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TABLE EGG PRODUCTION AND QUALITY

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ABSTRACT

To analyze table egg production and quality, research was performed on a poultry farm in the vicinity of Kruševac City. During the trial 60 ISA Brown hens aged between 51 and 59 weeks were monitored. Hens were housed in cage system. There were five hens in every cage. Delivery of water for drinking was automatized while the feed distribution was manual. Twice a day (morning and afternoon) and total feed amount was 3.6 kg per single distribution. During the trial, feed consumption, egg production, and egg quality were observed. The trial consisted of three-week intervals, respectively, at ages 51–53, 54–56, and 57–59 weeks. The differences between the monitored intervals were not statistically significant for average feed consumption, egg size (weight, height, width, and shape index), or the weight of the egg white, yolk, and shell ($p>0.05$). Egg laying was statistically significantly higher in the first two trial intervals compared to the third ($p<0.05$). The average number of eggs laid during the trial period was 57.43, 57.19, and 54.62, respectively. For most monitored parameters, statistically significant and highly significant correlations were noted ($p<0.05$, $p<0.01$). The Pearson correlation coefficients between egg weight and both outer and inner indicators of egg quality ranged from $r = 0.363$ to $r = 0.877$ throughout the entire trial period.

Keywords: *table eggs, quality, laying rate.*

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INTRODUCTION

Modern poultry production enables providing the great quantitites of high quality products for human nutrition in a relatively short period (Đekić et al., 2011). Both in developed and especially developing countries, poultry eggs are much more available for human nutrition than some other sources of products of animal origin. This fact gives an advantage to poultry breeding in comparison with other species of domestic animals (Shi et al., 2009). Poultry eggs have an exceptionally high nutritive value and are easily digestible. They are important foodstuff in human nutrition due to a high content of protein, simple preparation, large-scale availability on the market and low price in comparison with some other sources of protein of animal origin (Mendoza-Rodríguez et al., 2016). Egg quality is a concept that refers to different standards which define both an external and internal traits of eggs. A level of eggs consumption depends on those traits (Portillo-Salgado et al., 2020). All the traits of egg quality are affected by a few factors such as genotype and age of laying hens, nutrition, breeding system and a time period of egg laying (Ahmadi and Rahimi, 2011; Yang et al., 2014). An appropriate nutrition regime in an intensive poultry breeding system has an important role from the aspect of improving egg quality (Tolkamp et al., 2005), feed efficiency and flock profitability (Olawumi, 2014). An egg mass is the most important trait of egg external quality and depends directly on the way of providing the laying hens with feed (Anene et al., 2023). It is an important trait that can influence egg quality and represents a parameter for egg grading (Farooq et al., 2001). Mass and internal quality of egg have a great importance from the aspect of nutritive value and laying of egg (Shi et al., 2009). Egg mass is directly proportional to the mass of egg white, yolk and egg shell (Marion et al., 1964). During an egg-laying cycle the egg mass is increasing while the thickness and strength of shell are decreasing since the shell quality depends directly on the egg mass (Duman et al., 2016). Some authors state that high correlation between some external traits of egg quality (egg mass, egg length and width, shell weight) can serve as indicators of quality of some internal egg traits such as masses of egg yolk and white (Fajemilehin, 2008; Çiftsüren and Akkol, 2018). This way can facilitate the estimation of quality of egg internal traits without breaking the egg. The aim of this research was to examine the impact of twice a day feeding on egg production and to determine a correlation between the external and internal traits of eggs.

MATERIAL AND METHODS OF WORK

The research was carried out on a layer poultry farm in the vicinity of Kruševac City. The trial was carried out on a sample of 60 ISA Brown (SSL) laying hens being in the 51st to 59th weeks of age. The trial was set up according to the model of one-factorial trial in which the impact of three age periods was analyzed. The birds were placed in the cages of 50x50 cm dimensions, set up in three levels. Each cage housed 5 laying hens. Water supply was automatic via water nipple drinker while the distribution of feed was performed manually twice a day (at 6.00 am and 18.00 pm) the quantity of concentrate in each feed distribution being 3.6 kg. The composition of the concentrate mixture and ration nutritive value are presented in Tables 1 and 2.

