DOI: 10.17707/AgricultForest.65.4.13

Tatjana ŽDRALIĆ, Jelena NIKITOVIĆ [1]

CORRELATION BETWEEN THE MASS AND CHARACTERISTICS OF EGG STRUCTURE IN DIFFERENT AGE GROUPS OF LAYING HENS

SUMMARY

In order to determine the characteristic structure of consumer eggs of light line hybrids Isa Brown, and the correlation links between the eggs mass and the examined characteristics, the research was conducted on the eggs taken from the private farm "Poljoprom" in Vojkovici, Bosnia and Herzegovina. The eggs were taken from three periods of production cycle, 20th, 28th and 48th week of age of laying hens. In these periods, using random sample method, the appropriate number of eggs was taken for a detailed examination, analysis and statistical processing of eggs structure characteristics. During the production cycle the hens were raised in modern facilities and adequate technology was used for each particular aspect of production with all technological phases automatically regulated.

Along with the age of laying hens, the absolute value of the eggs structure (the mass of the shell and the membrane, egg whites and egg yolks) are usually statistically increased at the level of $P < 0.01$, except at the mass of the shell of laying hens in 48th week of age, where the significance was absent. The largest relative share of shell (14.41%) was in full production, 28th week of age (WA28), and the smallest (11.80%) in the middle of the production (WA48). Between WA20 and WA28, the differences in relative part of the shell were not statistically confirmed, while other differences were statistically significant at the level of $P < 0.01$. The largest share of egg whites in the mass of the egg was in WA48 (62.56%), and the lowest in WA28 (60.89%). The largest share of egg yolk (26.80%) was at the peak of production (WA48), and the smallest (22.50%) at the beginning of the production (WA20). All differences in terms of the share of egg yolks and egg whites were statistically confirmed.

Keywords: eggs weight; egg structure; yolk; egg whites; correlation.

INTRODUCTION

Many authors have found through their research that different factors affect the structure of the eggs for consumption, including an important role of the genotype and the age of the hens. The eggs are composed of three basic parts: the egg yolk, the egg whites and the shell. The yolk is situated in the center of the

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[1]Tatjana Zdralic *(corresponding author: tatjana.zdralic@gmail.com), University of East Sarajevo, Faculty of Agriculture, Vuka Karadzica 30, 71124 East Sarajevo, BOSNIA AND HERZEGOVINA; Jelena NIikitović, University of Banja Luka, Institute for Genetic Resources, Bulevar vojvode Petra Bojovica 1a, 78000 Banja Luka, BOSNIA AND HERZEGOVINA

Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.

egg, wrapped in membrane, fixed with halazama (thick part of egg whites). Egg white is wrapped in with two membranes (inner - thinner and outer - thicker). The shell is the hard part, composed of three layers, makes 11% of the egg mass, and 98% of calcium makes the shell (Jacqueline et al., 2000). The mass of egg is a significant feature, because all the components of an egg are dependent on mass (Hartmann et al., 2000). According to Li-Chang et al. (1995) the share of components in the mass of the entire egg mass of an average 57 g is the following: yolk 28-29%; egg whites 60-63%; shell 9-11%; while Juric at al. (2005) give slightly different values, that is, the share of components in the mass of the entire egg mass of an average 58 g is: yolk 31-33%; egg whites 57-58%; shell 10-11%. Rossi et Pompei (1995), Suk et Park (2001), Van den Brand et al. (2004), Rizzi et Chiericato (2005), Tůmová et Ledvinka (2009) concluded in their research that along with age, the weight and proportion of egg yolk and a mass of egg whites significantly increases, and the share of egg whites in the total mass of the egg decreases with the age. Basmaciúolu et Ergul (2005) found that genotype ISA Brown had average values for the egg yolk mass at 15.25 g and the egg yolk share in the total mass of the egg 25.07%, and mass of egg whites at 39.25 g and share of 65.04%. Also, the average mass of the shell is 5.99 g, while the share of shell in the total mass of the egg amounts 9.92%.

