized Study of Cancer Screening prostate (The European Randomized Study of Screening for Prostate Cancer - ERSPC) (Vertosick, Poon & Vickers, 2014).

Digital-rectal examination

Digital rectal examination (DRP) is primarily used in the detection of prostate cancer, due to the possibility of wide application and simple execution, the sensitivity and specificity of which depend on the degree of the disease. The examination evaluates the size, limitation from the environment, symmetry, sensitivity and firmness of the prostate, as well as suspicious changes in the structure of the prostate. DRP is a subjective procedure of low sensitivity and specificity with very little significance in the diagnosis of localized prostate cancer as the only curable form of cancer. Only the peripheral zone of the prostate can be palpated digitorectally, where the largest number of cancers are localized, and it is available for digitorectal examination if its volume is greater than 0.2 cm (Borkenhagen et al, 2019).

In DRP, a suspicious finding on the prostate can also occur in prostate tuberculosis, granulomatous prostatitis and prostate calculus. If the DRE finding is suspicious, it is an absolute indication for a TRUS biopsy of the prostate. As new diagnostic methods were introduced, primarily PSA, which helps to diagnose prostate cancer at an early stage of development, DRP as an independent screening method completely lost its importance. However, when DRP is combined with PSA testing, its positive predictive value for prostate cancer increases.

Even if the importance of DRP is diminished today, it still represents an indispensable screening examination in everyday urological practice. Naji et al. conducted a study with the aim of evaluating the diagnostic accuracy of DRP in screening for prostate cancer in primary care institutions. They concluded that given the significant lack of evidence supporting its effectiveness, they recommend against routine performance of DRP for prostate cancer screening in the primary care setting (Naji et al, 2018). It is necessary through daily work in primary health care to raise men's awareness of the importance of prostate cancer screening and to refer them to a urologist after the age of forty-five.

Transrectal ultrasonography

Transrectal ultrasonography (TRUS) is a standard diagnostic method in everyday urological practice. It is used to evaluate benign conditions of the prostate and calculate the volume of the prostate, but also to look at changes that are suspicious of prostate cancer. Prostate cancer occurs as a hypoechoic lesion in 60-70% of cases, isoechoic in 30-40% of cases, while hyperechoic lesions are extremely rare, up to 1.5% of cases at most. Toi et al conducted a study that showed that the probability of diagnosing prostate cancer was twice as high when a hypoechoic lesion was observed on TRUS, followed by a targeted biopsy of intraprostatic lesions. They concluded that the identification of hypoechoic lesions on TRUS is significant for the detection of prostate cancer (Toi et al, 2007).

CONCLUSION

Epidemiological data show that prostate cancer represents a major health and economic problem, both in the world and in the Republic of Serbia. For this reason, the prevention of prostate cancer has great public health potential, and if it is well organized and directed, it represents an effective approach in the control of malignant diseases.

The main etiological risk factors for the occurrence of prostate cancer are age, race and hereditary predisposition, and these are factors that we can hardly influence. That is why it is important to focus all potential on secondary prevention of prostate cancer, that is, on screening methods, which include a combination of prostate-specific antigen from serum, digital rectal examination and transrectal ultrasonography. None of these methods is completely safe, but for the early screening of prostate cancer, the determination of serum PSA is undoubtedly the most important.

Prostate cancer prevention and screening should include men over the age of forty-five. It is necessary that they were adequately informed about the importance of screening, and the most important role is played by health workers from primary health care. In order to raise the population's awareness of the importance of prostate cancer screening, participation in promotional activities should be carried out as a team with the local community.

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EARLY PREDICTION OF QUALITY OF LIFE IN PATIENTS WITH PROXIMAL FEMUR FRACTURES

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ABSTRACT

Introduction: The extension of the average lifespan has led to an increase in bone and joint diseases associated with older age, primarily degenerative joint diseases and bone fractures. The most commonly affected site by these conditions is the hip joint. Age, osteoporosis, and falls are the main risk factors for fractures in the hip region. More than 85% of hip fractures occur in individuals over 65 years of age. **Objective:** To present the quality of life of patients over 65 years of age with proximal femur fractures. **Material and Methods:** Data for this study were collected through analysis of available literature and searches on [Scindeks, Kobson, PubMed, Ref List, PsycINFO]. **Results and Discussion:** Hip fractures are one of the leading causes of illness and mortality among the elderly population, and as the number of older people increases worldwide, including in our region, hip fractures are reaching epidemic proportions. Proximal femur fractures account for more than half of all hip fractures, and their number is expected to continue rising over the next 30 years, representing a significant medical and economic burden. These fractures, which are the most common cause of hip surgery in older individuals, are associated with increased mortality, morbidity, and disability. Mortality rates after proximal femur fractures vary greatly: 4–6% at 30 days, 10–14% in the first six months, and 24% at 12 months. **Conclusion:** Implementing programs for early detection of cognitive impairments in older individuals is essential to reduce the risk of recurrent falls and prevent cases where falls occur due to declining mental health. Moreover, promoting mental and physical well-being, with a focus on regular physical activity and cognitive function screening for early signs of decline, could significantly contribute to reducing the expected increase in future femur fractures.

Keywords: mental health, femur fracture, elderly population, falls, quality of life.

INTRODUCTION

As people age, they often experience reduced neuromuscular coordination, vision, balance, and reaction time, which can increase the risk of falls and fractures in the hip region (Amarilla-Donoso FJ, López-Espuela F, Roncero-Martín R, Leal-Hernandez O, Puerto-Parejo LM, Aliaga-Vera I, et al). Fractures of the proximal femur are common and result in significant morbidity and mortality, as well as imposing a substantial socio-economic burden (Sheehan SE, Shyu JY, Weaver MJ, Sodickson AD, Khurana B.). In the USA alone, over 300,000 people are hospitalized annually due to proximal femur fractures. With the aging population, the incidence of proximal femur fractures is expected to increase steadily. In 1990, approximately 1.3 million hip fractures were reported worldwide, but by 2050, estimates suggest this number could range from 7.3 to 21.3 million [Fischer H, Maleitzke T, Eder CS, Ahmad S, Stöckle U, Braun KF. Mears SC.].

The proximal end of the femur is divided into several anatomical zones, including the femoral head, femoral neck, intertrochanteric region, and subtrochanteric region. Fractures in the proximal femur most frequently occur in the femoral neck and intertrochanteric region (approximately 45% of cases), with a smaller proportion occurring in the subtrochanteric region (about 10% of cases) [Mears SC.]. These fractures can be classified as intracapsular or extracapsular. In cases of proximal femur fractures, the primary fracture fragments can often become displaced due to muscle actions, particularly by the abductors, flexors, adductors, and short extensors of the hip [Kani KK, Porrino JA, Mulcahy H, Chew FS.].

For older patients, a proximal femur fracture often represents a significant life-altering event, impacting their ability to maintain independence. Within a year following a hip fracture, only 40–60% of elderly patients regain their previous level of mobility and functional independence [Sheehan SE, Shyu JY, Weaver MJ, Sodickson AD, Khurana B.]. Even minor events, such as infections or surgeries, can lead to substantial declines in health due to disrupted homeostasis balance. Frail patients with proximal femur fractures face a high risk of complications such as cardiovascular, pulmonary, thrombotic, infectious, or bleeding complications, further increasing the risk of mortality [Fischer H, Maleitzke T, Eder CS, Ahmad S, Stöckle U, Braun KF.].

These fractures significantly impair the ability to perform basic daily activities independently, such as mobility (especially climbing stairs), dressing, or bathing [González J, Pita S, Seoane T, López B.]. This loss of independence diminishes overall quality of life and is associated with increased morbidity and mortality [Van de Ree CLP, Landers MJF, Kruithof N, et al.]. Despite efforts, mortality rates remain high, particularly for institutionalized patients with advanced dementia, reaching up to 55% within 6 months after injury. Proximal femur fractures often signify the beginning of the end of life for these individuals [Mundi S, Pindiprolu B, Simunovic N, Bhandari M.].

Decision-making regarding treatment for proximal femur fractures in frail patients with limited life expectancy is complex. Surgical treatment should be carefully considered, and non-operative approaches may be preferable in certain cases [Loggers SAI, Willems HC, Van Balen R, Gosens T, Polinder S, Ponsen KJ, et al.]. Prior to initiating treatment, it is crucial to assess the patient's mental status [Zachwieja E, Butler AJ, Grau LC, Summers S, Massel D, Orozco F, Hernandez VH.]. Various questionnaires can aid in this assessment and inform treatment decisions. These questionnaires, along with other diagnostic evaluations, are integral to the comprehensive assessment of patients with proximal femur fractures [Alexiou KI, Roushias A, Varitimidis SE, Malizos KN.]. The goal

is to assess the neuropsychobehavioral status of the patient. If the patient's general condition is poor, mobility was limited before the injury, and mental status is significantly altered, non-operative treatment may be justified [Joosse P, Loggers SAI, Van de Ree CLPM, Van Balen R, Steens J, Zuurmond RG, et al.]. However, this approach may be associated with increased complications and reduced quality of life [de Miranda MA, Pontón AP, Guerra LM, Andrade-Silva FB, de Camargo Leonhardt M, Dos Reis PR, et al.].

RESEARCH METHODS

In this study, we conducted a thorough analysis of literature from reputable global journals and professional works, utilizing electronic databases to review documentation on the topic. The study employed a descriptive methodology. However, it is important to note that conducting research in Serbia would be valuable to assess the actual quality of life of patients with proximal femur fractures. This is crucial because factors such as advanced age, comorbidities, poor nutritional status, and low functional status prior to the fracture, as well as depression and cognitive impairments, are associated with poorer and longer functional recovery, increased postoperative morbidity and mortality, and higher hospital costs, all of which impact patient quality of life [Seematter-Bagnoud L, Frascarolo S, Büla CJ.].

RESULTS AND DISCUSSION

After fracturing the upper end of the femur bone, approximately 30% of patients succumb within the first year post-injury, and only 40-60% regain their pre-injury level of mobility and functionality [Maffulli N, Aicale R.]. Hip fractures rank among the primary causes of morbidity and mortality in older individuals, and as the elderly population grows, both globally and locally, these fractures are assuming epidemic proportions [Sheehan SE, Shyu JY, Weaver MJ, Sodickson AD, Khurana B]. Fractures of the upper end of the femur bone constitute over half a percent of all hip fractures, and their incidence is projected to rise over the next three decades, posing significant medical and economic challenges [Xia Y, Zhang W, Zhang Z, Wang J, Yan L.]. These fractures, predominant in hip surgeries for older individuals, correlate with heightened mortality, morbidity, and disability [McDonough CM, Harris-Hayes M, Kristensen MT, Overgaard JA, Herring TB, Kenny AM, et al.]. Mortality rates following these fractures vary: 4–6% within 30 days, 10–14% within six months, and 24% within 12 months [Loggers SAI, Willems HC, Van Balen R, Gosens T, Polinder S, Ponsen KJ, et al.].

