ID: 372

Effect of Egg Weight and Genotype on Egg Quality Traits in Brown and White-Egg Layer Pure Lines Housed in Enriched Cage System

Gökay Günay[1], Özlem Erol[1], Ahmet Akyol[1], Brian Tainika[2], Ahmet Şekeroğlu[1]

[1]Department of Animal Production and Technologies, Faculty of Agricultural Sciences and Technologies, Niğde Ömer Halisdemir University, 51240 Niğde, Türkiye
[2]Department of Animal Production and Management, Faculty of Agriculture and Animal Sciences, Busitema University, 203 Soroti, Uganda

Abstract

This study investigated the effect of egg weight and genotype on egg quality traits in brown-egg (Line-54, RIR 1, RIR 2, COL, BAR 1, and BAR 2) and white-egg (D-229, Brown, Blue, Black, and Maroon) layer pure lines reared in enriched cage system. 20 eggs from each pure line were collected on the same day at 33 weeks of hen age and classified into four different weight groups: small (S: ≤ 52 g), medium (M: 53-63 g), large (L: 63-72 g), and extra-large (XL: ≥ 73 g) according to Turkish Food Codex Communiqué on Eggs and Egg Products before the analysis of physical egg quality traits. It was identified that brown-egg pure lines differed regarding the shell-breaking strength, shell thickness, albumen index, and Haugh unit, all greatest in RIR 2 eggs and yolk color score, highest in BAR 2 eggs ($P<0.05$; $P<0.01$). White-egg layer pure lines only varied regarding yolk color score, highest in Blue pure line eggs ($P<0.05$), and the genotype effect on meat-blood inclusions in the yolk approached a significant level ($P=0.065$), the highest number of eggs with inclusions in D229 pure lines. For egg weight, while only the Haugh unit ($P<0.05$) varied among egg weight groups in brown-egg pure lines; highest in M and L eggs, the shape index, shell breaking strength, shell thickness, and yolk index differed greatly among the egg weight groups in white-egg layer pure lines ($P<0.05$; $P<0.01$). The egg weight did not significantly affect meat and blood inclusion in the yolk and albumen in both pure line groups ($P>0.05$). In conclusion, while brown-egg pure lines differed in several egg quality traits, the white-egg pure lines varied in only the yolk color score. The effect of egg weight on egg quality traits was very noticeable in white compared to brown-egg layer pure lines.

Key Words: *Egg quality traits, Egg weight, Genotype, Enriched cage system*

Introduction

The poultry industry continues to grow, owing to increasing population growth and rapid changes in sociodemographic patterns worldwide, which increases demand for cheap animal-origin foods, such as eggs. Indeed, eggs play an important role because aside from being the most affordable, they are a natural food that contains high-value protein, vitamins, minerals, and essential fatty acids among animal products (Altan, 2015). Apart from the importance of eggs in nutrition, the quality of eggs, which is examined by analyzing their internal and external traits, is critical for the layer chicken industry. External quality traits include egg weight, shell thickness, shell breaking strength, and shape index, while internal quality traits comprise albumen and yolk index, Haugh unit, yolk color score, and meat-blood inclusions (Altan, 2015).
Egg quality traits can vary based on egg weight, for instance, the yolk index and yolk color increased with an increase in egg weight, and the highest and lowest shell thickness were in medium and extra-large eggs, respectively (Şekeroğlu and Altuntaş, 2009). The same authors reported a positive correlation between egg weight and yolk color and yolk index and a negative correlation between egg weight and shell thickness. Shi et al. (2009) found an increase in shape index and shell thickness with the increasing egg weight, and the highest and lowest Haugh unit in small and medium eggs, respectively. Egg quality traits are related to genetic structure (Durmuş et al., 2010; Hanusova et al., 2015; Rakonjac et al., 2021). Thus, breeding programs are important in the modification of egg quality traits, in particular, egg weight and shell color show a significant genotypic variation. In addition, the preference for these traits varies significantly among consumers (Kurşun et al., 2024a). As a consequence of breeding programs to meet the different consumer preferences in the world, brown and white egg layers dominate the egg industry. For instance, in Türkiye at Ankara Poultry Research Institute, the successful progress in the breeding program of layers was reported in 1995, with the importation of six and four brown and white egg pure lines as starting materials from Canada. After the introduction of pure lines, they were first multiplied and later, the beginning of selection with the aim of developing important traits. With the crossings among the pure lines, high-yielding hybrid groups were obtained, including the first two brown (ATAK and ATAK-S) and one white (ATABEY) egg layers (Sarıca et al., 2014) and currently, a new white layer hybrid known as the AKBAY that

