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# The Comparison of Weight and Shape-related Traits in Eggs from Different Chicken Genotypes

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A B S T R A C T

Although there are intensively selected lines and non-selected standard breeds in terms of production characteristics in the chickens, there is limited information on the comparing their egg shape-related traits. This study aimed to compare using the parameters of weight, width, length, shape index-L/W (Length/Width), and shape index-W/L of egg in some meat-type (Anadolu-T, Ross 308, Dam Line and Sire Line), egg-type (Atak-S, Lohmann Brown and Lohmann Selected Leghorn), and standard breeds (Sultan and Ameraucana). The data from 2476 eggs from 9 genotypes obtained from 50-55 weeks hens and classified under 3 main types were analyzed with univariate and multivariate methods. The mean egg weights of Sire Line, Ross 308, Anadolu-T, Lohmann Brown, Atak-S, Dam Line, Lohmann Selected Leghorn, Sultan and Ameraucana genotypes were $69.89^{f}$, $69.10^{f}$, $62.84^{e}$, $59.59^{d}$, $59.58^{d}$, $59.51^{d}$, $56.81^{c}$, $45.87^{b}$ and $43.03^{a}$ g, respectively ($P<0.05$). In the same order, the mean egg width was determined as $44.72^{f}$, $45.61^{g}$, $43.41^{de}$, $43.32^{de}$, $43.62^{e}$, $43.17^{d}$, $42.46^{c}$, $39.90^{b}$ and $39.17^{a}$ mm ($P<0.05$). The mean egg length was found to be $61.97^{g}$, $58.80^{e}$, $59.72^{f}$, $56.12^{bc}$, $57.58^{d}$, $56.59^{c}$, $56.00^{b}$, $51.30^{a}$ and $51.47^{a}$ mm ($P<0.05$). The egg shape index-W/L and egg shape index-L/W was calculated to be $74.78^{a}$, $76.50^{b}$, $77.55^{c}$ % and $138.67^{c}$, $128.99^{a}$, $137.59^{c}$, $129.45^{a}$, $132.16^{b}$, $131.12^{b}$, $131.93^{b}$, $128.68^{a}$, $131.47^{b}$ %, respectively ($P<0.05$). The egg weights of meat-type, egg-type, and standard breeds were $64.61^{c}$, $58.36^{b}$, and $45.42^{a}$ g, respectively ($P<0.01$). The egg width was found to be $44.06^{c}$, $42.97^{b}$ and $39.78^{a}$ mm ($P<0.05$). The egg length was $59.05^{c}$, $56.20^{b}$, and $51.35^{a}$ mm ($P<0.05$). We also detected significant positive correlations ($P<0.01$) between the egg weight and the egg width (r=0.88), and the egg length (r=0.83). In the discriminant analyses, the success of assigning eggs to their groups was relatively low (52.4%) in terms of genotypes, but high (78.1%) in the type groups. The significant changes in the egg weight and shape-related traits were determined according to chicken genotypes and types. It was observed that intensive selection in chickens, especially in egg-type genotypes, had a strong effect on egg weight and shape-related traits.

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## Introduction

In chicken breeding, commercial stocks consist of lines improved from certain breeds according to their egg and/or meat characteristics. However, there are also standard chicken breeds that are partially studied. Each breed or line has unique characteristics regarding egg quality traits (Zita et al. 2009; Hejdysz et al. 2024). The external quality traits of eggs are an important characteristic that is affected by the biological processes of egg production. The main external egg quality traits are egg weight, eggshell thickness and, egg shape index (Leeson and Summers 2010; Batanov et al. 2024). External quality traits such as egg weight and shape index can be affected by the genotypes and yield types of the hens (Hrncar et al. 2016; González et al. 2022; Assefa et al. 2023). The heritability of these traits is relatively high compared to other egg-quality traits. The heritability of egg weight is in the range of 0.32-0.70 (Gervais et al., 2016a; Wan et al., 2019) and the heritability of shape index is in the range of 0.35-0.47 (Zhang et al., 2005; Blanco et al., 2014; Narinç et al., 2015).