Table 1. Composition of concentrate mixture

Components of concentrate mixture	Quantity of feed (%)
Corn	61
Soybean meal	10.6
Sunflower meal	8
Extruded full fat soybean	9
Calcium carbonate	9
Monocalcium phosphate	0.75
Salt	0.4
Vitamin and mineral premix*	1.25

*Mixture of vitamins and trace elements, 1 kg contains: Vitamin A (1000 UI) – 10000; Vitamin D (1000 UI) – 1500; Vitamin E – 10 mg; Vitamin K – 1 mg; Vitamin B_1 – 2 mg; Vitamin B_2 – 3 mg; Vitamin B_4 – 300 mg; Vitamin B_6 – 1.5 mg; Folic acid – 1.5 mg; Niacin – 50 mg; Metionine – 100 mg; P – 7 gr, J – 1.4 mg, Fe – 50 mg, Zn – 50 mg, Co – 0.7 mg.

Table 2. Nutritive value of ration

Parameter	Value
Crude Protein, %	15.05
Lysine, %	0.71
Methionine + cystine, %	0.55
Crude Fat, %	4.03
Fiber, %	2.50
Ash, %	12.61
Calcium, %	3.70
Phosphorus %	0.47
Sodium, %	0.17
ME, MJ/kg	10.40

In the course of the trial a feed consumption was monitored together with an egg production and quality of eggs in three-week intervals i.e. in 51 – 53, 54 – 56 and 57 - 59 weeks of age, respectively. Records on feed consumption were obtained by measuring both the quantity of feeds consumed during a trial period and non-consumed feed remains upon every meal. Mass, height and width of eggs were recorded at the end of every three-week period. The mass of eggs was measured on a digital scale while the height and width of eggs were measured by a vernier scale. On the basis of length and width of eggs the index of the shape of egg was calculated [index of shape = (width/length) x 100]. An internal quality of egg was analysed by means of various parameters such as the mass of shell, mass of egg white and mass of yolk. The masses of egg white and yolk and the mass of shell were measured on a digital scale**.**

During a procedure of data statistical processing the parameters of statistics (arithmetic mean, standard deviation) were determined. Data statistical processing was performed by means of a GNU PSPP (2024) computer program (accessed 15.12.2024). Statistical significance of differences between studied parameters was analysed using an ANOVA model and a test of the least significant difference (LSD). Besides, by calculating a Pearson correlation coefficient an interdependence of the mass of egg, the external and internal traits of egg quality were determined. Statistical analysis was conducted at $p<0.05$ and $p<0.01$ levels of significance.

RESULTS AND DISCUSSION

Daily production of eggs and feed consumption in the trial are presented in the graphs 1 - 3.

Figure 1. Daily feed consumption and egg production during the first three weeks of the trial