Moreover, elderly individuals often present with multiple comorbidities, predisposing them to falls and increased mortality rates post-hip fracture. Ninety-five percent of hip fractures result from falls, significantly impacting health and quality of life compared to falls alone [Pierrie SN, Wally MK, Churchill C, Patt JC, Seymour RB, Karunakar MA.]. Cumulative one-year mortality rates post-hip fracture range from 14 to 36% [Chen P, Shen X, Xu W, Yao W, Ma N], with 7-8% occurring within 30 days of injury [Vives JMM, Jornet-Gibert M, Cámara-Cabrera J, Esteban PL, Brunet L, Delgado-Flores L, et al.]. Additionally, the risk of mortality from other causes escalates five to eightfold post-fracture [Guzon-Illescas O, Perez Fernandez E, Crespí Villarias N, Quirós Donate FJ, Peña M, Alonso-Blas C, et al.]. Furthermore, most surviving patients fail to regain their pre-fracture functional status [Ucpunar H, Camurcu Y, Çöbden A, Sofu H, Kis M, Demirel H.].

Neuropsychiatric disorders among comorbidities significantly influence mortality and functional outcomes post-hip fracture. Neurological conditions often

contribute to decreased bone density and strength, exacerbating the risk of fracture [Kelly RR, Sidles SJ, LaRue AC.]. Neuropsychiatric disorders, particularly confusion, affect 30-50% of patients post-fracture, often pre-existing but undiagnosed at admission. Patients with severe cognitive impairment face triple the mortality risk four months post-hip fracture [Merloz, P.]. Detecting these disorders early improves survival and functional recovery. Routine assessments for prompt treatment initiation are crucial, impacting the remaining quality of life for older patients [Iolascon G, Cervone M, Gimigliano R, Di Pietro G, Gimigliano F.].

The presence of cognitive impairment escalates the risk of hip fracture by up to 55%, with dementia patients facing increased hospitalization and adverse outcomes [Wantonoro W, Wen-Yu KUO, Shyu YIL.]. Dementia, a significant risk factor for delirium, exacerbates post-fracture complications [de Jong L, van Rijckevorsel VAJIM, Raats JW, Klem TMAL, Kuijper TM, Roukema GR.]. Delirium, a common post-fracture complication, affects 23-39% of geriatric patients, hindering functional recovery [Bellelli G, Carnevali L, Corsi M, Morandi A, Zambon A, Mazzola P. et al.]. Although women have higher hip fracture incidence, men are more prone to post-treatment delirium diagnoses. The exact pathophysiology remains unclear, although neurotransmitter imbalance, inflammation, and metabolic disturbances are implicated [de Oliveira LDSSCB, Souza EC, Rodrigues RAS, Fett CA, Piva, AB.].

Depression prevalence among older adults post-hip fracture ranges from 9 to 47%, affecting functional recovery adversely [Milton-Cole R, Ayis S, Lambe K, O'connell MDL, Sackley C, Sheehan KJ.]. Depression significantly influences prognosis, with consistently high depressive symptoms correlating with reduced physical function recovery [Maharlouei N, Jafarzadeh F, Lankarani KB.]. Many hip fracture patients fail to regain pre-injury physical and mental functioning, highlighting the importance of assessing their quality of life [Fischer H, Maleitzke T, Eder CS, Ahmad S, Stöckle U, Braun KF.].

Given the life-threatening nature of these fractures, the World Health Organization advocates a holistic approach, considering both operative and non-operative treatments. Shared decision-making among healthcare providers, families, and patients is essential to determine optimal management strategies [Loggers SAI, Willems HC, Van Balen R, Gosens T, Polinder S, Ponsen KJ, et al.]. Addressing the social and economic implications of hip fractures in the elderly with cognitive impairments represents a public health challenge. Identifying these patients can improve treatment outcomes, enhance understanding of their needs, predict treatment results, and improve care, ultimately enhancing their remaining quality of life.

Additionally, with the expected rise in hip fracture incidences in our region, proactive planning and efficient healthcare service organization are imperative for effective management.

CONCLUSION

In conclusion, our exploration underscores the critical importance of early detection and management of cognitive impairments in the elderly population to mitigate the risk of recurrent falls and prevent instances where falls stem from deteriorating mental health. Furthermore, advocating for both mental and physical well-being, particularly through the promotion of regular physical activity and cognitive function screening to identify early signs of decline, emerges as pivotal strategies in curbing the anticipated surge in future femur fractures. By embracing a proactive approach encompassing comprehensive assessment protocols and tailored intervention

programs, healthcare providers can enhance patient outcomes, diminish healthcare burdens, and ultimately bolster the overall quality of life for older individuals vulnerable to femur fractures and associated complications.

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HEALTH CARE FOR PATIENTS DIAGNOSED WITH TUMORS OF THE UROTRACT

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ABSTRACT

Diseases of the urinary tract are very common and greatly impair the quality of life. Depending on the diagnosis itself and the affected organ, the needs of patients differ. However, a multidisciplinary approach, adherence to the health care process and the expertise of the health staff are necessary in order for patients to be cared for in the best way. Introduction: Urinary tract function disorders are quite common. In addition to numerous diseases that include infections, calculosis and inflammation, tumors of the urinary tract are quite common. All tumors can be divided into benign and malignant. Many symptoms are non-specific, such as pain, burning and frequent urination, but the dominant sign of a tumor is hematuria. The disease is curable if detected in time. Objective: Considering the increasing prevalence of urinary tract diseases, educating the population about them, providing comprehensive health care, as well as access to patients is the primary goal of this work. Material and methods: For the purposes of data collection in the preparation of this paper, a review of the literature was carried out through Internet search engines such as: (English Sci Index, Scopus, Medlaine). Results and discussion: Diseases of the urinary system are diverse, and cancers are in the leading position, especially in men. The treatment process itself, depending on whether the diagnosis is benign or malignant, is often exhausting and painstaking. However, thanks to modern diagnostics and treatment, survival and cure rates have increased. Conclusion: In order to at least in some way alleviate the patient's complaints and satisfy his needs, it is necessary to focus all attention on him and provide him with the best and highest quality health care, and to achieve this, the expertise and empathy of nurses who have a multidisciplinary approach are necessary to every problem.

Key words: urinary tract, tumors, quality of life, education, health care.

INTRODUCTION

Disorders affecting the urinary tract function are quite common, encompassing a range of conditions such as infections, calculi (stones), inflammations, and tumors.

These tumors can be categorized as either benign or malignant (Lakić, 2015). Among them, tumors of the urinary tract are more prevalent in men, with various risk factors contributing to their development. Notably, prostate carcinoma tops the list, followed by bladder carcinoma, ranking fourth among all malignancies in men in European and North American countries.

Symptoms can be nonspecific, including pain, tingling sensations, and frequent urination, but the primary indicator of a tumor's presence is hematuria (blood in urine). Detecting the disease early is pivotal, as modern treatment approaches offer improved life expectancy (Ivanković, 2015).

Surgical intervention often serves as the primary treatment method, and patient preparation is typically overseen by a nurse, who plays a crucial supportive role, particularly during the postoperative period.

Assisting the patient in adapting to a different lifestyle with patience and clear communication is paramount.

Diseases of the urinary tract

The urinary tract encompasses a wide array of diseases, ranging from developmental kidney disorders to various infections and structural issues. These include glomerular diseases, tubulointerstitial kidney diseases, urolithiasis and conditions affecting the ureters, bladder, and urethra, such as tumors.

Urinary tract infections (UTIs) are particularly common and can progress rapidly. Bacterial infections like cystitis, which primarily affect the lower urinary tract, are prevalent in women, while prostatitis, an inflammation of the prostate, is the most common UTI in men. Additionally, UTIs are more frequent in women, whereas urinary tract tumors are more prevalent in men. Urolithiasis, characterized by the presence of stones in the urinary system, tends to affect men more often. These stones can form in the kidneys, pass through the ureter to the bladder, and eventually exit the body through the urethra, with some forming directly in the bladder.

Symptoms of urinary tract diseases vary widely. Any symptoms should be carefully assessed to establish an accurate diagnosis. Generally, symptoms of infection include poor health accompanied by fever, frequent urination, and a sense of urgency. Frequent urination without an increase in urine volume may indicate bladder infection or irritation caused by foreign bodies, stones, or tumors. Additional symptoms may include tingling and pain during urination.

In cases of prostatitis, individuals typically experience small urine volume, along with frequent and difficult urination. Other symptoms can include unpleasant urine odor, cloudy urine, fatigue, vomiting, stomach or back pain, weight loss, and hematuria (blood in the urine).

Urinary tract infections can affect both the lower and upper parts of the tract, and treatment varies based on the complexity and location of the infection. UTIs rank as the second most common infections in the general population, following respiratory system infections, often necessitating hospitalization. Common symptoms include pain, burning, tingling during urination, frequent urination, and hematuria.

Diagnostic methods of urinary tract diseases

Urinary sediment analysis is performed using a non-invasive method, cytological examination, which can detect various pathological conditions. Urine can be taken from a catheter or spontaneously voided. Cytological methods are of great importance in detecting pre-malignant and malignant lesions, metastatic tumors, or lesions that cannot be seen by cystoscopy or biopsy (Babić, 2003). It is necessary to collect the first morning urine, three days in a row, and the patient is advised to drink half a liter of water and perform genital hygiene half an hour before urination. The most common diagnosis of urinary tract tumors is based on intravenous urography, which is conducted in cases of hematuria, unclear metastatic lesions, and unclear laboratory findings.

Ultrasound (US) is a unique, reliable, and inexpensive diagnostic method, often the first choice when there are any suspicions. By using endocavitary (transrectal and transvaginal probes) high-frequency, it is possible to examine the wall of the bladder, ureters, prostate in men, and uterus in women in more detail. Ultrasound examination can show solid tumors, and through Doppler, vascularization of the tumor can be seen, but it is not possible to differentiate benign from malignant tumors (Pokriva, 2018). A native image of the urinary tract is used as a safe and reliable diagnostic method before more complex imaging, and it is often combined with ultrasound examination.

Computed tomography is a highly reliable diagnostic method that can visualize the anatomical relationships of various pathological conditions in the retroperitoneal space. Multidetector computed tomography (MDCT) or urography does not require special and complex patient preparation. After a detailed explanation of the procedure, its duration, and how it will be performed, the patient should have urea and creatinine levels not older than two weeks. The patient is advised to drink a liter of water one hour before the procedure to prevent dehydration, promote diuresis, and outline the imaged parts of the urogenital system. The patient is placed in a supine position with arms placed above the head (Babić, 2003).

Magnetic resonance is a diagnostic method that corresponds to computed tomography but is considered more precise in showing pathological conditions and their extensions outside the place where they originated.