Turkish Science and Technology Publishing (TURSTEP)
www.turstep.com.tr

was obtained in 2019 (Kursun et al., 2024b). Furthermore, other genotypes are under development, with various breeding programs. This study was therefore conducted to determine the effect of egg weight and genotype on egg quality traits in six brown and five white-egg layer pure lines developed in Türkiye.

Materials and Methods

Study location and ethical approval

The Local Ethics Committee for Animal Experiments approval was not applicable because the study did not involve the direct handling of birds. Egg samples were collected from the genotypes that were housed at the laying hen commercial unit of Niğde Ömer Halisdemir University, Ayhan Şahenk Agricultural Application and Research Center.

Animal materials and housing

Briefly, eggs were collected from 33-week-old Line-54, Rhode Island Red-I (RIR1), Rhode Island Red-II (RIR2), Barred Rock 1 (BAR-I), Barred Rock 2 (BAR-II), and Colombian (COL) brown-egg layer pure line and D-229, Brown, Blue, Black, and Maron white-egg layer pure lines.

Hens were raised in enriched cages: 3 tiers with 40 cage units each (cage dimensions: 240 cm × 63.5 cm × 60 cm (length, width, and height). Each cage unit had a stainless-steel nipple and two parallel perches, each measuring 180 cm. The perches were equipped with nail clippers. Additionally, each cage cell had a nest area surrounded by a dark blue curtain, measuring 40 cm, 33.5 cm and 30 cm (length, width, height). There was also a scratch pad and wire mesh floor.

The birds were subjected to a photoperiod of 16 hours of light and 8 hours of darkness between 06:00 and 22:00. During this period, birds were offered standard concentrate feed (2nd phase layer feed, Table 1) purchased from a commercial company. Feed and water were provided without restriction.

Table 1. Nutrient content of the feed used in the study

Analytical Components		Additives	
Crude Protein	16.26%	Vitamin A	12.000 IU
Crude Fiber	4.70%	Vitamin D3	2.400 IU
Ash	12%	Vitamin E	30 Mg/KG
Crude Fat	4.0%	Manganese	80 mg
Calcium	3.58%	Zinc	60 mg
Phosphorus	0.37%	Copper	5 mg
Sodium	0.16%	Iron	60 mg
Lysine	0.78%	Iodine	2 mg
Methionine	0.38%	Selenium	0.15 mg
Metabolizable Energy	2720 Kcal/kg	Cobalt	0.5 mg

Egg weight classification and selection of egg samples

Egg weight groups were determined as Small. S (≤ 52 g); Medium. M (53-62 g); Large. L (63-72 g); Extra Large. XL (≥ 73 g) according to the egg weight classes specified in the Turkish Food Codex Communiqué on Eggs and Egg Products. In the study, 20 eggs were randomly collected from each of the six brown and five white-egg layer pure lines, and classified according to the above 4 different weight groups, each with five egg samples. The eggs were collected on the same day, and stored at room temperature for 24 hours in the laboratory, and thereafter, their physical quality characteristics were analysed.

Egg quality analysis

A scale with a precision of 0.001 g was used to measure egg weights and the width and length of eggs were measured using a digital caliper with a precision of 0.001 mm. Shell breaking strength in Kg. force was then determined with an Egg Force Reader (Orka food tech. FGV-10XY (5.000 kg) EFO493/2013). The egg was then broken on a glass table and shells were put aside for shell thickness determination. A digital caliper with a precision of ± 0.001 mm was used to determine the albumen length and width, and yolk width and diameter. A tripod micrometer was used to measure albumen and yolk height. DSM yolk color fan was used to score the yolk color. The albumen and yolk were checked for meat and blood inclusions by visual observation. After measuring the albumen and yolk dimensions, the albumen was then separately collected into a container. The pH meter was inserted in the containing with the collected albumen to record the albumen pH. Lastly, shell samples were taken from the broad, center, and pointed regions of the egg, and their shell thickness without the membrane was determined in mm using a tripod micrometer. Shell thickness (mm) was later determined as the average of the three measurements from the different regions of the egg. In addition, the criteria and equations used in the determination of other egg quality traits (shape index, albumen index, yolk index, and Haugh unit) are shown in Table 2. Furthermore, egg quality analysis was carried out according to Altan (2015) and Şekeroğlu et al. (2024).