The influence of genotype and age on the egg structure characteristics were examined by Lukas et al. (2009). Based on the results of experiment they concluded that the age has statistically significant ($P < 0.001$) impact on mass of the shell, egg yolk and egg whites, as well as their share in the total mass of the egg. Along with age, the mass and share of egg yolk increased, as well as mass of the shell and mass of egg whites. Also, along with age the share of shell and egg whites decreased. The correlation between the mass of eggs and the share of egg yolk was positive ($r_p = 0.182$) and statistically significant ($P < 0.001$). Negative, statistically confirmed phenotypic correlation occurred between the mass of eggs and the share of egg whites ($r_p = - 0.039$), ($P < 0.001$) and between the mass of eggs and the share of the shell ($r_p = - 0.400$), ($P < 0.001$).

In order to determine the impact of the age of the laying hens hybrid Lohmann Brown on the mass and structure of the eggs, as well as their interconnection and Pandurevic et al. (2013) carried out an experiment on two samples of eggs from laying hens who were 20 and 28 weeks old. Based on the obtained results they have noticed that older hens produced heavier eggs than younger hens; the share of egg whites in the mass of eggs was smaller, the share of the shell was similar, and the share of egg yolk was larger. At 20-weeks-old laying hens a statistically significant ($P < 0,001$) negative correlation coefficient is determined between the mass of the egg and the share of the shell in egg mass, while at 28-weeks-old laying hens was also determined a negative correlation coefficient that was not statistically significant ($P > 0.05$). Between the mass of eggs and egg yolk's share, at both groups of laying hens, a negative correlation coefficient was determined, statistically significant ($P < 0,001$) for elderly hens, while for younger hens the significance has not been confirmed ($P > 0.05$).

Along with age, the percentage share of egg whites in the egg mass increased, with the difference that for elderly hens was statistically significant ($P < 0.001$), while for younger hens the significance has not been confirmed ($P > 0.05$).

Rajicic et al. (2008) presented in their work results for the mass shell of hybrids Hisex Brown and Shaver 579. The mass of raw shell mass gradually increased along with age. With a hybrid Shaver 579 determined correlation coefficient ($r_p = 0.887$) has showed a very strong dependence between the age and the mass of the shell, and it was statistically significant ($P < 0.001$). The same dependence for hybrid Hisex Brown was high and it was not significant ($r_p = 0.579$), ($P > 0.05$).

The aim of this paper was somewhat similar to the previous examinations, with the difference to the individual characteristics of examination of the egg structure for the light line laying hens hybrid Isa Brown of different ages, i.e. the laying hens old 20, 28 and 48 weeks, as well as determining the strength and statistical significance of examined characteristics by calculating the phenotypic correlations.

MATERIAL AND METHODS

Laying hens od light line hybrids Isa Brown were raised in accordance with the current technological recommendations of selector (https://www.isa-poultry.com) and they were moved to the farm "Poljoprom" in the village of Vojkovici, localized in the Republika Srpska, Bosnia and Herzegovina at the age of 18 weeks. During the production period, they were held in a classic battery (cage) system to accommodate hens. The hens were fed with standard diet mixture for laying hens, at will (*ad libitum*).

According to the recommendations of the selector of a line of light hybrids Lohmann Brown, the forage during the production cycle should contain from 2,750 to 2,800 kcal ME and 17.5% of crude protein (load capacity below 5%), or 2,800 kcal ME and about 18% of crude protein (capacity over 5%). This food is used all the way until achieving the maximum production (28 week of age), and depending on the production of eggs and body mass, after which the concentrate diet is added with specific supplements of adequate content.

At the hens` age of 20 weeks (egg production initial stage), 28 weeks (peak load - the maximum laying eggs intensity) and 48 weeks, the random sample was taken by 120 eggs per each age stage. So, in the course of the entire production cycle there were three control measurements of the eggs (total eggs 360), that is, statistically speaking, there were three treatments of 120 repetitions. The eggs were packed and transported with air conditioning car to the experimental laboratory of the Faculty of Agriculture in East Sarajevo, University of East Sarajevo.