Among other diagnostic methods, excretory (intravenous), contrast urography can be used to visualize the canal system of the urinary tract, including the bladder and its emptying. Contrast antegrade and retrograde urography can also be used, as well as ureteroscopy. Voiding cystourethrography is another diagnostic method that can be used.

Bladder tumors

The urinary bladder is a hollow, mucosa-lined muscular organ that collects urine from the left and right ureters, and expels it through the urethra. It is located in the subperitoneal space of the pelvic cavity. The bladder functions to collect urine, which is expelled through the act of urination (Lakić, 2015). Tumors are defined as growths that arise due to uncontrolled tissue growth. Today, tumors are a common occurrence and represent a significant public health problem. They signify the growth and proliferation of abnormal cells within a tissue, disrupting the body's defense mechanisms. Tumors can be benign or malignant. Not all tumors have to be a fatal diagnosis, which is why preventive screenings and early detection are very important (Stanković, 2007). The symptoms of bladder tumors are similar to those of inflammation. Bladder tumors are a

very common condition today. Primary bladder tumors are significantly more common, while secondary, metastatic tumors are very rare.

Benign bladder tumors

There is a large number of benign bladder tumors whose symptoms are nonspecific. Bladder papillomas are defined as stalk-like changes covered with normal epithelium. Papillomas are classified as non-invasive tumors because they do not tend to progress into deeper layers of the bladder. Metaplasia is most often a consequence of bladder resection, trauma, urinary tract infection, or catheterization. Cystitis cystica or glandularis are benign changes caused by chronic obstruction or inflammatory processes (Jakopović, 2016). They are characterized by frequent urination and common hematuria, and are treated by addressing the underlying cause of obstruction or inflammation, as well as by transurethral resection.

Malignant bladder tumors

Bladder carcinomas can be invasive and non-invasive, and are macroscopically papillary or flat. Papillary carcinomas can be solitary or multiple. The key symptom of papillary carcinomas is hematuria. Hematuria is usually intermittent, relatively mild, or macroscopically visible. It may be accompanied by other symptoms such as pollakiuria and dysuria, i.e., painful and frequent urination. These tumors often recur (Stanković, 2007). Bladder tumors can have various histopathological forms, but in 95% of cases, they are urothelial carcinomas. Bladder carcinoma is extremely rare in individuals younger than 30 years old. It is almost non-existent in childhood (Prelević, 2015). The treatment of bladder carcinoma typically involves surgery, and may also be multimodal, involving immunotherapy, chemotherapy, and radiotherapy. The method of choice is transurethral endoscopic tumor resection.

Prostate tumors

The prostate is a gland that is part of the male reproductive system and produces substances that contribute to the composition of semen. It has a chestnut shape. Prostate carcinoma is the most commonly diagnosed malignancy in males and the second leading cause of death. It rarely occurs before the age of forty. The incidence increases with age. Risk factors include age, sex, race, ethnicity, genetic factors, hormones, diet, and chronic inflammatory processes. Some authors associate prostate carcinoma with sexually transmitted diseases, especially human papillomavirus and chlamydia (Dujic, 2013). In over 95% of cases, it is adenocarcinomas. In the initial phase, the disease is asymptomatic, and is usually diagnosed when it has already progressed to the bones, lymph nodes, or even parenchymal organs. If detected early, prostate cancer is curable and the individual can continue with their life after treatment. If detected late, the disease is fatal, but treatment still prolongs life. Radical prostatectomy is used in the treatment of localized prostate cancer with the goal of curing or ensuring survival for at least ten years.

Kidney tumors

The kidneys are paired organs, bean-shaped. Urine created in the kidneys passes through the ureters to the urinary bladder. The primary function of the kidneys is urine formation and blood purification. They remove harmful products and substances from the body (Grubišić, 2019). Kidney tumors can be benign or malignant. Benign tumors have no significant clinical significance. More than 90% of kidney tumors are

carcinomas. Oncocytoma is the most common benign kidney tumor that can be localized in various parts of the body such as the thyroid and parathyroid glands, adrenal glands, etc. It is more common in males and is characterized by abdominal pain and hematuria. Kidney carcinomas are adenocarcinomas. Clear cell and papillary carcinomas originate from proximal convoluted tubules, while chromophobe carcinomas originate from distal parts of the nephron (Prelević, 2015). The most prevalent types of kidney carcinomas include clear cell carcinoma, followed by papillary and chromophobe renal carcinomas. Together, these three subtypes comprise over 90% of all kidney carcinomas. The primary therapy for kidney tumors is surgical treatment. Radical nephrectomy is most commonly performed, where the kidney, perirenal fat tissue within Gerota's fascia with the adrenal gland, and regional lymph nodes are removed. Partial nephrectomy involves removing only part of the kidney where the tumor is located. Kidney carcinoma poorly responds to chemotherapy and hormonal therapy (Dujic, 2013).

Health care and education of urological patients

Malignant diseases, or malignant tumors, encompass diseases of tissue in the human body that destroy and disrupt healthy tissue. In accepting malignant diseases, both for the patient and their families, counseling with a nurse is of great importance (Poterson, 2018). It is very important to know all the patient's needs. After radical surgeries, patients often withdraw, and their physical appearance and impaired functionality can contribute to this. It is considered that there is not enough data on this topic, and according to some studies, patients most commonly cited difficulty in meeting physical and social needs, as well as the need for intimacy (Dujic, 2013).

Nursing diagnoses are very important, especially in patients with bladder tumors, considering that they are health professionals who spend the most time with the patient. The concept of nursing diagnosis refers to current or potential health problems that nurses, based on their knowledge and experience, independently recognize and resolve. Based on nursing diagnoses, the exact responsibilities of the nurse can be seen, increasing personal responsibility, as well as professional autonomy (Kičić, 2014). It is very important that all nursing interventions are directed towards the patient in order to alleviate his/her troubles and meet his/her needs in some way. The purpose of health care in patients operated on for bladder tumors, in addition to satisfaction and education about the new way of life, is also to accept and alleviate the patient's current situation (Bolić, 2017).

The process of health care represents one of the problem-solving methods in nursing and consists of a series of activities aimed at achieving the best outcome for the patient. The process is constantly evolving. Patient and family education is one of the most common interventions performed by nurses. During the process of health care, the goal is to achieve greater independence and satisfaction for the patient and his/her family, and to improve the quality of life, thus raising awareness of health (Poterson, 2018). Due to constant technological advancement, nurses often change their way of communication, with virtual communication increasingly finding its place.

Education involves a process that is individual for each patient, but the purpose is to better understand and prepare for the existing situation and changes due to illness in order to overcome difficulties and prevent numerous complications in the best possible way. Every longer stay in the hospital leads to negative emotions and depression, and treatment can be hindered, so it is very important to motivate the patient to participate in planning and implementing health care. In order to avoid

obstacles and ambiguities in communication with the patient, access to information should be provided to them at all times.

Part of health care involves informing patients about their medical condition, expected changes in health behavior, and the various treatment options available to alleviate symptoms or address the condition.

In order for the postoperative recovery of patients after radical cystectomy to proceed as quickly and without complications as possible, twenty-four-hour supervision by a nurse who communicates with other health care workers of different profiles is necessary to provide the greatest satisfaction for both the patient and his/her family with the provided health services (Bolić, 2017).

Modern technology allows health education at any time through a computer, where listening and viewing appropriate health content is enabled, both for patients undergoing hospital treatment and for patients at home (Kičić, 2014).

CONCLUSION

Diseases of the urinary system are diverse, with carcinomas being at the forefront, especially in males. Malignant diseases, or malignant tumors or carcinomas, destroy and disrupt healthy tissue in the human body. Diagnostic and therapeutic procedures are very demanding and exhausting for both patients and their families. In this entire process, it is necessary to provide support to the patient due to changes in physical appearance, but also due to the upcoming change in lifestyle. In order to alleviate the patient's troubles and meet his/her needs in some way, it is necessary to direct all attention towards him/her and provide him/her with the best and highest quality health care, and to achieve this, the expertise and empathy of nurses are necessary, who have a multidisciplinary approach to every problem.

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IT, technology and inovations

ANALYSIS OF THE ACTIVITIES ON SOCIAL NETWORKS OF THE BEST-KNOWN WINERIES IN THE COUNTRIES OF THE OPEN BALKANS

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ABSTRACT

The Covid19 pandemic has brought new challenges and risks, both for wine production and sales. The wineries in the Balkans, faced with a changed business environment, have recognized the extraordinary importance of timely, measured and appropriate activities on social networks. Using platforms such as Instagram, Facebook and TikTok can certainly provide greater exposure to potential customers, but on the other hand, it can also bring new risks. Wine producers can easily promote their brands and develop a closer relationship with end consumers by sharing daily stories of wine production and consumption. In addition, social networking platforms are great for feedback and market research. In this way, winery owners can customize their adjust startup activities to maintain customer satisfaction and focus. At the same time, the orientation towards social networks and openness to new projects of connection between wine producers and consumers has led to the recent opening of the largest wine fair in Southeast Europe, "Wine Vision by Open Balkan" in cooperation with the governments and best-known wineries of Serbia, Albania, and North Macedonia.

The aim of this paper is to investigate the digital presence and consumer engagement and reactions on social networks used by wine producers in the Open Balkan countries. The paper specifically focuses on Instagram and compares data for the period between 2019 and 2023, including the outbreak of COVID-19, using social networks analysis tools. The results show that by maintaining active accounts with relevant content created in accordance with targeted strategic activities, wine producers can increase their reach and promote awareness of their wines, which is more efficient and cost-effective than traditional marketing techniques.

Keywords: best-known wineries, social networks, marketing, market, Open Balkan.

INTRODUCTION

The Covid-19 pandemic has brought new challenges and risks, both for the production and sale of wine. The best-known wineries in the Balkans, faced with a changed business environment, have recognized the extraordinary importance of timely, measured, and appropriate activities on social networks. Using platforms such as Instagram, Facebook and TikTok can certainly provide greater exposure to potential customers, but on the other hand, it can also bring new risks (Haller et al., 2021). Wine producers can easily promote their brands and develop a closer relationship with end consumers by sharing everyday stories about wine production and consumption. Furthermore, social media platforms are great for feedback and market research (Obermayer et al., 2022).

Wineries can reap numerous benefits from the effective use of social media platforms such as Instagram, Facebook, Twitter, and others. First, it should be kept in mind that social media provides a platform for wineries to present their brand, wines, vineyards, and unique story to a global audience. Consistent and engaging content can help increase brand visibility and recognition among wine enthusiasts and potential customers (Chen et al., 2024). Social media accounts allow wineries to communicate directly with their audience, including customers, followers, and wine enthusiasts. Through comments, direct messages, and interactive features such as polls and Q&A sessions, wineries can foster meaningful connections and build relationships with their audiences. Social media allows wineries to create engaging content that resonates with their audience, such as behind-the-scenes looks, vineyard tours, winemaking processes, and food pairing suggestions (Dabiah et al., 2024). By sharing valuable and relevant content, wineries can keep their audience interested and engaged, leading to increased loyalty and advocacy (Canovi & Pucciarelli, 2019).