External egg quality characteristics, especially egg weight and egg shape index, are important in both table and hatching production (Ayeni et al. 2020; Nowaczewski et al. 2022; Uçar et al. 2022). When compared to standard or local chicken breeds, it is seen that commercial genotypes have heavier eggs generally (Sokołowicz et al. 2019; Hejdysz et al. 2024). Although the improved materials have the same yield direction, egg weights vary considerably according to genotypes (Hristakieva et al. 2014; Kraus et al. 2020). While there is generally a high and positive correlation between egg weight and egg width and length, it is generally reported that there is a low and negative correlation between egg weight and shape index. Although it varies according to genotypes, average correlations are between egg weight and egg width in the range of 0.400-0.839, between egg weight and egg length in the range of 0.510-0.820, and between egg weight and shape index in the range of -0.440-0.310 (Abanikannda et al. 2007; Shaker et al. 2020; Imouokhome and Omastuli, 2022; Tyasi et al. 2022). In a study conducted on a meat line belonging to the White Plymouth Rock breed, it was emphasized that there was a significant positive correlation of 0.734 between egg width and 28th-day broiler live weight, and therefore egg width could be a selection criterion in terms of live weight (Dymkov et al. 2020).

Different chicken breeds naturally produce eggs of varying shapes and sizes. For example, some breeds, like the Leghorn, are known for producing elongated eggs, while others might lay more rounded eggs. It is known that some genotypes have more oval eggs, while others have more spherical eggs (Parkhurst and Mountney, 2012; Gervais et al., 2016b; Rizzi, 2020). In a study conducted on 14 different genotypes, the average shape index was reported to be 75%, although it varied according to genotypes (Hejdysz et al. 2024). Although the shape index of eggs is desired to be between 72-76%, higher rates of shape index can be seen in meat-type chickens (Altuntaş and Şekeroğlu, 2008; Elibol, 2018). Younger hens tend to lay eggs that are more irregular in shape as their reproductive systems are still maturing. As hens age, their egg shape typically becomes more consistent and closer to the ideal oval shape (Nikolova and Kocevski, 2006; Crosara et al. 2019). It is observed that eggs obtained from hens with the same genotype in different weeks of the egg production period are more homogeneous in terms of shape (Shaker et al. 2017). The characteristics of egg shape data are an important criterion for the prediction of eggshell. Chicken eggs have an optimum egg shape without any defects, which is indispensable for the effective hatching of chicks, good packaging of eggs, and safe operation to market (Nikolova and Kocevski, 2006; Gervais et al., 2016b; Shaker et al. 2017).

Certain external quality traits, such as the egg shape index, can be easily measured without having to break the egg shell, providing us with a large amount of information that allows us to correctly classify eggs of different genotypes (González et al. 2022). The egg shape traits play a crucial role in incubation (Onasanya and Ikeobi, 2013; Jabbar et al. 2018). The egg shape index is important to achieve high hatchability rates in incubation. Because deviations from the standard egg shape index can cause a decrease in hatchability rates as a result of embryos taking a bad position, especially an increase in the number of embryos that stick to the shell and die. An ideal chicken egg is typically elliptical, with a slightly rounded end and a smoother, tapered opposite end. Variations in egg shape can occur, but significant deviations from the standard oval shape may lead to higher hatchability (Jabbar et al. 2018). In conclusion, egg shape quality is a vital aspect of poultry production that can significantly impact the economic success of production or incubation.

This study aimed to compare using the parameters of egg weight, egg width, egg length, and egg shape index in some meat-type (Anadolu-T, Ross 308, Dam Line and Sire Line), egg-type (Atak-S, Lohmann Brown and Lohmann Selected Leghorn), and standard breeds (Sultan and Ameraucana).

## Materials and Methods

### *Materials*

It used 9 genotypes Anadolu-T, Ross 308, Dam Line, Sire Line (Meat-type), Atak-S, Lohmann Brown, Lohmann Selected Leghorn (Egg-type), Sultan and Ameraucana (Standard breeds). It was collected 2476 eggs from 9 genotypes at 50-55 weeks old. All the hens were kept under similar standard environmental conditions and fed with the same ration. While meat and egg-type breeds had similar management practices under commercial conditions, similar practices had been applied to standard breeds in controlled poultry houses. The content of laying feed given to all breeds was 16-17% crude protein, 3.2-3.5% calcium, and 2750-2850 kcal/kg metabolic energy. Although there are some differences in meat and egg types, all these genotypes are raised in environmentally controlled poultry houses. Although environmental conditions are effective in the characteristics related to egg weight and shape, it is known that genotype is the main factor (Goto & Tsudzuki, 2017).