Table 2. Equations for some egg quality traits

No	Trait	Symbol	Equation and criteria
1	Shape Index, %	SI	SI = (Egg width/egg length) × 100
2	Yolk Index, %	YI	YI = (Yolk height/ yolk diameter) × 100
3	Albumin Index, %	AI	AI = (Albumen height/ ((albumen length + albumen width)/2) × 100.
4	Haugh Unit	HU	HU = 100 log (albumen height -1.7 W0.37 + 7.57). W; egg weight (g).

Statistical analysis

The normality assumption of the data was examined with the Kolmogorov-Smirnov test and the homogeneity of variances with the Levene test. Logarithmic transformation was performed on variables that did not meet the above assumptions. Analysis of variance and Duncan's multiple comparison test were used. In addition, Chi-Square analysis was used in the analysis of egg meat-to-blood ratios. SPSS package program was used in statistical analysis.

Results

Table 3 indicated that there was greater variability among brown-egg pure lines regarding shell breaking strength, shell thickness, albumen index, and Haugh unit, all highest in the RIR2 pure line eggs and yolk color score, highest in the BAB2 pure line eggs (P<0.01; P<0.05). On the other hand, there was no significant difference in the egg weight, shape index, yolk index, and albumen pH among the brown genotypes (P>0.05). It was observed that while egg weight had a significant effect on Haugh unit (P<0.05), highest in M and L eggs and lowest in XL eggs, the other egg quality traits were not influenced by the egg weight (P>0.05). In addition, a significant genotype × egg weight interaction effect was observed on Haugh unit and albumen pH (P<0.05).

Table 6 indicated that white-egg pure lines differed only in yolk color score, highest and lowest in Blue and Brown pure line eggs, respectively (P<0.05). In addition, there was a significant difference among egg weight groups regarding the shape index, highest in L and lowest in XL eggs; shell breaking strength, highest in XL and lowest in M and L eggs; shell thickness, highest in XL and lowest in M eggs; yolk index, highest in M and L and lowest in S and XL eggs; and yolk color score, highest in XL and lowest in S eggs (P<0.01; P<0.05). On the other hand, egg weight did not significantly affect albumen index, Haugh unit, and albumen pH (P>0.05).

There was no significant effect of egg weight and genotype on the presence of meat and blood inclusions in the albumen (P>0.05; Table 7). However, the effect of genotype on meat-blood inclusion in the yolk approached a significant level, with D229 pure line eggs having the highest number of eggs with meat-blood inclusions, followed by Black and no inclusions in Brown, Blue, and Moron pure line eggs (P=0.065; Table 8). Furthermore, egg weight did not affect the presence of inclusions in the yolk (P>0.05).

Table 3. Effect of genotype and egg weight on egg quality traits of brown-egg layer pure lines

Factor		Egg weight (g)	Shape index (%)	Shell breaking strength (kg. force)	Shell thickness (mm)	Albumen index (%)	Haugh unit	Yolk index (%)	Yolk color score (DSM)	pH
Genotype (G)	L54	62.60	76.26	2.90^{a}	0.212^{ab}	8.11^{ab}	80.27^{ab}	43.48	12.85^{cd}	9.67
	RIR2	62.20	76.03	3.67^{c}	0.249^{c}	10.81^{d}	91.40^{c}	43.77	12.75^{bcd}	9.74
	COL	61.10	78.84	2.98^{ab}	0.210^{a}	9.89^{cd}	86.29^{bc}	44.06	12.35^{b}	9.62
	RIR1	62.25	76.57	3.58^{bc}	0.232^{bc}	9.30^{bc}	85.79^{bc}	43.39	12.45^{bc}	9.68
	BAR1	62.21	75.76	3.36^{abc}	0.215^{ab}	7.97^{a}	78.70^{a}	42.97	11.84^{a}	9.70
	BAR2	61.85	78.78	3.36^{abc}	0.233^{bc}	9.84^{cd}	85.40^{bc}	45.88	13.05^{d}	9.66
Egg weight (EW, g)	S	51.33^{a}	79.01	3.30	0.226	8.99	83.54^{ab}	42.94	12.43	9.70
	M	58.00^{b}	76.39	3.37	0.223	9.82	87.33^{b}	44.48	12.40	9.71
	L	64.73^{c}	77.02	3.17	0.220	9.60	86.75^{b}	44.03	12.70	9.62
	XL	74.48^{d}	75.74	3.40	0.232	8.90	81.02^{a}	44.29	12.69	9.68
SEM		0.821	0.514	0.082	0.003	0.201	1.001	0.301	0.070	0.013
P value	G	0.312	0.282	<0.036	<0.000	<0.000	<0.000	0.066	<0.000	0.172
	EW	<0.000	0.126	0.772	0.574	0.136	<0.022	0.259	0.162	0.056
	G × EW	0.269	0.753	0.503	0.388	0.157	<0.032	0.280	0.138	<0.028