At the same time, wineries can gain a profitable platform to promote their wines, events, promotions, and special offers by engaging more on social media. With targeted advertising options, wineries can reach specific demographics and geographic regions, maximizing the impact of their marketing efforts. Social media platforms offer valuable insights into consumer preferences, trends, and behaviors (Alambeigi et al., 2023). By tracking comments, likes, shares and other engagement metrics, wineries can gather feedback, identify emerging trends, and adjust their offerings accordingly. Social media allows wineries to build a community of loyal followers and brand advocates. By fostering a sense of belonging and inclusivity, wineries can create a dedicated fan base that shares their passion for wine and spreads the word about their brand through word-of-mouth recommendations (Bitakou et al., 2023).

Wineries can use social media to educate their audiences about different aspects of wine, including grapevine varieties, winemaking techniques, *terroir*, and food pairing recommendations. By sharing educational content in an accessible and engaging way, wineries can improve their audience's knowledge and appreciation of wine. A strong social media presence can give wineries a competitive advantage in the marketplace. By staying active and relevant on social media platforms, wineries can differentiate themselves from their competitors, attract new customers and retain existing customers. Overall, social media offers wineries a powerful tool to build their brand, engage with customers and drive business growth in an increasingly digital world. Through the effective use of social media, wineries can connect with their audience, promote their wines, and ultimately improve their overall success and profitability (Ahmed et al., 2024). Considering the fact that the planting of new vineyards is subsidized for a long period of time and the countries of the open Balkans support the

development of viticulture (Petrović et al., 2024), wineries should put more emphasis on marketing activities, so that quality wines reach the interested parties. Climate changes have had an impact on the quality of certain wines (Jakšić et al., 2023), and wines made from autochthonous or local grape varieties are being promoted significantly more.

The importance of this analysis is that it provides a relevant overview of the importance of social networks for the business of winery. Wine production is important, but in today's digital world, it is equally important to be present on social media and to interact with stakeholders daily (Zondo & Nodoro, 2023). Understanding a winery's social media activity provides valuable insight into consumer preferences, market trends, and the dynamics of wine industry development. By examining the types of content shared, frequency of posts, engagement metrics, and other parameters, we can decipher the effectiveness of various strategies used by best-known wineries to capture the attention and loyalty of their target audience.

At the end of 2019, the idea of establishing the Open Balkan initiative arose as a result of years of intensification of cooperation between companies in Serbia, Albania and North Macedonia, which gained new momentum in the field of the political establishment, bringing a new wind at the back and an increase in mutual trade exchange. The Open Balkan is actually the economic and political zone of the three mentioned Balkan countries and includes a population of around 12 million citizens.

The Open Balkan initiative, also known as the Mini-Schengen Initiative, is a regional cooperation agreement designed to promote economic integration and political stability between the countries of the Western Balkans. It was originally proposed by the leaders of Serbia, Albania and North Macedonia in October 2019 during a summit held in Novi Sad, Serbia. The agreement aims to remove barriers to trade, investment and the free movement of people within the region. The Western Balkans region includes Albania, Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia. These countries have faced various challenges since the break-up of Yugoslavia, including ethnic tensions, political instability and economic underdevelopment. The Open Balkans initiative aims to respond to some of these challenges by promoting cooperation and integration between the countries of the region.

The initiative aims to simplify customs procedures and reduce trade barriers in the region, making it easier for businesses to trade goods and services across borders. This can help stimulate economic growth and attract foreign investment to the Western Balkans. The initiative aims to improve transport infrastructure and connectivity within the region, including road, rail and air links. By strengthening connectivity, the initiative aims to facilitate the movement of people and goods, as well as promote tourism and regional cooperation. In addition to economic integration, the Open Balkan initiative aims to strengthen political cooperation among the participating countries. This includes cooperation on issues such as security, border management and the fight against organized crime and corruption. At the same time, the initiative aims to promote cultural exchange, tourism and educational cooperation among the countries of the Western Balkans. By encouraging people-to-people contacts, the initiative seeks to build trust and understanding among the region's diverse communities. Although the Open Balkan initiative is supported by some countries in the region, including Serbia, Albania and North Macedonia, it has been met with criticism and skepticism from others. Certain states, such as Bosnia and Herzegovina, have expressed concern about the potential impact of the initiative on their sovereignty and integration into the European Union.



Picture 1: Open Balkan countries

Source: <https://www.fair.openbalkan.com/about-us/>

Despite this, in 2022, a unique manifestation, Wine Vision by Open Balkan, was realized, launched under the auspices of the governments of Serbia, North Macedonia and Albania, offering citizens of the countries of the Open Balkan and numerous other visitors a completely new wine experience and the opportunity to discover the exciting world of authentic and autochthonous wines of the Western Balkans, as well as those whose geography indicates that they are the most famous wine-growing regions. Wine Vision by Open Balkan was realized with great success. The event was held in as many as six halls of the Belgrade Fair and promoted the entire region as an original and unique tourist, cultural and geographical destination, which offers magnificent natural resources and various historical sights (Han et al., 2022).

Looking at the best-known wineries that participated in Wine Vision by Open Balkan and the ever-evolving nature of the digital world, social networks have proven to be powerful platforms for wineries to intensify interaction with their customers, build a brand identity and expand their reach. The intersection of technology and viticulture-oenology has led to a new paradigm in which wineries navigate the digital realm alongside their traditional practices. The aim of this paper is to investigate the digital presence and engagement of consumers and reactions on social networks used by wine producers in the Open Balkan countries. The paper focuses specifically on Instagram and compares data for the period between 2019 and 2023, including the outbreak of COVID-19, using social network analysis tools. The results show that by maintaining active accounts with relevant content created in line with targeted strategic activities, wine producers can increase their reach and promote awareness of their wines, which is more effective and cost-effective than traditional marketing techniques (Pelet et al., 2024).

MATERIAL AND METHODS OF WORK

Tripadvisor is a popular travel platform where users can find information, reviews and recommendations for hotels, restaurants, attractions and other travel-related topics. While Tripadvisor may be best-known for hotel and restaurant reviews, it also offers reviews and rankings of wineries and vineyards around the world. Tripadvisor's ranking of wineries is based on user reviews. Tripadvisor relies on user-generated content, including reviews and ratings submitted by travelers who have visited wineries and vineyards. Users can submit reviews based on their experiences and rate factors such as the quality of the wines, the ambience of the winery, the friendliness of the staff and the value for money. The portal uses an algorithm to calculate the ranking of the best-know wineries based on various factors, including the quantity and quality of reviews, the recency of reviews and the overall rating given by users.

This algorithm is designed to prioritize reviews from trusted and active users, while also taking into account factors such as the size and popularity of the winery.

With close to five hundred million monthly users who access the internet portal and view reviews and read more than one billion comments and opinions of travelers, Tripadvisor is positioned high on the list of tools for improving business in the hospitality industry, and if we look at wineries, it also represents those how important aspect of internet advertising and maintaining and increasing reputation. Wine quality alone is no longer enough, it is necessary for wineries to have a clear and high-quality strategy for marketing activities on social networks. Tripadvisor collects data from different wineries and reviews and comments left by users and applies weighting when determining the scoring and ranking of wineries, which includes various elements such as location, popularity, booking method, prices, availability, ratings on a scale of one to five and The popularity index on which the selection of wineries for further analysis will be based, because it represents a key algorithm that aims to predict, based on the results and consistency of previous reviews, what level of experience the winery is likely to provide to the guest. The purpose of the Popularity Index is to present travelers with the best options first, ensuring that their experience is reliable and reassuring. The popularity index includes three elements: the overall quality of reviews, the quality of recent reviews, and the total number of reviews. The overall rating given by users in the reviews is reflected in a single rating on a scale of one to five based on a summary of the written reviews and the overall rating given by all visitors to the specific winery who left a review. The number of reviews represents the total number of reviews that a specific winery has, on the other hand, the portal also considers how recently the reviews were sent for a specific winery. It is possible that wineries with a lower rating are sometimes ranked above wineries with a better rating depending on how accurately each of these factors is weighted. The popularity ranking algorithm is designed to provide a statistical measure of confidence about the current user experience with a winery. As the portal collects more reviews about the winery over time, it has more insight into the potential experience that consumers can expect. What is important is that when a critical mass of reviews is reached, the portal can more accurately determine the ranking of wineries.

In addition to this, when determining the popularity index of a winery, the portal also considers the ratings of other related wineries, so that the ranking of each winery depends to a certain extent on the ranking of other similar wineries in the same geographical area. Bearing this in mind, it can be said that this way of ranking the ranking is variable, and that as one winery moves up or down in the ranking, it will affect all other wineries, which indicates the need for the research presented in below repeats a minimum of each year, so that the results show data that is relevant for the current time. Additionally, depending on which sort of option is selected, the ranking can vary significantly. There are currently three main ways to sort properties and that is best value, ranking by traveler reviews and distance from the city center. In the paper, ranking according to value was used for further analysis. The best value is the default sort option. This ranking algorithm aggregates a variety of data elements available to TripAdvisor, including review scores, prices, availability and preferences of specific users and recent site activity. This sorting option is very detailed and personalized and sorting the result in this way displays all properties that match the user's search criteria, regardless of the type of winery.

Users can filter the best-known wineries based on criteria such as location, price range and type of wine. Tripadvisor also categorizes wineries into different types, such as boutique wineries, family wineries, and large commercial wineries, to help users find establishments that match their preferences. At the same time, lists of the top-rated wineries in different regions, countries and wine-growing areas are published. These lists highlight the top-rated wineries based on user reviews and ratings and provide travelers with recommendations for their wine tasting adventures. The portal also generates an interactive map that allows users to explore wineries and vineyards in different regions of the world. Users can zoom in on specific areas, view winery locations, read reviews and plan their visits accordingly. A list of the 12 most popular wineries from the Republic of Serbia, Albania and North Macedonia, totaling 36 wineries, was created by the review of the internet portal Tripadvisor, which are listed below in Table 1.