### *Methods*

Each egg was coded from the small end and its measurements were made separately. Egg weight was measured with a precision scale to the nearest 0.01 g. Egg width and length were measured with a precision digital caliper to the nearest 0.01 mm. The Egg Shape Index was calculated from both the Egg width / Egg length × 100 (W/L) and Egg length / Egg width × 100 (L/W) formulas (Sarıca et al., 2012; Uçar et al. 2022).

### *Statistical Analysis*

Before the statistical analyses, the 9 genotypes of classified as meat-type, egg-type, and standard breeds. The Anadolu-T, Ross 308, Dam Line, and Sire Line genotypes were classified as meat-type, Atak-S, Lohmann Brown and Lohmann Selected Leghorn as egg-type, and Sultan and Ameraucana genotypes as standard breeds groups.

ANOVA was used to compare some external quality traits according to 9 genotypes and 3 types, and Duncan's multiple range test was used to determine which groups have significant differences in multiple comparison tests. The Discriminant Analysis (DA) was used in multivariate analysis. SPSS 20 statistical package program was used in all statistical analyses.

## Results

Significant differences ($P<0.01$) were found in all external egg traits of nine different chicken genotypes. The differences in the egg weight, egg width, egg length, egg shape index-W/L, and egg shape index-L/W were statistically significant ($P>0.05$) between some genotypes (Table 1). The egg weight ranged from 36.00 to 96.74 g (Table 1 and Table 2).

Table 1. The external egg traits (n, standard deviation, minimum and maximum) of different chicken genotypes*