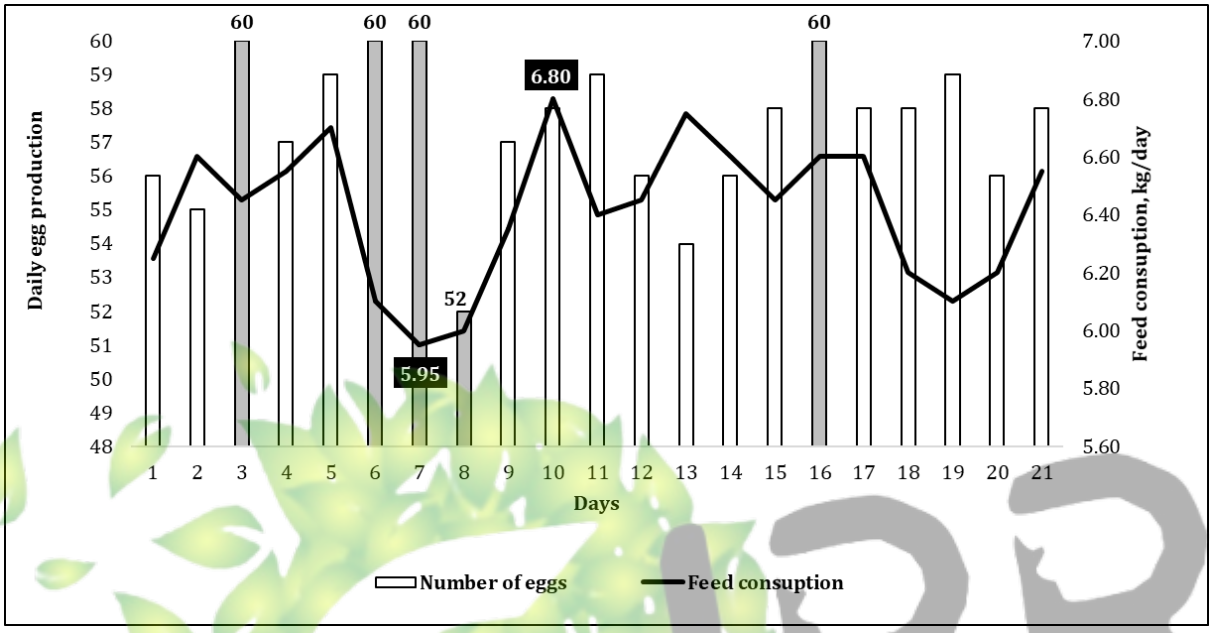


Figure 2. Daily feed consumption and egg production during the second three weeks of the trial

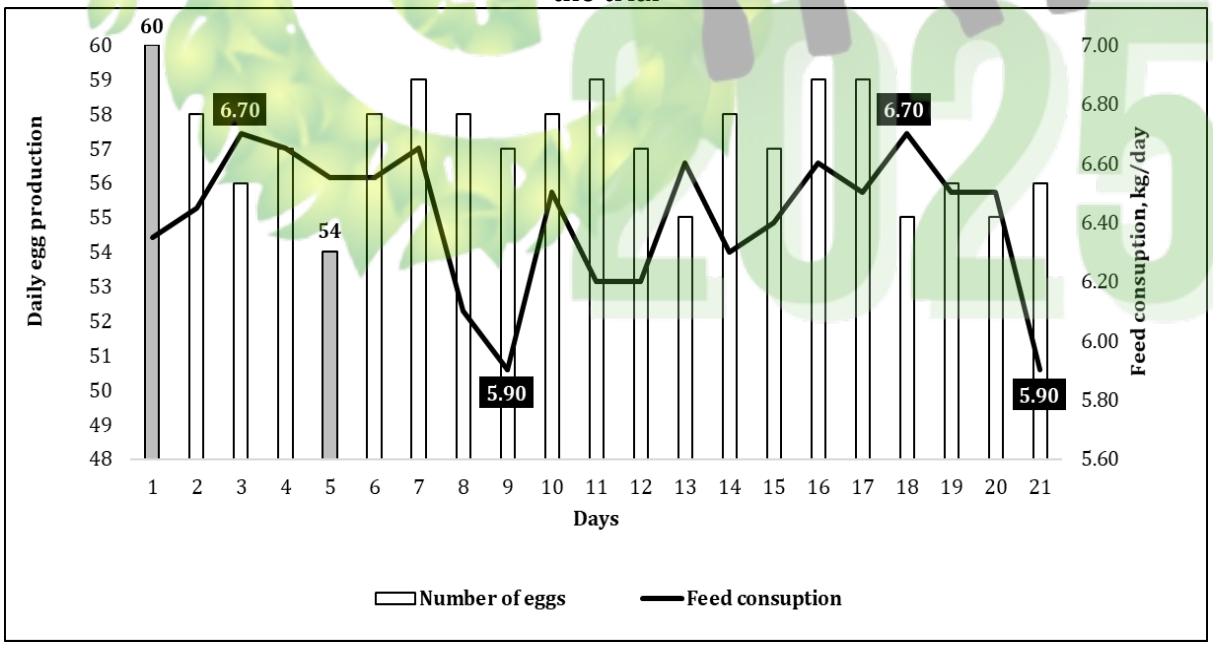
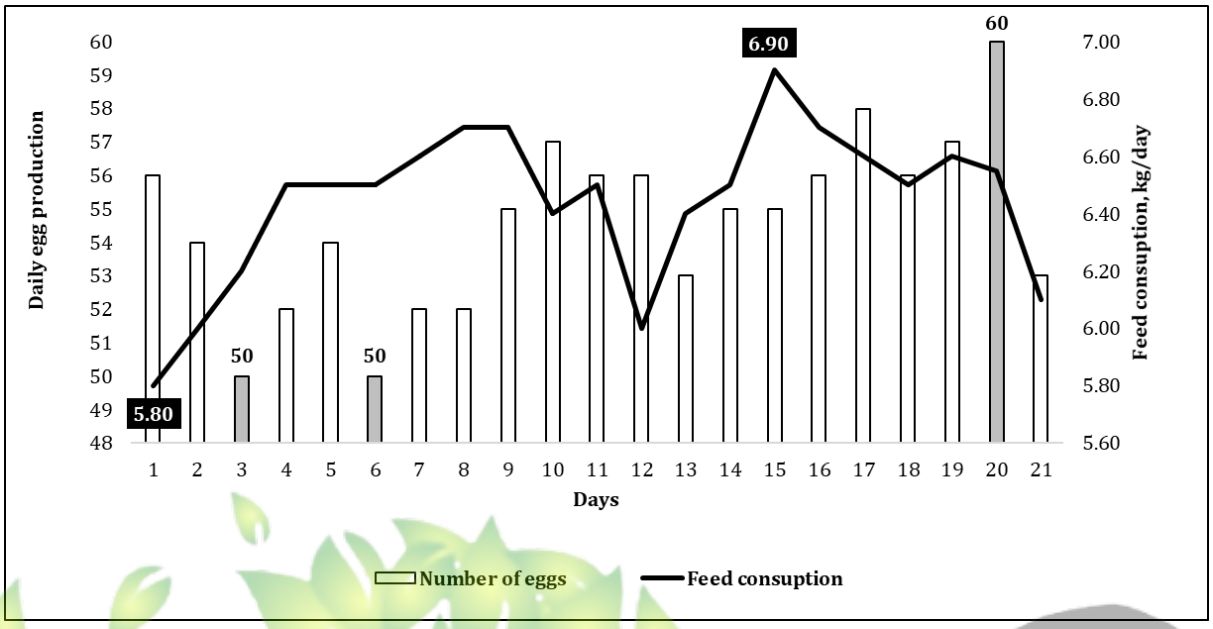