Table 1: Top 12 Open Balkan wineries and group of wineries by Tripadvisor

no./country	Serbia	Albania	North Macedonia
1	Podrum Probus	Cobo Winery	Monastery Winery
2	Winery Zvonko Bogdan	Nurellary Winery	Kartal Winery
3	Podrum Panajotovic	Abaia Winery & Vineyard	Brzanov Artisan Winery
4	Winery Aleksandrovic	Alpeta Agrotourism & Winery	Tikves Winery
5	Plavinci Organic Winery	Duka Winery and Vineyard	S&S Winery Ohrid
6	Winery Jovic	Kantina E Veras Isak	Chateau Kamnik
7	Wine cellar Malca	Kantina Mani	Jostela Winery
8	Winery Kis	Kantina Balaj	Stobi Winery
9	Deuric Winery	Luani Winery	Winery Kuvini
10	Acumincum Winery	Kantina Gjergj Kastrioti Skenderbeu Durres	Peshkov Family Winery
11	Grabak Winery	Kantina Kallmeti	Wine Tourism
12	Rajacke Pivnice (group of wineries and turistic facilities)	Kantina Edoni	Royal Winery Queen Maria

Source: <https://www.tripadvisor.com>

For the selected best-known wineries, an insight into their accounts on the social network Instagram is provided, whereupon their structure, popularity, number of followers and quality of content are examined using the techniques of analyzing activity on social networks. For each selected winery, the analysis begins by visiting the winery's Instagram profile and reviewing the basic information listed in the profile description, such as the physical location, website link, and a brief description of the brand or current offer. Reviewing the posts will give you an insight into the type of content the wineries are posting, particularly in terms of whether they are mainly showcasing their wines, vineyards, or the winemaking process and similar topics. The engagement metrics for their posts, including likes, comments, and shares, are evaluated. High engagement rates indicate a strong connection with their consumers and other stakeholders.

Analyzing the types of comments best-known wineries receive on social media can show the strengths and weaknesses of their approach and strategy for managing social media, in terms of whether followers are asking questions, leaving positive feedback, or

expressing concerns. Examining the size and structure of their followers will provide insight into the diversity of their social media portfolio and the reach of their posts depending on whether they are primarily local buyers, wine enthusiasts or industry professionals. Checking the hashtags used in their posts will give you an insight into whether the observed wineries are using popular wine-related hashtags, such as #vinetasting, #vineoclock or #vinelover, and whether the hashtags are increasing their visibility and attracting new followers. Through all the above steps, a comprehensive analysis of the winery's Instagram account is realized, providing valuable insights into their brand, engagement strategies and follower structure. This information can provide valuable insights to stakeholders and help the wineries covered by the Western Balkans initiative to better connect with customers and wine enthusiasts on Instagram.

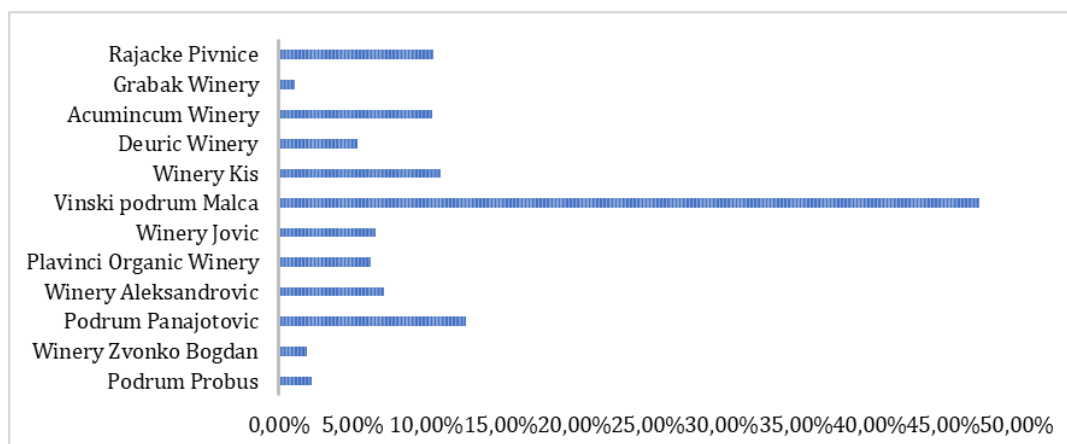
RESULTS AND DISCUSSION

If we look at the territory of Serbia, Podrum Probus, which is the best-rated on the Tripadvisor portal, has a total of 361 followers and only 8 posts with no links to other websites and no hashtags. It is a relatively new winery located near of Sremska Mitrovica in the Srem wine-growing region (Protected Designation of origin/PDO), on the edge of the Fruška Gora National Park.

no./country	Serbia	no. of followers	no. of posts	percentage (%)
1	Podrum Probus	361	8	2.22
2	Winery Zvonko Bogdan	38,800	725	1.87
3	Podrum Panajotovic	2,833	359	12.67
4	Winery Aleksandrovic	25,000	1,780	7.12
5	Plavinci Organic Winery	2,429	150	6.18
6	Winery Jovic	2,611	170	6.51
7	Wine cellar Malca	59	28	47.46
8	Winery Kis	1,594	174	10.92
9	Deuric Winery	24,900	1,316	5.29
10	Acumincum Winery	1,509	156	10.34
11	Grabak Winery	9,210	99	1.07
12	Rajacke Pivnice (group of wineries and turistic facilities)	4,730	493	10.42

Source: <https://www.instagram.com>

Right behind him, in second place, according to the Tripadvisor portal, is the Winery Zvonko Bogdan with 38,800 followers and 725 posts, resulting in an engagement rate of 1.87 %. It is located near Subotica in the Subotica wine-growing region (PDO) in northern Serbia and has a barrique cellar with unique tasting rooms, a large restaurant that testifies to the cultural wealth of Subotica and Palić, as well as a unique view of the vineyards. Podrum Panajotovic has 2,833 followers and 359 posts with an engagement rate of 12.67% and a link to the website in the profile description. This winery brings together different varieties of domestic producers from the territory of Serbia, combining Traminac, Sauvignon blanc, Rhine Riesling, Merlot and Cabernet Sauvignon wines. This winery is located in Belgrade.

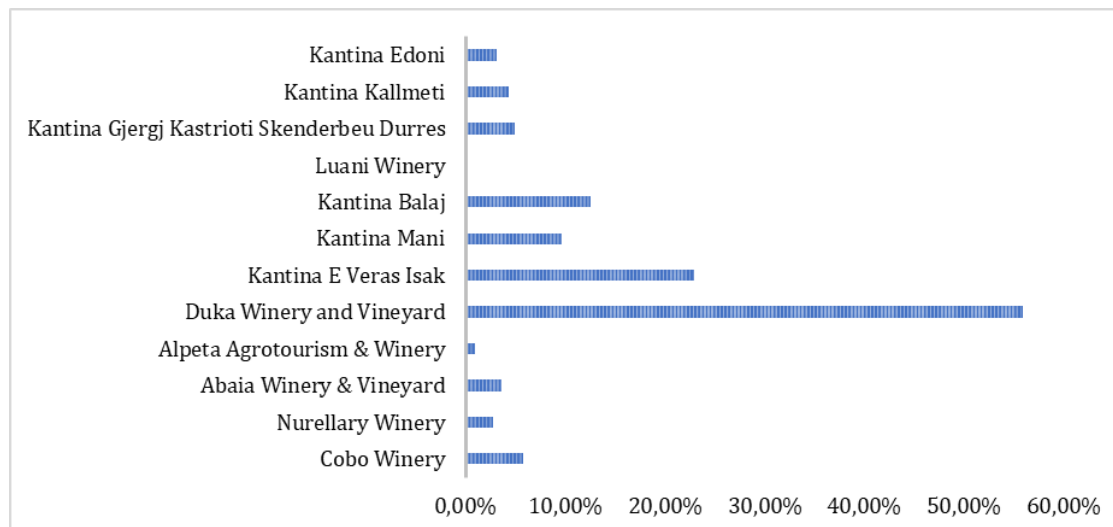


Graph 1: Top 12 Serbian wineries and group of wineries by percentage of engagement rate

Source: <https://www.instagram.com>

Winery Aleksandrovic has 25,000 followers and 1,780 posts with an engagement rate of 7.12 % and a link to the website in the profile description. This winery is located near Topola in the Šumadija wine-growing region (PDO) (Jakšić et al., 2015), in central Serbia, with vineyards at an altitude of 250 to 350 meters and several grapevine varieties. Plavinci Organic Winery has 2,429 followers and 150 posts with an engagement rate of 6.18 % and a link to their website in their profile description. This winery is located not far from Belgrade (Belgrade wine-growing region/PDO) (Jakšić, 2019), with vineyards on the banks of the Danube with the application of organic wine production. Winery Jovic has 2,611 followers and 170 posts with an engagement rate of 6.51 % and a link to the website in the profile description. It is located not far from Knjazevac (Knjazevac wine-growing region/PDO) (Jakšić et al., 2015) in eastern Serbia on an area of 15 hectares with the production of Vranac, Cabernet Sauvignon, Muscat Hamburg, Chardonnay, Rhine Riesling, and Sauvignon Blanc grapevine varieties. Wine cellar Malca has by far the smallest number of followers, only 59 followers and 28 posts with an engagement rate of 47.46 %, without links in the profile description. It is located in the village of Malca, not far from the city of Nis, and is one of the oldest wineries founded as a cooperative of local grape producers. Winery Kis has 1,594 followers and 174 posts with an engagement rate of 10.92 % and a link to the website in the profile description. It is located on Fruška Gora (Srem wine-growing region/PDO) (Jakšić et al., 2015). Deuric Winery has 24,900 followers and 1,316 posts with an engagement rate of 5.29 % and a link to their website in their profile description. It is located in the village of Mala Remeta, at an altitude of 250 meters, on the southern, sunny slopes of Fruška Gora. Acumincum Winery has 1,509 followers and 156 posts with an engagement rate of 10.34 % and a link to their website in their profile description. It is located in Stari Slankamen, also in the Srem wine-growing region in northern Serbia (Jakšić, 2019). Grabak Winery has 9,210 followers and 99 posts with an engagement rate of 1.07 % and a link to the website in the profile description. It is located in Vrnjacka Banja in the central region of Serbia. Rajacke Pivnice, as a group of wineries and turistic facilities, has 4,730 followers and 493 posts with an engagement rate of 10.42 % and a link to the website in the profile description. They are located near Negotin in the Negotinska Krajina wine-growing region (PDO) in eastern Serbia (Jakšić, 2019).

In Albania, the top-rated winery on Tripadvisor, Cobo Winery has a total of 5,198 followers and 301 posts, with an engagement rate of 5.79 %.