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, SEM: standard of mean, ×: interaction. Means with different superscripts significantly differ (P<0.05); Tables 4 and 5 indicated that there was no significant effect of genotype and egg weight on meat-blood inclusions in the albumen and the yolk (P>0.05).

Table 4. Effect of genotype and egg weight on meat-blood inclusions in the albumen in brown-egg layer pure lines

Factor		Number of eggs (%)						
		Normal (eggs without inclusions)	Eggs with meat inclusions	Eggs with blood inclusion	Eggs with both meat-blood inclusions	Total	χ^2	*P*
Genotype	L54	18 (90)	2 (10)	0 (0)	0 (0)	20 (100)	17.146	0.310
	RIR2	13 (65)	4 (20)	2 (10)	1 (5)	20 (100)		
	COL	18 (90)	2 (10)	0 (0)	0 (0)	20 (100)		
	RIR1	15 (75)	5 (25)	0 (0)	0 (0)	20 (100)		
	BAR1	13 (68.4)	5 (26.3)	1 (5.3)	0 (0)	19 (100)		
	BAR2	14 (70)	6 (30)	0 (0)	0 (0)	20 (100)		
Egg Weight, g	S	20 (66.7)	10 (33.3)	0 (0)	0 (0)	30 (100)	8.587	0.476
	M	22 (73.3)	6 (20)	1 (3.3)	1 (3.3)	30 (100)		
	L	25 (83.3)	4 (13.3)	1 (3.3)	0 (0)	30 (100)		
	XL	24 (82.8)	4 (13.8)	1 (3.4)	0 (0)	29 (100)		
Total		91 (76.5)	24 (20.2)	3(2.5)	1 (0.8)	119 (100)		

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, χ^2: chi-square. The first value, in front of the bracket, is the absolute number of eggs and the value in the bracket is the percentage.

Table 5. Effect of genotype and egg weight on meat-blood inclusions in the yolk in brown-egg layer pure lines

Factor		Number of eggs (%)						
		Normal (eggs without inclusions)	Eggs with meat inclusion	Eggs with blood inclusions	Eggs with both meat-blood inclusions	Total	χ^2	*p*
Genotype	L54	11 (55)	3 (15)	5 (25)	1 (5)	20 (100)	18.472	0.239
	RIR2	17 (85)	0 (0)	3 (15)	0 (0)	20 (100)		
	COL	13 (65)	2 (10)	5 (25)	0 (0)	20 (100)		
	RIR1	15 (75)	0 (0)	5 (25)	0 (0)	20 (100)		
	BAR1	14 (73.7)	0 (0)	4 (21.1)	1 (5.3)	19 (100)		
	BAR2	10 (50)	1 (5)	9 (45)	0 (0)	20 (100)		
Egg Weight, g	S	25 (83.3)	2 (6.7)	3 (10)	0 (0)	30 (100)	10.084	0.344
	M	17 (56.7)	2 (6.7)	10 (33.3)	1 (3.3)	30 (100)		
	L	18 (60)	2 (6.7)	10 (33.3)	0 (0)	30 (100)		
	XL	20 (69)	0 (0)	8 (27.6)	1 (3.4)	29 (100)		
Total		80 (67.2)	6 (5.0)	31 (26.1)	2 (1.7)	119 (100)		

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, χ^2: chi-square. The first value, in front of the bracket, is the absolute number of eggs and the value in the bracket is the percentage.