In all three examined groups of lying hens (WA20, WA28, WA48), we have determined the egg weight (g), the shares of raw shell (g; %), yolk (g; %) and egg whites (g; %). The egg weight was determined by individual egg measurements using special technical weighing scale, brand „KERN_{PFB}“, which is accurate to 0.01 g. To determine the structure of the egg, each egg was broken after the measurement. Then the raw shell, egg yolk and egg white were also measured. The weight of raw shell was measured by breaking the egg, separating its content from the shell and measuring its mass, together with egg membranes. The values are expressed in grams (absolute value) and as a percentage of the total egg mass. The yolk mass was measured on technical weighing scale, after the yolk was previously separated from the egg white by separator. The mass of the egg white is obtained by calculating the difference between the egg mass on one side, and the mass of the shell and yolk on the other side. Absolute measures were used to determine the shares of shell, yolk and egg white. The percentages of raw shell, yolk and egg white in the egg mass were calculated.

Based on sample data and defined distribution frequency of examined occurrences, the following parameters were determined for tracked characteristics: the average value ($\bar{X}$), the standard error of the mean ($S\bar{x}$), standard deviation (*S*) and the coefficient of variation (CV, %). Determined differences between the parameters of the structure of the egg of laying hens aged 20, 28 and 48 weeks, were tested with student's t-test. The phenotype correlation coefficients, (r_p) between the weight of the eggs and tracked the characteristics of the structure of the eggs were calculated by standard form (SAS).

RESULTS AND DISCUSSION

In this paper we examined the characteristics of the egg structure of different age laying hens, during the production cycle. For these tracked characteristics of egg structure, by random sample method, a 120 eggs was taken for the analysis during various stages of the production cycle.

The average values and variabilities of the basic indicators of the structure of eggs for consumption of light line hybrids Isa Brown, are shown in table 1. From table 1 we can see that the average value of the mass of the shell increased through the first two periods of the studies (WA20 – 6.10 g and WA28 – 7.03 g), and in the third period of examination the mass of the shell was slightly lower (WA48 – 6.07 g). The share of the shell in total egg mass were reduced with age, while at the time of maximum production (WA28) the average was slightly higher (14.41%). A slightly lower values in terms of share of the shell were found by Dikmen et al. (2017), Gjorgovska et al. (2016), and Zaheer (2015)

Along with the aging, the average absolute values of the egg whites mass increased (28.15 g; 36.30 g; 41.79 g), the mass of egg yolk (10.68 g; 14.37 g; 16.60 g) as well as the average relative values of the egg whites mass, except when WA28 (60.89%), when it was slightly lower than the previous one, while the share of egg yolks in the mass increased to WA28, and then dropped in the WA48 (25.39%). As for the egg whites, a slightly lower share was found by Kralik and Ljuboja (2017). A slightly lower values of the mass and yolk share were noted by Dikmen et al. (2017), while higher values were found by Kralik and Ljuboja (2017), Gjorgovska et al. (2016).

-Table 1. The average values and variabilities of eggs structure in certain stages of the production cycle.

Indicators	The age of laying hen	$\bar{x}$	S	$S\bar{x}$	C.V.
The shell mass, g	WA_{20}	6.10	0.77	0.06	12.90
	WA_{28}	7.03	0.70	0.04	7.97
	WA_{48}	6.07	0.43	0.03	5.20
The share of the shell, %	WA_{20}	13.20	1.35	0.10	10.15
	WA_{28}	14.41	0.80	0.06	6.22
	WA_{48}	11.80	0.73	0.05	6.22
The egg whites mass, g	WA_{20}	28.15	3.02	0.22	10.36
	WA_{28}	36.30	3.14	0.24	8.69
	WA_{48}	41.79	4.03	0.29	9.38
The share of egg whites, %	WA_{20}	61.13	2.14	0.15	3.32
	WA_{28}	60.89	2.11	0.15	3.39
	WA_{48}	62.56	1.85	0.12	2.86
The egg yolk mass, g	WA_{20}	10.68	1.43	0.11	12.31
	WA_{28}	14.37	0.68	0.04	4.53
	WA_{48}	16.60	0.74	0.06	4.78
The share of egg yolk, %	WA_{20}	22.50	1.65	0.14	7.02
	WA_{28}	26.80	1.30	0.10	5.15
	WA_{48}	25.39	1.11	0.08	4.47