Figure 3. Daily feed consumption and egg production during the last three weeks of the trial



Data presented in the graphs 1, 2 and 3 show similar variations of daily feed consumption (5.95 to 6.80; 5.90 to 6.70 and 5.80 do 6.90 kg/day, respectively) in laying hens. A daily egg production varied in the intervals of 52-60, 54-60 and 50-60, in the first, second and the last three weeks of trial, respectively. In other words, greater variations were observed in the last three weeks compared to the first two weeks of the trial.

An average feed consumption, average egg production and the values of the traits of egg quality are presented in Table 3.

Table 3. Average feed consumption, average egg production and egg quality indicators

Indicators	51 – 53. weeks		54 – 56. weeks		57 – 59. weeks		*p*
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ	
Feed consumption, kg/day	6.41	0.25	6.42	0.24	6.44	0.27	0.931^{ns}
Egg production	57.43	2.13	57.19	1.63	54.62	2.56	0.004**
Egg mass, g	62.33	4.61	62.76	5.62	63.10	5.50	0.895^{ns}
Egg height, mm	57.05	1.66	57.19	1.89	57.33	2.69	0.910^{ns}
Egg width, mm	44.71	1.68	44.81	1.86	45.14	1.90	0.726^{ns}
Width-lenght ratio, %	78.42	3.23	78.39	3.22	78.80	2.62	0.891^{ns}
White mass, g	38.43	4.11	37.81	5.25	37.71	4.23	0.859^{ns}
Yolk mass, g	15.86	1.59	16.33	1.20	16.67	1.85	0.252^{ns}
Eggshell mass, g	8.19	1.25	8.43	1.03	8.57	1.29	0.582^{ns}

On the basis of the results displayed in Table 3 it can be concluded that with the ageing of laying hens an average volume of feed consumption increases (6.41; 6.42; 6.44 kg/day, respectively) but differences between age periods were not statistically significant ($p>0.05$). Similar results were obtained also by Shim et al. (2013) who determined a 0.05kg/day increase in feed consumption in 55 to 59 weeks old laying hens in relation to 51 to 54 weeks old laying hens.

On the other hand, Khatibi et al. (2021) in their research report that with the ageing of laying hens a daily volume of feed consumption decreases. Mentioned authors came to a conclusion that in 49 to 60 weeks old laying hens a daily volume of feed consumption decreases by 2.1%. Some studies show that greater volume of feed consumption in laying hens can affect negatively the uniformity of flocks and external and internal parameters of egg quality (Parkinson et al., 2015). However, an increased volume of feed consumption is not always connected with higher egg production (Lacin et al., 2008). The main factor in the expenses of an intensive production of edible eggs is the nutrition of laying hens while the income in this production is determined by a volume of feed consumed, number, size and quality of eggs, health state and the care of poultry welfare issues (Anene et al., 2023).