| Traits | Genotypes | N | Mean | Std. Dev. | Min | Max. |
|---|---|---|---|---|---|---|
| Egg Weight (g) | Anadolu-T | 408 | 62.84$^{e}$ | 4.545 | 43.00 | 77.00 |
| | Dam Line | 595 | 59.51$^{d}$ | 3.952 | 47.00 | 73.11 |
| | Sire Line | 437 | 69.89$^{f}$ | 5.639 | 50.52 | 96.74 |
| | Ross 308 | 327 | 69.10$^{f}$ | 4.443 | 58.00 | 82.00 |
| | Ameraucana | 30 | 43.03$^{a}$ | 3.518 | 36.00 | 51.00 |
| | Sultan | 149 | 45.87$^{b}$ | 2.659 | 40.00 | 53.00 |
| | Atak-S | 53 | 59.58$^{d}$ | 4.012 | 53.00 | 68.00 |
| | Lohmann Brown | 238 | 59.59$^{d}$ | 3.893 | 51.00 | 70.00 |
| | Lohmann Selected Leghorn | 239 | 56.81$^{c}$ | 3.312 | 48.00 | 67.00 |
| | Total | 2476 | 61.88 | 7.829 | 36.00 | 96.74 |
| Egg Width (mm) | Anadolu-T | 408 | 43.41$^{de}$ | 1.267 | 39.00 | 47.00 |
| | Dam Line | 595 | 43.17$^{d}$ | 1.138 | 40.00 | 47.00 |
| | Sire Line | 437 | 44.72$^{f}$ | 1.308 | 40.67 | 49.28 |
| | Ross 308 | 327 | 45.61$^{g}$ | 1.354 | 41.00 | 49.00 |
| | Ameraucana | 30 | 39.17$^{a}$ | 0.986 | 37.00 | 41.00 |
| | Sultan | 149 | 39.90$^{b}$ | 0.985 | 37.00 | 42.00 |
| | Atak-S | 53 | 43.62$^{e}$ | 1.924 | 41.00 | 49.00 |
| | Lohmann Brown | 238 | 43.32$^{de}$ | 1.095 | 40.00 | 47.00 |
| | Lohmann Selected Leghorn | 239 | 42.46$^{c}$ | 0.994 | 40.00 | 46.00 |
| | Total | 2476 | 43.52 | 1.862 | 37.00 | 49.28 |
| Egg Length (mm) | Anadolu-T | 408 | 59.72$^{f}$ | 2.343 | 52.00 | 67.00 |
| | Dam Line | 595 | 56.59$^{c}$ | 2.014 | 51.68 | 63.00 |
| | Sire Line | 436 | 61.97$^{g}$ | 2.725 | 50.48 | 71.52 |
| | Ross 308 | 327 | 58.80$^{e}$ | 2.156 | 49.00 | 66.00 |
| | Ameraucana | 30 | 51.47$^{a}$ | 1.525 | 48.00 | 54.00 |
| | Sultan | 149 | 51.30$^{a}$ | 1.807 | 47.00 | 57.00 |
| | Atak-S | 53 | 57.58$^{d}$ | 2.274 | 54.00 | 65.00 |
| | Lohmann Brown | 238 | 56.12$^{bc}$ | 1.822 | 52.00 | 61.00 |
| | Lohmann Selected Leghorn | 239 | 56.00$^{b}$ | 1.522 | 51.00 | 61.00 |
| | Total | 2475 | 57.88 | 3.526 | 47.00 | 71.52 |
| Egg Shape Index (%, Width/Length) | Anadolu-T | 408 | 72.82$^{a}$ | 3.195 | 63.27 | 81.16 |
| | Dam Line | 595 | 76.38$^{b}$ | 2.896 | 67.49 | 85.79 |
| | Sire Line | 436 | 72.27$^{a}$ | 3.437 | 62.66 | 92.04 |
| | Ross 308 | 327 | 77.68$^{c}$ | 3.482 | 70.11 | 93.81 |
| | Ameraucana | 30 | 76.11$^{b}$ | 1.936 | 70.92 | 79.30 |
| | Sultan | 149 | 77.84$^{c}$ | 3.123 | 67.10 | 86.46 |
| | Atak-S | 53 | 75.75$^{b}$ | 2.599 | 69.27 | 84.97 |
| | Lohmann Brown | 238 | 77.32$^{c}$ | 2.351 | 68.78 | 83.00 |
| | Lohmann Selected Leghorn | 239 | 75.85$^{b}$ | 2.062 | 69.51 | 83.55 |
| | Total | 2475 | 75.35$^{b}$ | 3.681 | 62.66 | 93.81 |
| Egg Shape Index (%,Length/Width) | Anadolu-T | 408 | 137.59$^{c}$ | 6.091 | 123.21 | 158.06 |
| | Dam Line | 595 | 131.12$^{b}$ | 4.993 | 116.57 | 148.17 |
| | Sire Line | 436 | 138.67$^{c}$ | 6.523 | 108.65 | 159.60 |
| | Ross 308 | 327 | 128.99$^{a}$ | 5.635 | 106.60 | 142.63 |
| | Ameraucana | 30 | 131.47$^{b}$ | 3.395 | 126.10 | 141.01 |
| | Sultan | 149 | 128.68$^{a}$ | 5.277 | 115.66 | 149.04 |
| | Atak-S | 53 | 132.16$^{b}$ | 4.474 | 117.69 | 144.37 |
| | Lohmann Brown | 238 | 129.45$^{a}$ | 3.984 | 120.48 | 145.39 |
| | Lohmann Selected Leghorn | 239 | 131.93$^{b}$ | 3.565 | 119.69 | 143.86 |
| | Total | 2475 | 133.03 | 6.583 | 106.60 | 159.60 |

*Different small letters denote significant differences (P<0.05) between the means for each trait