In the following table are the values that indicate the significance of the calculated difference structure of consumer eggs hybrids Isa Brown, in three age periods of production (table 2).

From the results in table 2 we can see that with the age of laying hens the absolute value of the eggs structure generally increased. Heavier eggs originating from older laying hens had significantly higher absolute mass of egg whites ($P < 0.01$) and egg yolks than smaller (lighter eggs) originally from young laying hens.Also, determined differences in the absolute mass at the shell of the egg were statistically significant ($P < 0.01$), except the differences between the second and third sampling, when significance has not been confirmed ($P > 0.05$).

The percentage share of egg whites and egg yolks, a statistical significance was found in all three periods of the studies ($P < 0.01, P < 0.05$), while at the percentage share of the shell, statistical significance occurs between the first and third, that is, the second and third period, and between the first and second periods there is no statistical significance ($P > 0.05$).Similar results, with three different genotype (Isa Brown, Hisex Brown and Moravia BSL), were found by Dikmen et al. (2017).

Phenotype correlation connection between the mass and structure of the eggs.

The mass of the egg represents a significant characteristic, because each component of the egg depends on it. In support of this, in table 3 are calculated coefficients of phenotypic correlation between the mass of eggs originating from three age groups of laying hens (WA20, WA28 and WA48) and the examined characteristic of egg structure.

Table 2. Significance of difference structure of eggs in certain stages of the production cycle

Indicators	The age of laying hen	Average value	Difference	Significance
The shell mass, g	WA_{20}	6.10-7.03	-0.93	**
	WA_{28}	6.10-6.07	0.03	**
	WA_{48}	7.03-6.07	0.96	ns
The share of the shell, %	WA_{20}	13.20-14.41	-1.21	ns
	WA_{28}	13.20-11.80	1.40	**
	WA_{48}	14.41-11.80	2.61	**
The egg whites mass, g	WA_{20}	28.15-36.30	-8.15	**
	WA_{28}	28.15-41.79	-13.64	**
	WA_{48}	36.30-41.79	-5.49	**
The share of egg whites, %	WA_{20}	61.13-60.89	0.24	**
	WA_{28}	61.13-62.56	-1.43	*
	WA_{48}	60.89-62.56	-1.67	**
The egg yolk mass, g	WA_{20}	10.68-14.37	-3.69	**
	WA_{28}	10.68-16.60	-5.92	**
	WA_{48}	14.37-16.60	-2.23	**
The share of egg yolk, %	WA_{20}	22.50-26.80	-4.30	**
	WA_{28}	22.50-25.39	-2.89	**
	WA_{48}	26.80-25.39	1.41	**

Based on the results from table 3 we can see that in young laying hens (WA20) the correlation coefficient between the egg mass and the mass of the shells amounted to $r_p = 0.086$ and was not statistically significant, while the correlation coefficients for older laying hens showed a stronger connection between these two characterestics, as well as the statistical significance.

Unlike the previous one, the coefficients of phenotypic correlation between eggs mass and shell shares were negative for all periods and statistically significant.

A positive correlation coefficients were found between the mass of eggs and mass of egg whites, as well as the mass of the egg yolk, and all of them were statistically significant.

From table 3 we can see that the young hens did not have a significant correlation coefficients, calculated between the mass of eggs and shares of egg whites and egg yolks. With the age of laying hens, the correlation coefficients were significant at the level of ($P < 0.01$).