The lowest average egg production (54.62) was obtained by 57 to 59 weeks old laying hens (Table 3). It was 4.9% less compared to hens in the age 51 to 53 weeks, and 4.5% less than during the 54-56 week period. Differences between various ages were statistically very significant ($p<0.01$). These results are in line with the results obtained by numerous authors who suggest that with the ageing of laying hens the volume of egg production decreases (Khatibi et al., 2021; Anene et al., 2021; Shim et al., 2013; Đekić et al., 2013). Some studies suggest that restrictive feeding during the first 40 weeks of age can decrease the egg production by 3.6%. However, such nutrition, in older age can increase the egg production by 0.7 % (Saibaba et al., 2021).

By analysing the data (Table 3) it can be observed that in all the parameters of egg quality there were no statistically significant differences between different time intervals in the trial ($p>0.05$). An average egg mass increased by intervals (62.33; 62.76; 63.10g, respectively) but differences were not statistically significant. Similar results were obtained also by Biesiada-Drzazga et al. (2022) who determined that egg mass in laying hens between 50 and 60 weeks of age ranged in the interval of 64.51 to 65.40g, respectively. Shim et al. (2013) report that egg mass in laying hens 51 to 62 weeks old increases by 2% while Khatibi et al. (2021) report that in the same age of laying hens an egg mass increases by 7%. Paleja et al. (2008) determined that egg mass was 52.43g in laying hens 56 weeks old while the egg mass in the laying hens 51 and 72 weeks old was 62.20, i.e. 63.29 grams, respectively (John-Jaja et al., 2016). In several studies the authors point to the fact that in over 50 weeks old laying hens feeding two times a day can have a positive effect both on the mass and internal egg quality (Saibaba et al., 2021).

The average values of the height and width of eggs were very similar in all trial intervals (Table 3). Namely, the highest height (57.33mm) and width of eggs (45.14mm) were determined in the laying hens from 57 to 59 weeks of age. It suggests the fact that with the ageing of laying hens the values of mentioned parameters increase. In the research conducted by Biesiada-Drzazga et al. (2022) somewhat higher values for egg height (59.53mm) were determined but somewhat lower for egg width (43.23mm) in the same age of laying hens. Abanicannada and Leigh (2012) report that the egg height ranged in the interval of 56.5 to 57 mm in 44 to 65 weeks old laying hens. The same authors suggest that in the same age of laying hens the width of eggs ranged in the interval of 42.4 to 42.95mm. Similarly to the height and width of eggs, the index of egg shape during the trial was almost identical (78.42; 78.39; 78.80, respectively). The results of our trial are incompatible with the results of Nikolova and Kocevski (2006) who came to a conclusion that average value of the egg shape index in laying hens over 45 weeks of age was 74.17%.

An average egg white mass had a tendency of decreasing during the trial but those differences were not statistically significant ($p>0.05$) as shown in Table 3. The mass of egg white in the first interval of research was on average higher by 0.72 grams compared to the mass of egg white in the last interval. The studies by some authors suggest that with the ageing of laying hens the mass of egg white increases by 2.22, i.e. by 3.63 grams (Khaitibi et al., 2021). However, Biesiada-Drzazga et al. (2022) report that the mass of egg white did not differ in 50 to 60 weeks old laying hens and that those values were 37.49 i.e. 37.07 grams, respectively. Many authors report that control of volume of feed consumption in laying hens can stimulate egg production with better egg white quality (Anene et al., 2021; Moreira et al., 2021).

Lower mass of egg yolk indicates greater compactness of eggs while greater mass of yolk can be connected with an increased accumulation of fats in the laying hen body or with depositing the fatty matters in yolk (Anene et al., 2023). The results of the research suggest the increase of yolk mass with ageing of laying hens (15.86; 16.33; 16.67g, respectively) but these differences were not statistically significant (Table 3). Similar results were achieved also by Shim et al. (2013) who determined that egg yolk in laying hens between 51 and 54 weeks of age was 16.23 grams, in the laying hens between 55 and 58 weeks of age 17.20 grams and in laying hens from 59 to 62 weeks of age 17.23 grams. Biesiada-Drzazga et al. (2022) report that difference in the mass of yolk was higher by 1.7 grams in laying hens 60 weeks old in comparison with layers 50 weeks old. Studies showed that greater egg mass is not often the consequence of a larger volume of feed consumption but the result of the increased deposition of lipids in yolk what leads to increasing both the mass of yolk and mass of eggs (Li et al, 2011).