Graph 2: Top 12 Albanian wineries by percentage of engagement rate

Source: <https://www.instagram.com>

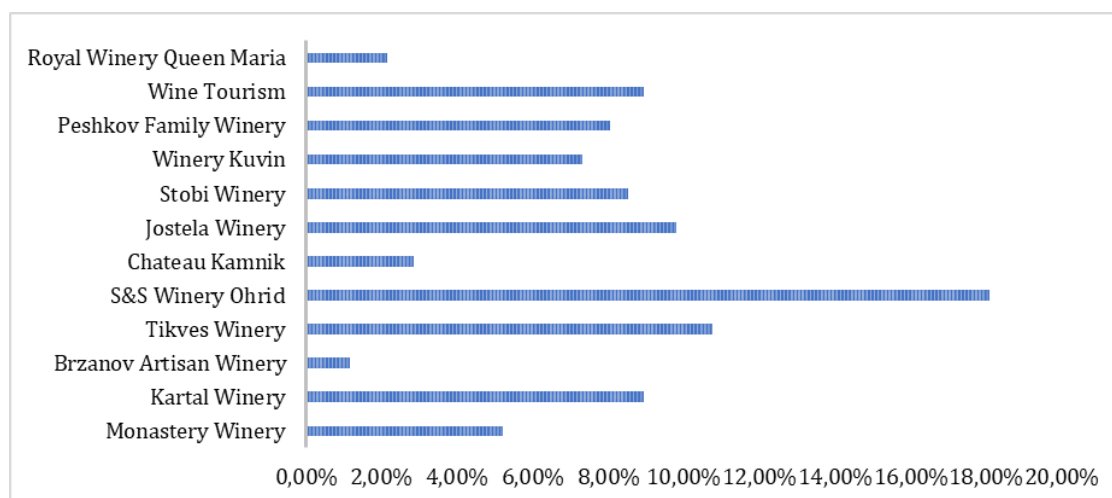
Of the other best-known Albanian wineries, Alpeta Agrotourism & Winery has the most followers, totaling 24,000, with 233 posts and an engagement rate of 0.97 %, Luani Winery, which has 24,300 followers and 26 posts with the lowest engagement rate of all observed wineries, only 0.11%, and Kantina Gjergj Kastrioti Winery Skanderbeu Durres, which has a total of 10,300 followers and 503 posts with an engagement rate of 4.88 %.

Table 3: Top 12 Albanian wineries by Instagram

no./country	Albania	no. of followers	no. of posts	percentage (%)
1	Cobo Winery	5,198	301	5.79
2	Nurellary Winery	5,419	146	2.69
3	Abaia Winery & Vineyard	2,010	72	3.58
4	Alpeta Agrotourism & Winery	24,000	233	0.97
5	Duka Winery and Vineyard	93	52	55.91
6	Kantina E Veras Isak	921	211	22.91
7	Kantina Mani	1,168	113	9.67
8	Kantina Balaj	1,627	203	12.48
9	Luani Winery	24,300	26	0.11
10	Kantina Gjergj K. Skenderbeu Durres	10,300	503	4.88
11	Kantina Kallmeti	2,947	129	4.38
12	Kantina Edoni	1,515	48	3.17

Source: <https://www.instagram.com>

In North Macedonia, Monastery Winery, which is the top-rated on Tripadvisor, has a total of 1,808 followers and 94 posts, with an engagement rate of 5.20.



Graph 3: Top 12 North Macedonian wineries by percentage of engagement rate

Source: <https://www.instagram.com>

If the number of followers is monitored, the situation looks different. Namely, Tikves Winery has the most followers, with a total of 13,400, with 1,442 posts and an engagement rate of 10.76 %. Chateau Kamnik winery has 8,648 followers and 248 posts with an engagement rate of 2.87 %.

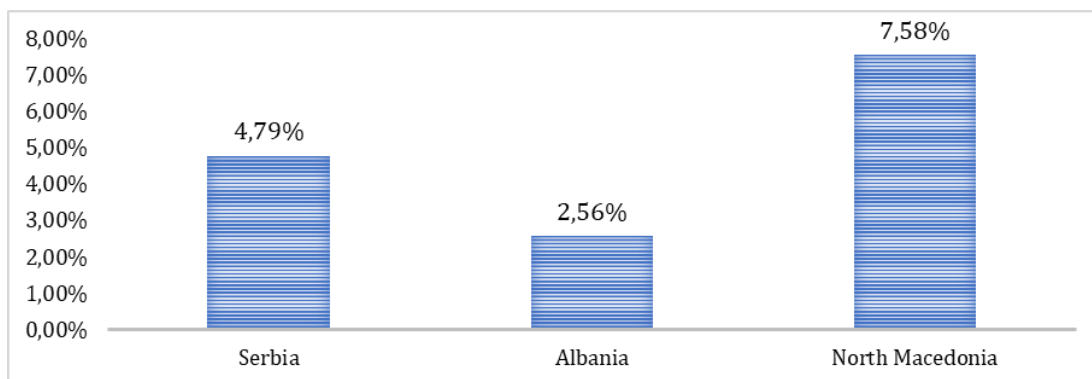
Table 4: Top 12 North Macedonian wineries by Instagram

no./country	North Macedonia	no. of followers	no. of posts	percentage (%)
1	Monastery Winery	1,808	94	5.20
2	Kartal Winery	2,539	227	8.94
3	Brzanov Artisan Winery	426	5	1.17
4	Tikves Winery	13,400	1,442	10.76
5	S&S Winery Ohrid	470	85	18.09
6	Chateau Kamnik	8,648	248	2.87
7	Jostela Winery	1,040	102	9.81
8	Stobi Winery	2,630	224	8.52
9	Winery Kuvín	2,457	180	7.33
10	Peshkov Family Winery	821	66	8.04
11	Wine Tourism	9,092	813	8.94
12	Royal Winery Queen Maria	3,758	81	2.16

Source: <https://www.instagram.com>

This means that engagement rate does not have to be a measure of success on social networks, especially in this case on the Instagram network. Consider the case of Malca Wine Cellar, which has only 59 followers, but also 28 posts with a low number of likes and a rather ineffective reach, with an extremely high engagement rate, even 47.46 %. On the other hand, Winery Zvonko Bogdan, which has by far the largest number of followers on the Instagram network, observed for all the most popular wineries in all

three countries of the Open Balkans, which has an engagement rate of 1.87 %, with a much larger number of posts, but with a noticeably higher effectiveness, as evidenced by numerous positive comments from followers.



Graph 4: Engagement rate by country

Source: <https://www.instagram.com>

At the level of all 36 most popular and best-known wineries in all three countries of the Open Balkans, wineries from Serbia have the largest number of followers, totaling 114,036, with a total of 5,458 posts and an engagement rate of 4.79%. Wineries from Albania have a total of 79,498 followers with a total of 2,037 posts and an engagement rate of 2.56%. Wineries from North Macedonia have a total of 47,089 followers with a total of 3,567 posts and an engagement rate of 7.58 %.

CONCLUSIONS

The study highlights the importance of maintaining active social media accounts with relevant content to increase reach and promote awareness of wines advertised on the Tripadvisor platform. Social media platforms, particularly Instagram, are highlighted as powerful tools for engaging with consumers and building brand presence. This study examines the digital presence and consumer engagement and responses to social networks used by wine producers in the Open Balkan countries, i.e. Serbia, North Macedonia and Albania. The study focuses on the use of promotion via Instagram (period between 2019 and 2023) and concludes that by maintaining active accounts with relevant content created in line with targeted strategic activities, the best-known wineries can increase their reach and promote awareness of their wines. With a classic approach, such as participating in the regional wine manifestation "Wine Vision by Open Balkan", social media platforms can serve as powerful tools to engage with consumers and build brand presence.

According to the Tripadvisor portal, the top-rated winery in Serbia is Podrum Probus. This winery has a total of 361 followers and only 8 posts with no links to other websites and no hashtags. This means that it may be missing an important opportunity to use social media effectively. The Winery Zvonko Bogdan appears to have a much stronger social media presence, with a significantly higher number of followers and posts. Their engagement rate of 1.87 % is also quite impressive, indicating that their content is resonating well with the target audience.

In Albania, there are differences in social media presence and engagement among the top-rated and best-known wineries. The top-rated winery on Tripadvisor, Cobo Winery, has a total of 5,198 followers and 301 posts, with an engagement rate of 5.79 %.

On the other hand, Alpeta Agrotourism & Winery has the most followers, totaling 24,000, but only 233 posts and an engagement rate of 0.97 %. This means that while they have more followers, their engagement rate indicates that their content is not as effective at engaging their audience.

In North Macedonia, Monastery Winery, which has the highest rating on Tripadvisor, has a total of 1,808 followers and 94 posts with an engagement rate of 5.20 %. If the number of followers is monitored, the situation looks different. Of the other North Macedonian best-known wineries, Tikves Winery has the most followers, a total of 13,400, with 1,442 posts and an engagement rate of 10.76 %.

At the level of the 36 most popular and the best-known wineries in all three countries of the Open Balkans, wineries from Serbia have the most followers, totaling 114,036, with a total number of 5,458 posts and an engagement rate of 4.79 %. Wineries from Albania have a total of 79,498 followers with a total number of 2,037 posts and an engagement rate of 2.56 %. Wineries from North Macedonia have a total of 47,089 followers with a total of 3,567 posts and an engagement rate of 7.58 %.

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THE APPLICATION OF BIOPOLYMERS IN CAPSULE PRODUCTION

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ABSTRACT

Active substances are rarely applied alone; instead, they are typically combined with one or more excipients/materials used to achieve the desired characteristics of the final drug form, i.e., for various specialized functions in the medicinal product. Excipients are added to the medicinal substance with the aim of enabling the intake/administration of the appropriate dose of the medicinal substance, facilitating the manufacture of a specific pharmaceutical form of the drug/medicinal product (final product), improving the patient's acceptance of the drug, and the "functioning" of the pharmaceutical form as a system that should deliver the medicinal substance to the site of action. Biopolymers are currently considered a key material in capsule production, playing a vital role in ensuring stability, controlling release, and enhancing the bioavailability of active ingredients. Various types of biopolymers are used for formulating biodegradable capsules, such as: polylactic acid, copolymers of poly(lactic-co-glycolic acid), poly(ϵ -caprolactone), gelatin, alginates, chitosan, hydroxypropyl methylcellulose (HPMC), methylcellulose, starch, etc. Through careful selection of biopolymers, it is possible to control the rate of drug release from capsules, enabling the achievement of desired pharmacokinetic profiles. This is essential for drugs that require slower or controlled release, as well as for combined formulations that integrate multiple active ingredients with different release needs. Furthermore, biopolymers provide stability to capsules during storage and transport, minimizing the degradation of active ingredients and maintaining the pharmaceutical efficacy of the product throughout its shelf life. These properties make them a key component in the development of long-lasting and reliable pharmaceutical formulations.

Keywords: biopolymers, capsules, pharmaceutical form, stability, release.