Table 2. The External egg traits of different chicken types*

| Traits | Types | N | Mean | Std. Deviation | Min. | Max. |
|---|---|---|---|---|---|---|
| Egg Weight | Meat-type | 1767 | 64.62$^{c}$ | 6.452 | 43.00 | 96.74 |
| | Egg-type | 530 | 58.34$^{b}$ | 3.902 | 48.00 | 70.00 |
| | Standard | 179 | 45.40$^{a}$ | 3.005 | 36.00 | 53.00 |
| | Total | 2476 | 61.88 | 7.829 | 36.00 | 96.74 |
| Egg Width | Meat-type | 1767 | 44.06$^{c}$ | 1.574 | 39.00 | 49.28 |
| | Egg-type | 530 | 42.96$^{b}$ | 1.252 | 40.00 | 49.00 |
| | Standard | 179 | 39.78$^{a}$ | 1.020 | 37.00 | 42.00 |
| | Total | 2476 | 43.52 | 1.862 | 37.00 | 49.28 |
| Egg Length | Meat-type | 1766 | 59.05$^{c}$ | 3.095 | 49.00 | 71.52 |
| | Egg-type | 530 | 56.21$^{b}$ | 1.803 | 51.00 | 65.00 |
| | Standard | 179 | 51.33$^{a}$ | 1.760 | 47.00 | 57.00 |
| | Total | 2475 | 57.88 | 3.526 | 47.00 | 71.52 |
| Egg Shape Index (Width/Length) | Meat-type | 1766 | 74.78$^{a}$ | 3.896 | 62.66 | 93.81 |
| | Egg-type | 530 | 76.50$^{b}$ | 2.367 | 68.78 | 84.97 |
| | Standard | 179 | 77.55$^{c}$ | 3.023 | 67.10 | 86.46 |
| | Total | 2475 | 75.35 | 3.681 | 62.66 | 93.81 |
| Egg Shape Index (Length/Width) | Meat-type | 1766 | 134.08$^{c}$ | 7.008 | 106.60 | 159.60 |
| | Egg-type | 530 | 130.84$^{b}$ | 4.048 | 117.69 | 145.39 |
| | Standard | 179 | 129.15$^{a}$ | 5.112 | 115.66 | 149.04 |
| | Total | 2475 | 133.03 | 6.583 | 106.60 | 159.60 |

*Different small letters denote significant differences (P<0.05) between the means for each trait.

The mean egg weights of Sire Line, Ross 308, Anadolu-T, Lohmann Brown, Atak-S, Dam Line, Lohmann Selected Leghorn, Sultan and Ameraucana were 69.89, 69.10, 62.84, 59.59, 59.58, 59.51, 56.81, 45.87, and 43.03 g, respectively. The lowest mean in the egg weight was observed in the Ameraucana genotype (43.03 g), and the highest mean was observed in the Sire Line (69.89 g) and Ross 308 (69.10 g) genotypes (P<0.05). The egg width that ranged from 37.00 to 49.28 was determined to have a mean of 44.72, 45.61, 43.41, 43.32, 43.62, 43.17, 42.46, 39.90, and 39.17 mm, in the same genotype order. The widest mean in eggs was measured from Ross 308 (45.61 mm), and the narrowest mean was from the Ameraucana (39.17 mm) genotype (P<0.05). The minimum and maximum values of the egg length were determined to be 47.00 and 71.52 mm. The mean egg length was 61.97, 58.80, 59.72, 56.12, 57.58, 56.59, 56.00, 51.30, and 51.47 mm. The lowest means of egg length were determined in the Sultan (51.30 mm) and Ameraucana (51.47 mm) genotypes and the longest mean was in the Sire Line (61.97mm, P<0.05). The egg shape index-W/L and egg shape index-L/W were determined to be 72.27, 77.68, 72.82, 77.32, 75.75, 76.38, 75.85, 77.84, 76.11 %, and 138.67, 128.99, 137.59, 129.45, 132.16, 131.12, 131.93, 128.68, 131.47 %, respectively (P<0.05).

The differences between meat-type (Anadolu-T, Ross 308, Dam Line, and Sire Line), egg-type (Atak-S, Lohmann Brown, and Lohmann Selected Leghorn), and the standard breeds (Sultan and Ameraucana) in the egg weight, egg width, egg length, egg shape index-W/L, and egg shape index-L/W were statistically significant (P<0.05, Table 2). The eggs from meat-type were heavier, and bigger than egg-type and standard breeds. The mean egg weights from meat-type hens (64.61 g) were heavier 10.70 and 42.25 % than egg-type (58.36 g), and standard breeds (45.42 g), respectively (P<0.01). The differences in mean egg widths (44.06, 42.97, and 39.78 mm) and lengths (59.05, 56.20, and 51.35 mm) were also statistically significant (P<0.05) between the meat-type, egg-type, and standard breeds. The differences in the egg shape index-W/L (74.78, 76.50, and 77.55 %) and egg shape index-L/W (134.08, 130.84, 129.15 %) were found significant between type groups (P<0.01).