Table 6. Effect of genotype and egg weight on egg quality traits in white-egg layer pure lines

Factor		Egg weight (g)	Shape index (%)	Shell breaking strength (kg. force)	Shell thickness (mm)	Albumen index (%)	Haugh unit	Yolk index (%)	Yolk color score (DSM)	pH
Genotype (G)	D229	61.95	75.93	4.31	0.251	11.95	94.21	43.39	11.50^{a}	9.40
	Brown	62.20	75.97	3.88	0.228	11.86	92.47	43.11	11.35^{a}	9.47
	Blue	62.60	76.67	3.76	0.243	10.49	89.49	44.11	11.90^{b}	9.50
	Black	62.10	76.08	4.12	0.247	11.79	93.46	44.08	11.60^{ab}	9.48
	Moron	61.95	77.17	3.58	0.248	12.36	94.18	43.59	11.70^{ab}	9.46
Egg weight (EW, g)	S	50.36^{a}	76.27^{ab}	4.07^{ab}	0.244^{ab}	11.69	92.71	42.96^{a}	11.44^{a}	9.51
	M	58.60^{b}	76.19^{ab}	3.63^{a}	0.228^{a}	12.08	94.01	44.74^{b}	11.64^{ab}	9.47
	L	65.04^{c}	77.39^{b}	3.74^{a}	0.243^{ab}	11.99	94.37	45.34^{b}	11.52^{ab}	9.47
	XL	74.64^{d}	74.82^{a}	4.29^{b}	0.257^{b}	11.00	89.96	41.58^{a}	11.84^{b}	9.40
SEM		0,929	0.324	0.098	0.003	0.213	0.629	0.326	0.060	0.016
P value	G	0.922	0.268	0.067	0.104	0.063	0.095	0.774	<0.028	0.281
	EW	<0.000	<0.049	<0.029	<0.005	0.242	0.053	<0.000	0.064	<0.070
	G × EW	0.077	0.710	<0.006	0.252	0.444	0.750	0.183	0.085	0.406

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, SEM: standard of mean, ×: interaction. Means with different superscripts significantly differ (P<0.05).

Table 7. Effect of genotype and egg weight on meat-blood inclusions in the albumen in white-egg layer pure lines

Factor		Number of eggs (%) Normal (eggs with inclusions)	Eggs with meat-blood inclusions	Total	χ^2	*P*
Genotype	D229	19 (95)	1 (5)	20 (100)	3.061	0.548
	Brown	20 (100)	0 (0)	20 (100)		
	Blue	20 (100)	0 (0)	20 (100)		
	Black	20 (100)	0 (0)	20 (100)		
	Maron	19 (95)	1 (5)	20 (100)		
Egg weight, g	S	24 (96)	1 (4)	25 (100)	2.041	0.564
	M	24 (96)	1 (4)	25 (100)		
	L	25 (100)	0 (0)	25 (100)		
	XL	25 (100)	0 (0)	25 (100)		
Total		98 (98.0)	2 (2.0)	100 (100.0)		

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, χ^2: chi-square. The first value, in front of the bracket, is the absolute number of eggs and the value in the bracket is the percentage.

Table 8. Effect of genotype and egg weight on meat-blood inclusions in the yolk in white-egg layer pure lines

Factor		Number of eggs (%) Normal (eggs with inclusions)	Eggs with meat-blood inclusions	Total	χ^2	*P*
Genotype	D229	17 (85)	3 (15)	20 (100)	8.854	0.065
	Brown	20 (100)	0 (0)	20 (100)		
	Blue	20 (100)	0 (0)	20 (100)		
	Black	19 (95)	1 (5)	20 (100)		
	Maron	20 (100)	0 (0)	20 (100)		
Egg weight, g	S	24 (96)	1 (4)	25 (100)	6.250	0.100
	M	22 (88)	3 (12)	25 (100)		
	L	25 (100)	0 (0)	25 (100)		
	XL	25 (100)	0 (0)	25 (100)		
Total		96 (96.0)	4 (4.0)	100 (100.0)		

Abbreviations: S: small, ≤ 52 g; M: medium, 53-62 g; L: large, 63-72 g; XL, extra-large, ≥ 73 g, χ^2: chi-square. The first value, in front of the bracket, is the absolute number of eggs and the value in the bracket is the percentage.