INTRODUCTION

Medicinal substances are combined with various excipients, and such a mixture is processed through appropriate technological procedures to obtain a product called a pharmaceutical dosage form. Pharmaceutical dosage forms can be simple formulations (drug dosage forms), such as powders, solutions, but also complex therapeutic systems (drug delivery systems) such as implants, liposome injections, transdermal patches, etc. (Vuleta et al., 2012). Medicinal substances are rarely administered alone as simple powders, but are usually combined with one or more excipients/substances used to achieve the desired characteristics of the final drug form, i.e., for various specialized functions in the medicinal preparation. Excipients are added to the medicinal substance to enable the administration of the appropriate dose of the medicinal substance, facilitate the manufacture of a certain pharmaceutical dosage form/medicinal preparation (final product), improve the patient's acceptance of the drug, and the functioning of the pharmaceutical form as a system that should deliver the medicinal substance to the site of action. Excipients enable/promote dissolution, suspension, thickening, dilution, emulsification, stabilization, preservation, coloring, flavoring, and shaping of the medicinal substance into efficient and aesthetically acceptable medicinal preparations. The medicinal substance, appropriate pharmaceutical form of the substance, and packaging constitute the so-called therapeutic triad, which affects the quality, safety, and efficacy of the drug. Excipients/materials included in medicinal preparations have various "specialized" roles and specific technological characteristics (Vuleta et al., 2012).

Biopolymers are widely used in pharmaceutical products, traditionally as excipients, such as binders, fillers, thickeners, and disintegrants. A brief review of the Pharmaceutical Handbook of Excipients reveals a large number of biopolymers listed for pharmaceutical use (Rowe et al., 2009). Biopolymers are used in most pharmaceutical forms including: oral use, ocular use, nasal sprays, topical formulations (gels and ointments), lung delivery forms, and even parenteral delivery. Traditional drug forms are the subject of much research to improve stability and drug efficacy, reduce costs, increase patient adherence to prescribed therapy, and enhance therapeutic performance. The wide range of biopolymers, available as diverse compounds with varied properties and natural origins with the possibility of easy production, makes them popular in pharmaceutical research. In addition to numerous applications in traditional dosage forms, biopolymers have recently been used for the controlled delivery of biological substances such as proteins, peptides, and vaccines (Ebnesajjad, 2013). Pharmaceutical dosage forms based on the rate of release of the medicinal substance, the rate of achievement, and the duration of action after administration, in the broadest sense, can be classified as:

- Conventional pharmaceutical forms,
- Modified-release pharmaceutical forms.

Modern unconventional drug dosage forms represent a highly heterogeneous group of complex systems and special carriers of active substances including:

- Drug delivery systems (DDS),
- Drug carriers, Drug carrier systems (Vuleta et al., 2012).

Carriers for biological therapeutic substances (active substances obtained by modern biotechnology methods/biopharmaceutical drugs) vary, ranging from well-known excipients of natural origin to purposefully designed synthetic excipients with "enhanced" protection and targeting capabilities. However, natural and semi-synthetic excipients still prevail.

The wide application of biopolymers is a consequence of a good understanding of their properties (years of experience in their use) and good physiological tolerance. An additional reason for their use is the fact that new synthetic substances require long and expensive safety testing before human use. This complicates their timely evaluation, except for the use of in vitro and animal models (Vuleta et al., 2012).

THE PRODUCTION PROCESS OF BIOPOLYMER CAPSULES

Pharmaceutical capsules are solid dosage forms composed of a shell of soluble polymer enclosing drugs and excipients, in powdered, liquid, or semi-solid form, as well as in pellet or granule form (Debotton and Dahan, 2017; Kharkwal et al., 2013). Although rectal or vaginal capsules are occasionally used, oral capsules are far more prevalent in clinical practice, as oral intake of solid pharmaceutical forms (tablets and capsules) is a convenient and most common way of taking medication (Debotton and Dahan, 2017). According to the flexibility of the shell, two types of capsules can be produced: soft and hard (Jones, 2004; Debotton and Dahan, 2017). Most two-piece hard capsules used for pharmaceutical products are made of gelatin, first produced in 1834 by Francois Mothes, who immersed a mold into a gelatin solution and allowed it to dry before removing the resulting capsule (Ebnesajjad, 2013; Vilivalam, 2009). Since then, this technology has been continuously refined and improved, resulting in the variety of capsule forms available today, and there are ongoing efforts to find alternative substances to replace gelatin (Vilivalam, 2009).

The capsule shell is made of synthetic or natural substances. Today, synthetic capsules, due to environmental concerns, are mostly being replaced by biodegradable capsules. Biodegradable capsules have certain advantages over synthetic capsules. They are made from biopolymers, renewable, and biodegradable raw materials. Various types of biopolymers are used for formulating biodegradable capsules, such as polylactic acid, poly(lactic-co-glycolic acid) copolymers, polycaprolactone, gelatin, alginates, chitosan, HPMC, methylcellulose, starch, etc. (Kharkwal et al., 2013). Gelatin, purified protein fractions of animal collagen, are most commonly used as biopolymers for capsule production. Gelatin is produced by partial acidic hydrolysis of collagen (gelatin A) or partial alkaline hydrolysis of collagen (gelatin B) (Plackett, 2011; Debotton and Dahan, 2017). The properties of the final gel of gelatin, which serves as an important starting material for capsule production, depend not only on the pH value but also on the molecular weight, temperature, aging time, and concentration (Plackett, 2011). Type A contributes to the plasticity and elasticity in the mixture of excipients, compared to the properties of type B that yield extremely strong gels. Therefore, both types of gelatin are used in the pharmaceutical industry as capsule shells, either separately or in a combined blend, according to the desired physical properties of the pharmaceutical form (Debotton and Dahan, 2017). Gelatin A produces capsules that are softer and more transparent than gelatin B (Plackett, 2011). When gelatin is combined with suitable plasticizers (such as sorbitol or glycerin), soft capsule shells can be obtained (Debotton and Dahan, 2017).

Gelatin can be used for the production of hard and soft elastic capsules (Jones, 2004; Debotton and Dahan, 2017). In the first category, the capsule shell is composed of gelatin, sugar, water, and color (if necessary). The gelatin capsule is filled with active components and additionally, fillers (filling agents or diluents) are added. Fillers, such as starch and microcrystalline cellulose, are used to achieve the appropriate filling volume in the capsule and can also provide powder cohesion to aid in capsule filling.

To assist in the disaggregation of the capsule contents in gastrointestinal fluid, various starch derivatives such as pregelatinized starch and sodium starch glycolate are added to the capsule filling. In contrast, soft gelatin capsules are made from gelatin that is plasticized by adding glycerol or sorbitol. This type of capsule is used for hermetically sealing and encapsulating liquids, suspensions, or dry powders (Jones, 2004). Compounds encapsulated in soft gelatin capsules include pharmaceutical preparations such as anti-inflammatory agents (e.g., ibuprofen) and antihistamines (e.g., chlorpheniramine maleate). Further examples of soft gelatin capsules include dietary supplements, which encompass phospholipids (e.g., lecithins) and carotenoids (e.g., lycopene and lutein), personal care products (e.g., bath oils) (Plackett, 2011). The production processes for obtaining hard and soft gelatin capsules are different and require special equipment (Jones, 2004).

The production principle of two-piece hard gelatin capsules, by molding immersion, has remained relatively unchanged since its first application in the 19th century by Mothes. Today, capsule production is carried out using automated machines, where stainless steel pins (for the body and cap) are immersed in a water solution of gelatin (25-30% w/w), maintained at around 50-55°C. Once the pins are withdrawn, they rotate to evenly distribute the gelatin and are cooled below the gelation temperature. The capsules are then dried under controlled humidity, removed from the pins, processed, and assembled. Typically, the capsules are prepared with a self-locking mechanism or can be hermetically sealed once filled with medicinal content (Ebnesajjad, 2013).

The production process of soft gelatin capsules consists of several steps: preparation of the gelatin solution, preparation of capsule filling materials, encapsulation, drying, quality control, polishing, and packaging. In the gelatin solution preparation phase, gelatin granules are mixed with glycerin and water. Additionally, colors can be added at this stage. Glycerin acts as a plasticizer for gelatin. Other plasticizers may also be used alone or in combination with glycerin, such as sorbitol. The proportion of each component included in the mixture needs to be carefully considered, as the capsule material needs to be adapted to the formulation and/or environmental requirements. For example, the gelatin proportion may need to be adjusted to acidity, moisture content in the filling material, or conditions with high humidity. After combining the ingredients, the mixture is transferred to a reactor labeled as a gelatin melting reactor. The reactor has a jacket for heating the mixture, while a high-speed turbine mixer under vacuum mixes the content until the gelatin is transformed into a dissolved liquid mass. Once the liquid gelatin mass is ready for the encapsulation process, it is transferred to heated reservoirs that are moved to a clean room, where the main encapsulation machine is located (Figure 1). It is extremely important that the gelatin solution remains warm before and during the encapsulation process; otherwise, it will gel and solidify. The prepared capsule filling material must be homogeneous to ensure the uniformity of each dose of the soft gelatin capsule, as well as certain consistency and viscosity properties to pass through the capsule filling injection machine appropriately (<https://www.pharmacy180.com/article/soft-gelatin-capsules-2844/>).

The encapsulation is a production process that involves the joining of the gelatin shell and the filling material to form soft gelatin capsules. This occurs in a closed environment called a clean room, where the relative humidity is around 20%. Gelatin and the filling material are combined in an encapsulation machine (Figure 1).

A pump delivers warm gelatin solution over two cooled drums located on opposite sides of the machine, through a spraying chamber located above each drum. The warm liquid gelatin flows over the drums and transforms into two solid gel films. The left and right film strips pass over rollers, which guide them between two rotating dies that determine the shape and size of the soft gelatin capsules and cut the capsule shells from the film as they rotate. Simultaneously, a sensitive and highly precise pump delivers the filling material into a heated injector, located between the rotating dies. The injector injects the filling material into the cavities between the strips just before the rotating dies cut the film and seal the two halves together. Cold, dry air solidifies the gelatin as the drum rotates, pulling out the sticky, elastic strip at the other end. The resulting gelatinous, thin strip is continuously and automatically formed into capsules, which are filled with drugs, vitamins, or other products, sealed, and collected in a shallow outlet channel for the finished product. If the air blowing onto the drum is too low in temperature, the gelatin will quickly cool and form a brittle film, which can halt the production process. Excessive air speed will disrupt the sustainable thickness of the gelatin film being formed. If the air temperature and humidity are too high or the air speed is too low, the gelatin will not solidify into a film. Therefore, constant control of the air entering the drum is extremely important in the process (<https://www.pharmacy180.com/article/soft-gelatin-capsules-2844/>).

After the formation, the soft, moist capsules are transferred to drying drums or rapid drying chambers. The amount of moisture removed during drying depends on the size of the capsule, the number of capsules, and the drying time. The final step before packaging is cleaning and polishing the soft gelatin capsules to remove any residues of mineral oil or glycerin that the capsules may have on the outer shell. The most useful production method for cleaning soft gelatin capsules is tumble processing, among others, such as solvent washing. There is no difference in packaging soft gelatin capsules compared to traditional tablets or hard capsules. Any finished product of soft gelatin capsules should be stored in an environment with a temperature around 20-24°C and a relative humidity of 35% (<https://www.pharmacy180.com/article/soft-gelatin-capsules-2844/>).