Significant positive and negative correlations (P<0.01) were found between the all external egg traits (Table 3). The egg weight was significantly correlated with the egg width (0.878), the egg length (0.825) the egg shape index-W/L (-0.254) and the egg shape index-L/W (0.264). It was also observed significant correlations between the egg width and the egg length, and the egg shape index-W/L and the egg length diameter, 0.578 and 0.719, respectively.

The discriminant analysis successfully reallocated 52.4% (Figure 1, Table 4) and 78.1% and (Figure 2, Table 5) of the eggs to their pre-assigned genotype and type groups, respectively. Interestingly, the majority of eggs (77%) obtained from the egg-type hen genotypes were classified as the eggs from the meat-type genotypes.

Table 3. The correlation coefficient (r) of external egg traits

| Traits | Egg Weight | Egg Width | Egg Length | Egg Shape Index (Width/Length) | Egg Shape Index (Length/Width) |
|---|---|---|---|---|---|
| Egg Weight | 1 | | | | |
| Egg Width | 0.878** | 1 | | | |
| Egg Length | 0.825** | 0.578** | 1 | | |
| Egg Shape Index (Width/Length) | -0.254** | 0.137** | -0.719** | 1 | |
| Egg Shape Index (Length/Width) | 0.264** | -0.128** | 0.727** | -0.997** | 1 |

** The Correlation is significant at the 0.01 level (2-tailed).

Table 4. Classification success of external egg traits to genotypes*.

| Ratio | Genotypes | Estimated Group Distribution | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | An_T | Da_L | Si_L | Ross | Amer | Sult | Atak | L_Br | LS_L | Total |
| Number | An_T | 190 | 122 | 74 | 17 | 0 | 2 | 0 | 0 | 3 | 408 |
| | Da_L | 62 | 462 | 11 | 38 | 0 | 3 | 2 | 1 | 16 | 595 |
| | Si_L | 63 | 41 | 273 | 57 | 0 | 0 | 2 | 0 | 0 | 436 |
| | Ross | 16 | 51 | 48 | 211 | 0 | 0 | 1 | 0 | 0 | 327 |
| | Amer | 0 | 0 | 0 | 0 | 3 | 26 | 0 | 0 | 1 | 30 |
| | Sult | 0 | 3 | 0 | 0 | 1 | 138 | 0 | 0 | 7 | 149 |
| | Atak | 7 | 34 | 2 | 3 | 0 | 0 | 7 | 0 | 0 | 53 |
| | L_Br | 10 | 197 | 5 | 18 | 0 | 3 | 1 | 0 | 4 | 238 |
| | LS_L | 8 | 209 | 1 | 1 | 0 | 5 | 1 | 0 | 14 | 239 |
| % | An_T | 46.6 | 29.9 | 18.1 | 4.2 | 0 | 0.5 | 0 | 0 | 0.7 | 100 |
| | Da_L | 10.4 | 77.6 | 1.8 | 6.4 | 0 | 0.5 | 0.3 | 0.2 | 2.7 | 100 |
| | Si_L | 14.4 | 9.4 | 62.6 | 13.1 | 0 | 0 | 0.5 | 0 | 0 | 100 |
| | Ross | 4.9 | 15.6 | 14.7 | 64.5 | 0 | 0 | 0.3 | 0 | 0 | 100 |
| | Amer | 0 | 0 | 0 | 0 | 10 | 86.7 | 0 | 0 | 3.3 | 100 |
| | Sult | 0 | 2 | 0 | 0 | 0.7 | 92.6 | 0 | 0 | 4.7 | 100 |
| | Atak | 13.2 | 64.2 | 3.8 | 5.7 | 0 | 0 | 13.2 | 0 | 0 | 100 |
| | L_Br | 4.2 | 82.8 | 2.1 | 7.6 | 0 | 1.3 | 0.4 | 0 | 1.7 | 100 |
| | LS_L | 3.3 | 87.4 | 0.4 | 0.4 | 0 | 2.1 | 0.4 | 0 | 5.9 | 100 |

* An_T: Anadolu-T, Da_L: Dam Line, Si_L: Sire Line, Ross: Ross 308, Amer: Ameraucana, Sult: Sultan, Atak: Atak-S, L_Br: Lohmann Brown, LS_L: Lohmann Selected Leghorn

Table 5. Classification success of external egg traits to types.