Discussion

In the present study, there was no significant effect of genotype, both in brown and white-egg layer pure lines on egg shape index, which is in contrast with the study of Calik and Obrzut (2023) who identified significant variations among genotypes: Rhode Island Red/RIR (R-11 and K-22) and Rhode Island White (A-33) regarding the egg shape index. Kraus et al. (2019) reported a genetic influence on shell-breaking strength in a study conducted using eggs from Hy-Line Brown and ISA Brown hens at 36-64 weeks of age, which is in agreement with our study, with brown-egg layer pure lines. Durmuş et al. (2010) reported that shell thickness, Haugh unit, albumen index, and yolk index values of BAR 1, RIR 2, and Colombian breeds at 37 weeks of age were statistically significant.
In this study, shell thickness, albumen index, and Haugh unit were found statistically significant, but the yolk index was found statistically insignificant in particular to brown layer pure lines. Hanusova et al. (2015) stated that yolk color was affected by breed in a study conducted in 47-week-old Oravka and Rhode Island Red laying hens and emphasized that the yolk color of the Rhode Island Red breed was significantly darker than Oravka breed. Similarly, in the current study, yolk color differed among the genotypes, in both the brown and white-egg layer pure lines that were used. Aygün et al. (2017) reported that the minimum and maximum pH values of brown eggs were 7.96 and 8.78, respectively. In this study, the minimum and maximum values were found to be 9.62 and 9.74 for the brown-egg pure lines, respectively, which is higher than the above report. In a study involving Black, Blue, Brown, and Maroon genotypes, Durmuş and Türkoğlu (2007) found a genetic influence on shell-breaking strength, shell thickness, and albumen index, which is contrary to our findings of the white-egg pure lines. However, Durmuş and Türkoğlu (2007) identified that there was no genetic influence on shape index, yolk index, and Haugh unit, which is in line with the findings of the current study, with the white-egg pure lines. Kamanlı and Türkoğlu (2018) determined that D229, Black, Blue, Brown, and Maroon genotypes differed regarding shape index, shell-breaking

strength, shell thickness, albumen index, yolk index, Haugh unit, and meat-blood inclusions in eggs, which is in contrast to the findings of the present study. Mızrak et al. (2010) found a significantly higher shape index of Blue compared to Maroon pure line eggs, and this variability in genotypes is contrary to the present findings. Nevertheless, some authors reported a genetic influence on the percentage of eggs of blood and meat spots (Şekeroğlu and Sarıca, 2005; Hammershoj et al., 2021), which is not in line with the present data of the individual pure line groups.

In the current study, the egg weight effect was observed only on Haugh unit in brown-egg pure lines and on shape index, shell breaking strength, shell thickness, yolk index, and yolk color score in white-egg pure lines. In line with the present findings, Şekeroğlu and Altuntaş (2009) found egg weight effect on yolk index, yolk color score, and shell thickness. Also, Shi et al. (2009) identified egg weight effect on shape index and Haugh unit. It is worth noting that there was an increase in yolk index and yolk color (Şekeroğlu and Altuntaş, 2009), and shape index and shell thickness (Shi et al., 2009) with increasing egg weight. Such clear trends were not determined in the present study, and the possible explanation might be associated with the differences in egg samples that were analysed, genotypes that were used in studies, study region, age of hens during egg analysis, etc.

Conclusions

In this study, RIR2 and BAR2 pure lines can be selected for the production of hybirds that lay brown-shell eggs with superior shell and albumen quality traits and yolk color, respectively. Blue pure lines can be preferred for the development of hybrids that lay white-shell eggs with a darker yolk. The results regarding the egg weight effect on egg quality traits indicated no clear trend, warranting further studies. However, in brown-egg pure lines, M and L eggs had higher Haugh unit and in white-egg pure lines, L eggs are more oval, XL eggs are higher in terms of shell-breaking strength and shell thickness, and M and L eggs are higher in terms of yolk index.

References

Altan Ö (2015) Egg: Formation, Quality and Bioactive Components. Ege University Printing House.

Aygün, A., & Narinç, D. (2017, April). Differences in internal egg quality characteristics between white and brown shell eggs. In AIP Conference Proceedings (Vol. 1833, No. 1). AIP Publishing.