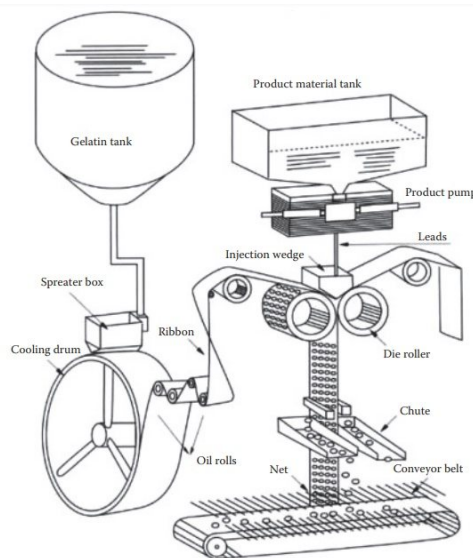


Figure 1. Production process of soft gelatin capsules
(<https://www.pharmacy180.com/article/soft-gelatin-capsules-2844/>)

Under conditions of high humidity and high temperature, gelatin can react with many pharmaceutical excipients present in capsules, including: anionic and cationic polymers, aldehydes and aldose sugars, electrolytes, metal ions, plasticizers, preservatives, and surfactants. With aging, these reactions eventually lead to cross-linking of stressed gelatin and the formation of a covalent bond between the amino group of the lysine side chain of one gelatin molecule with a similar amino group of another gelatin molecule. Cross-linking of gelatin forms a thin, swollen, and water-impermeable membrane barrier (pellicle) on the inner/outer surface of the capsule shell, which greatly reduces the rate of release of the pharmacologically active substance. To avoid cross-linking, extremely pure excipients and gelatin highly resistant to cross-linking should be used. In the case of granulated and/or compressed fillings, appropriate disintegrants should be added to the content of hard gelatin capsules. To improve the dissolution of the diuretic agent hydrochlorothiazide from hard gelatin capsules, 4% superdisintegrant - cross-linked sodium carboxymethylcellulose is necessary, while dissolution from capsules without disintegrants is in accordance with diffusion from insoluble matrix forms (Debotton and Dahan, 2017).

Gelatin is the material of choice for capsule production due to its exceptional film-forming properties and rapid dissolution in gastric fluid. However, pharmaceutical companies have been compelled to develop non-gelatin capsules or replace them with capsules obtained from non-animal sources for various reasons, including the increasing number of vegetarians, religious objections to animal products, and the instability of hygroscopic drugs or those containing reactive aldehyde groups (Ebnesajjad, 2013; Kharkwal et al., 2013). Several alternatives to gelatin capsules are available on the market, based on biopolymers such as HPMC (Ebnesajjad, 2013; Debotton and Dahan, 2017) chitosan (Plackett, 2011) starch (Vilivalam et al., 2000; Bae et al., 2007), pullulan (Mishra et al., 2011), blends such as HPMC and κ -carrageenan, HPMC and gellan gum (Ebnesajjad, 2013), starch and pectin, pectin and casein, sodium alginate and chitosan, chitosan and chitosan sulfate (Kharkwal et al., 2013). Capsules consisting of HPMC are an attractive alternative to gelatin because HPMC is of plant origin obtained semi-synthetically. Therefore, hard HPMC capsules are the most popular among vegetarian formulations and over-the-counter products (Debotton and Dahan, 2017). HPMC capsules are designed to dissolve and release their contents in the stomach (Ebnesajjad, 2013). Experience indicates that HPMC, compared to gelatin, prolongs the *in vitro* disintegration time and the dissolution rate of the medicinal substance/substances from the capsules but essentially does not affect *in vivo* bioavailability. This observation has been confirmed for the antibiotic azithromycin, where the *in vitro* dissolution time and pharmacokinetic parameters are similar for HPMC capsules compared to gelatin capsules, using superdisintegrants such as sodium croscarmellose and sodium starch glycolate (Debotton and Dahan, 2017). In the production of HPMC capsules, HPMC is the film-forming substance, κ -carrageenan, and gellan gum are gelling agents that provide structure to HPMC during production (Ebnesajjad, 2013).

One of the possible alternatives to gelatin capsules is the use of chitin and chitosan. Materials based on chitin/chitosan find applications in the form of powders and flakes, but most commonly as gels used for capsule formation. Gel preparation is a crucial phase in capsule production. Methods for preparing chitosan gels, as described in the literature, can be categorized into five groups:

- solvent evaporation method (casting method), commonly used,
- neutralization method, by adding NaOH solution to the chitosan solution,

- cross-linking method,
- ionotropic gelation method, by adding dropwise a solution of anionic polyelectrolyte (alginate, carrageenan, xanthan) into acidic chitosan solution,
- freeze-drying process, which involves freezing the chitosan solution or gel, followed by lyophilization (Plackett, 2011).

Capsules made from chitosan have additional value due to their antibacterial and anticarcinogenic effects (Alami and Permatasari, 2016). A direct alternative to hard gelatin capsules is starch capsules, a unique solid oral pharmaceutical form made from potato starch. In search of a method that could replace the molding of gelatin capsules, Capsugel® (a division of Warner Lambert) investigated and developed the injection molding technique for producing starch capsules (Capill®) (Vilivalam et al., 2000). In some aspects, starch capsules can be considered equivalent to hard gelatin capsules. However, starch capsules have several advantages: dissolution is pH-independent, they are suitable for enteric coating, moisture in the capsule wall is tightly bound to starch, capsules with tamper-evident features, and without preservatives are made from non-animal ingredients. The hard shell capsule made from potato starch consists of two parts, the cap (lid) and the body, which are sealed together at the time of filling to prevent separation. Sealing is achieved by applying a hydroalcoholic solution to the inner part of the cap just before placing it on the body.

Recent advancements in injection molding technology have enabled the production of starch capsules. Various authors have described this process in detail, with the basic parts of a conventional injection molding machine illustrated in Figure 2. During the production process, starch feed (in powder, granule, or pellet form) is fed through a rotating auger feeder. The feed material moves along the screw towards the head. During this process, the temperature increases using external heaters, around the outer cylinder and due to the action of the screw's rotation. From the feed zone to the compression zone, the fed material gradually melts. It then passes through the metering zone, where solution homogenization occurs, to the end of the plunger screw. Once a sufficient amount of injection solution is collected, it is injected into the mold. Screw rotation stops while the polymer in the mold cools enough for the mold to be opened and the formed parts ejected. Pressures between 700-2000 bar and temperatures between 120-180°C are usually monitored in the transfer, injection, and forming operations. From start to finish, the molding process temperature is maintained below the glass transition temperature for starch, and the complete cycle time is typically a few seconds (Vilivalam et al., 2000).

The production of the body and cap of starch capsules is separate, requiring existing capsule filling machines to be modified for filling and sealing starch capsules. Starch capsules can be produced in different sizes (size numbers 0, 1, 2, 3, and 4) by changing the mold. The fundamental advantage of the capsule design is that caps of the same size fit different body lengths. The diameter of the cap-body junction is always the same for all sizes of starch capsules. Unlike the "enclosed" closure of gelatin capsules, the cap of a starch capsule is evenly placed over the body, creating a good finishing surface. This is another advantage because the capsule opening can be easily detected (tamper-evident). Starch capsules are odorless and rigid, exhibiting similar dissolution behavior to gelatin capsules. *In vitro* release studies of acetaminophen, as a model drug, have shown that the release properties of starch capsules are independent of pH. Storage conditions, especially humidity, significantly influence the integrity of these types of capsules. Typically, the moisture content in starch capsules ranges between 12-14% w/w, with more than 50% firmly bound to the starch.

The presence of bound moisture suggests that starch capsules may have better stability properties and reduced susceptibility to changes during storage (Vilivalam et al., 2000).

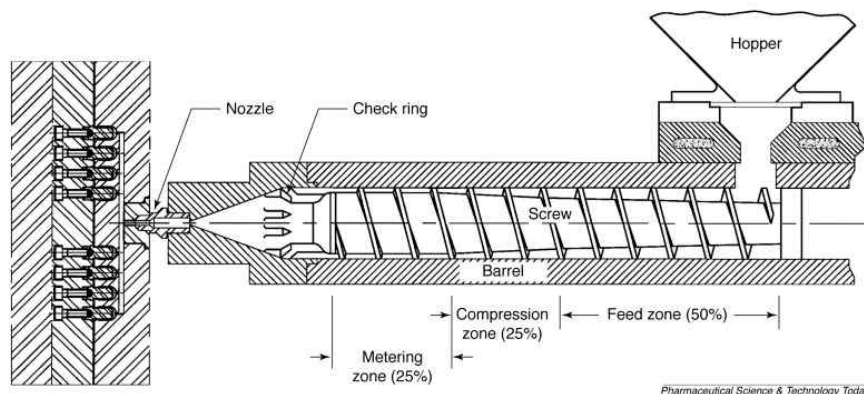


Figure 2. Schematic representation of a section of the production equipment for injection molding of starch capsules (Vilivalam et al., 2000).

The physical and mechanical characteristics of biodegradable films obtained using starches from different plant sources have been investigated and evaluated. Among the tested samples, samples of examined plant species (sweet potato, golden mung bean, Chinese water chestnut) have relatively good mechanical and physical properties compared to gelatin and HPMC films and low-density polyethylene. Starch films have better oxygen barrier and improved water barrier compared to gelatin and HPMC. The tested starches were used to produce hard capsules for the pharmaceutical industry using conventional dip molding technique. The produced starch capsules are transparent, have smooth surfaces, and are flexible. Starches with a high amylose content provide better films and capsules compared to those with low amylose content and high amylopectin content. Starch capsules are produced without gelling agents in highly amylose starches. Starch capsules do not completely disintegrate and have some fragments in water or HCl solution (Bae et al., 2007). Capsules made of pullulan are used instead of gelatin due to different cultural and dietary needs, for delivery involving vegetarians, diabetics, and patients with limited diets (Mishra et al., 2011).

CONCLUSIONS

The production process of biopolymer capsules, such as gelatin, HPMC, or starch capsules, represents a complex and precise procedure that requires careful balancing of material selection, technological parameters, and process steps. Biopolymer materials such as gelatin, HPMC, chitosan, or starch enable various characteristics of capsules and determine their application in the pharmaceutical industry. While traditional gelatin capsules prove to be an efficient choice for rapid dissolution and release of active substances in the gastrointestinal tract, biopolymer alternatives like HPMC and starch capsules offer the possibility of vegetarian and vegan options, as well as greater stability under certain storage conditions. The production processes of these capsules require precise techniques, temperature and humidity control, as well as the use of appropriate additives to ensure stability and quality of the final product. Additionally, research on new biopolymer materials and technological innovations continuously contribute to the development of pharmaceutical capsules that are efficient, safe, and tailored to various patient needs and therapy requirements.

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