In the work of the Dikmen et al. (2017), the authors have found similar results of phenotypic correlations for all three components of the structure of eggs, with the difference that the level of significance in this paper was $P < 0.01$, while at authors mentioned above was at the level of $P < 0.01$, where the comparisons with tabular values showed a statistically significant difference.

Table 3. Phenotypic coefficients of correlation between the mass of eggs and shell, egg yolk and egg whites.

Indicators	The age of laying hen	r_p	t_{exp}
The shell mass, g	WA_{20}	0.086^{ns}	1.211
	WA_{28}	0.655**	11.012
	WA_{48}	0.410**	5.748
The share of the shell, %	WA_{20}	-0.415**	5.899 1.703
	WA_{28}	-0.132^{ns}	15.978
	WA_{48}	-0.782**	
The egg whites mass, g	WA_{20}	0.823**	18.080
	WA_{28}	0.904**	26.109
	WA_{48}	0.945**	37.050
The share of egg whites, %	WA_{20}	0.084^{ns}	1.080 7.938
	WA_{28}	0.533**	14.427
	WA_{48}	0.753**	
The egg yolk mass, g	WA_{20}	0.811**	17.359
	WA_{28}	0.604**	9.600
	WA_{48}	0.738**	13.745
The share of egg yolk, %	WA_{20}	-0.090^{ns}	1.170
	WA_{28}	-0.772**	15.459
	WA_{48}	-0.703*	10.452

***P<0.01; *P<0.05; ns P>0.05*

CONCLUSIONS

In order to determine the characteristic structure of consumer eggs of light line hybrids Isa Brown, and the correlation links between the eggs mass and the examined characteristics, the research was conducted on the eggs taken from the private farm "Poljoprom" in Vojkovici, Bosnia and Herzegovina, from three periods of production cycle, 20th, 28th and 48th week of age of laying hens. In these periods, using random sample method, the appropriate number of eggs was taken for a detailed examination, analysis and statistical processing of eggs structure characteristics.

Based on the examinations of the eggs structure that originated from laying hens of different ages during the production cycle (WA20, WA28 and WA48), the following conclusions can be drawn:

Along with the age of laying hens the absolute value of the eggs structure (the masses of the shell and membranes, egg whites and egg yolks) are usually a statistically increased at the level of $P < 0.01$, except at shells mass of laying hens aged 48 weeks, where the significance is absent.

The largest relative share of shell (14.41%) was in full production, 28th week of age (WA28), and the smallest (11.80%) in the middle of the production

(WA48). Between WA20 and WA28, the differences in relative part of the shell were not statistically confirmed, while other differences were statistically significant at the level of $P < 0.01$. The largest share of egg whites in the mass of the egg was in WA48 (62.56%), and the lowest in WA28 (60.89%). All differences were statistically confirmed.

The largest share of egg yolk (26.80%) was at the peak of production (WA48), and the smallest (22.50%) at the beginning of the production (WA20). All differences were statistically significant.

In young lying hens (WA20), the correlation coefficient between the egg mass and shell mass was not statistically significant, while in older hens the correlation coefficients showed a stronger correlation between these two traits, as well as statistical significance.

The phenotypic correlation coefficients between the egg mass and shell share were negative for all periods and statistically significant.

Positive correlation coefficients were determined between the egg mass and the mass of yolk, as well as the mass of egg whites, and they were all statistically significant.

The young lying hens did not have significant correlation coefficients calculated between the egg mass and the shares of yolk and egg whites.

Taken as a whole, it can be concluded that in the analyzed commercial flock of light Isa Brown hybrid on the poultry farm "Poljoprom" in Vojkovici, Bosnia and Herzegovina, the age of the lying hens influenced certain characteristics of the structure of consumer eggs, for all three examined periods, as shown by correlation between egg mass and examined characteristics of the egg structure.

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