Average mass of egg shell has a similar tendency of decreasing as the mass of yolk. The highest mass of egg shell (8.57g) was in 57 to 59 weeks old laying hens (Table 3). Differences between the ages examined were not statistically different. These results are incompatible with the results obtained by Biesiada-Drzazga et al. (2022) who report that mass of egg shell decreases in 50 to 60 weeks old laying hens (7.90:7.51 g). However, John-Jaja et al. (2016) concluded that in older laying hens (from 52 to 72 weeks of age) the mass of egg shell increases statistically significantly from 7.62 to 7.81 grams ($p<0.05$).

Pearson correlation coefficient between the egg mass, external and internal traits of the egg quality is displayed in Table 4.

Table 4. Correlation of the investigated indicators off egg quality

Indicators	Egg mass	Egg height	Egg width	White mass	Yolk mass	Eggshell mass
Egg mass	1.000	0.510***	0.658***	0.877***	0.393**	0.228^{ns}
Egg height		1.000	0.499***	0.446***	0.247^{ns}	0.112^{ns}
Egg width			1.000	0.535***	0.363**	0.203^{ns}
White mass				1.000	0.126^{ns}	0.005^{ns}
Yolk mass					1.000	0.068^{ns}
Eggshell mass						1.000

On the basis of correlation coefficients between analysed parameters (Table 4) a positive strong correlation can be determined ($p<0.0001$) between the egg mass and height ($r_p=0.510^{***}$) and width of egg ($r_p=0.658^{***}$). These results correspond to the results of the research conducted by Abanikannda et al. (2012). Mentioned authors determined very positive strong and statistically significant correlation between mentioned parameters ($r_p=0.728^{***}$; $r_p=0.805^{***}$).

The results of research indicate that there is a positive strong correlation between egg mass and mass of egg white ($r_p=0.877^{***}$) i.e. medium strong correlation between egg

mass and yolk mass (r_p=0.393**). Positive strong correlations between examined parameters of egg quality were determined also in the research by John-Jaja et al. (2016) where Pearson correlation coefficent accounted for r_p=0.998***. On the other hand, a correlation between egg mass and egg shell mass was not determined (p>0.05). These results are incompatible with the research conducted by Anderson et al. (2004). In this research the authors determined a positive correlation between the egg mass and egg shell mass (p<0.05) contrary to some other authors (Shi et al., 2009) who report a negative correlation between egg mass and shell mass (r_p=-261*). The results of our research (Table 3) indicate a weak correlation between egg shell mass and other parameters of egg quality (p>0.05). Shi et al. (2009) report a negative strong correlation between shell mass and mass of yolk (r_p=-0.534**), i.e. a positive correlation between shell mass and mass of white (r_p=0.603**). By analysing the records (Table 4) a positive strong correlation between the egg height, width and the mass of white can be determined (r_p=0.499***; r_p=0.446***; r_p=0.535***). Similar results were reported by Supasini et al. (2024) who report a positive strong correlation between the height and width of egg (r_p=0.353**). A statistically significant difference was not determined regarding correlation between the height of egg and the mass of yolk (p>0.05). The records presented in Table 3 show a positive strong correlation between the width of egg and the mass of white (r_p=0.535***) and a positive moderate correlation between the width of egg and the mass of yolk (r_p=0.363**). Some authors report a positive moderate correlation between the masses of egg white and yolk (Supasini et al., 2024) where the value of Pearson correlation coefficient accounted for r_p=0.500**.

CONCLUSIONS

Having a production and quality of eggs produced by a laying hans as an objective of our research, a trial was conducted on 51 to 59 weeks old birds. The results of the trial suggest that with the ageing of laying hens a feed consumption increases along with the external and internal parametres of egg quality while the mass of egg white decreases. The established differences of significance of mean values of examined parameters were not statistically significant (p>0.05). However, obtained results indicate that the age of laying hens has a significant effect on the number of produced eggs (p<0.01). For a majority of the traits of egg quality a positive strong correlation dependance was determined. It can be concluded that the mass of egg is the most important parameter of egg quality since it has a positive effect on the height and width of egg and the masses of egg white and yolk. It affirms that on the basis of the egg mass the quality of external and internal egg traits can be estimated.

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