Durmuş, İ., & Türkoğlu, M. (2007). Geliştirilmekte olan yerli beyaz yumurtacı saf hatlar ve melezlerinde bazı verim ve yumurta kalitesi özellikleri. Tavukçuluk Araştırma Dergisi, 7(1), 23-30.

Durmuş, İ., Demirtaş, Ş.E., Kamanlı, S. and Demir, S. (2010). Egg quality characteristics in Barred Rock-1, Rhode Island Red-2 and Colombian laying pure lines. Lalahan Hayvancılık Araştırma Enstitüsü Dergisi, 50(1), 33-39.

Hammershøj, M., Kristiansen, G. H., & Steenfeldt, S. (2021). Dual-purpose poultry in organic egg production and effects on egg quality parameters. Foods, 10(4), 897. https://doi.org/10.3390/foods10040897.

Hanusová, E., Hrnčár, C., Hanus, A., & Oravcová, M. (2015). Effect of breed on some parameters of egg quality in laying hens. Acta fytotechnica et zootechnica, 18(1), 20-24.

Kamanlı, S., & Türkoğlu, M. (2018). Tavukçuluk araştırma enstitüsünde bulunan beyaz yumurtacı saf hatlar ve melezlerinin yumurta iç ve dış kalite özelliklerinin belirlenmesi. Journal of Poultry Research, 15(1), 23-28.

Kraus, A., & Zita, L. (2019). The effect of age and genotype on qualıty of eggs ın brown egg-layıng hybrıds. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, 67(2).

Kursun, K., Abdallah, N., Boga, Y. E., & Baylan, M. (2024b). The Influence of Different Production Systems on the Welfare of a New Commercial Layer Hen Hybrid. Brazilian Journal of Poultry Science, 26(01), eRBCA-2023. http://dx.doi.org/10.1590/1806-9061-2023-1868.

Kurşun, K., Abdallah, N., & Baylan, M. (2024a). Egg quality characteristics of sussex chickens reared under the housing conditions of Cukurova University farm. In BIO Web of Conferences (Vol. 85, p. 01047). EDP Sciences. https://doi.org/10.1051/bioconf/20248501047.

Mızrak, C., Şahnur, A. G., Demir, D. S., Yıldız, U. Y. T., & Tunca, Z. A. M. (2010). Tavukçuluk araştırma enstitüsünde geliştirilen beyaz yumurtacı ebeveynlerin çeşitli verim özellikleri. Tavukçuluk Araştırma Dergisi, 9(1), 5-10.

Rakonjac, S., Dosković, V., Bošković, S. B., Škrbić, Z., Lukić, M., Petričević, V., & Petrović, D. M. (2021). Production performance and egg quality of laying hens as influenced by genotype and rearing system. Brazilian Journal of Poultry Science, 23(02), eRBCA-2019. https://doi.org/10.1590/1806-9061-2019-1045.

Sarıca, M., Türkoğlu, M., Yamak, S. M. (2014). Tavukçuluktaki Gelişmeler ve Türkiye Tavukçuluğu, in Tavukçuluk Bilimi Yetiştirme, Besleme ve Hastalıklar, edited by M. Türkoğlu and M. Sarıca (Bey Ofset Matbaacılık, 2014), Vol. 4, pp. 1-39.

Shi, S. R., Wang, K. H., Dou, T. C., & Yang, H. M. (2009). Egg weight affects some quality traits of chicken eggs. Journal of Food, Agriculture and Environment, 7(2), 432-434.

Şekeroğlu, A., & Altuntaş, E. (2009). Effects of egg weight on egg quality characteristics. Journal of the Science of Food and Agriculture, 89(3), 379-383. https://doi.org/10.1002/jsfa.3454.

Şekeroğlu, A., & Sarıca, M. (2005). The effects of free range system on egg productions and egg quality of brown and white layer genotypes. Journal of Poultry Research, 6(1), 10-16.

Şekeroğlu, A., Şentürk, Y. E., Tainika, B., Duman, M., & Akyol, A. (2024). The Impact of Laying Hen Age, Egg-Laying Time, Cage Tier, and Cage Direction on Egg Quality Traits in Hens in an Enriched Cage System. Brazilian Journal of Poultry Science, 26(2), eRBCA-2024. http://dx.doi.org/10.1590/1806-9061-2024-1902.