| Ratio | Types | Estimated Group Distribution | | | Total |
|---|---|---|---|---|---|
| | | Meat type | Egg type | Standart breeds | |
| Number | Meat-type | 1654 | 106 | 6 | 1766 |
| | Egg-type | 408 | 118 | 4 | 530 |
| | Standart breeds | 0 | 18 | 161 | 179 |
| % | Meat-type | 93.7 | 6.0 | 0.3 | 100.0 |
| | Egg-type | 77.0 | 22.3 | 0.8 | 100.0 |
| | Standart breeds | 0.0 | 10.1 | 89.9 | 100.0 |

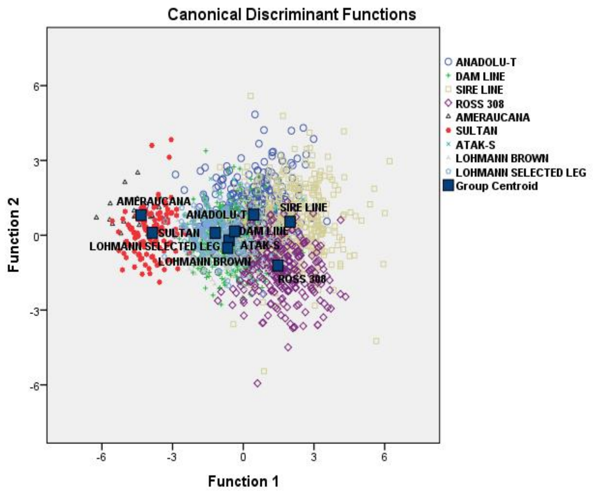


Figure 1. Scatter plot of the external egg traits to genotypes

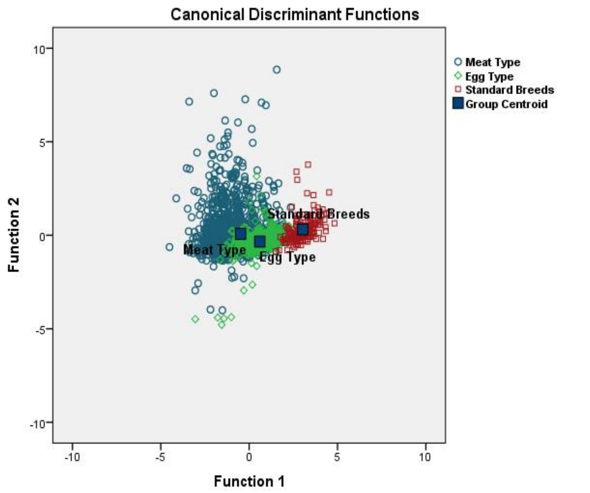


Figure 2. Scatter plot of the external egg traits to types

**Discussion**

Successful results have been obtained from studies on increasing egg weight and decreasing live weight in commercial white and brown layers. Thus, a certain average egg weight has been provided in line with consumer demands (Sarıca et al., 2024). Similar to results of this study, it is known that commercial layer hens that lay white-shelled (such as Lohmann Selected Leghorn) eggs are approximately 2-3 g lower on average than those that lay brown-shelled (such as Lohmann Brown and Atak-S) eggs (Sarıca & Uçar, 2024). It is also seen that the dam line within the meat-type has similar egg weights to brown layers. It has been determined that the egg weights of unimproved standard genotypes are quite low compared to the other genotypes and the egg weights of the Sire line, Anadolu-T and Ross 308 are high compared to the others. In our study, Ross 308 had eggs approximately 6 g heavier than Anadolu-T, and in another study, it was determined that Cobb 500 eggs were 2 g heavier than Ross 308 eggs (Hristakieva et al., 2014). Differences in hatching egg weight create variation in daily chick weight. As the egg weight changes, the weight of the chicks obtained from these eggs also changes and as a result, broiler performance is affected. Moreover, it can be said that the egg weight increases in meat type hens with high live weight and decreases somewhat compared to other meat breeds in the dam line where egg yield is taken into account (Ulmer-Franco et al., 2010; Duman and Şekeroğlu, 2017; Iqbal et al., 2017; Sarıca et al., 2024).

Many studies have reported differences between genotypes in terms of egg weight, similar to our study results (Isidahomen et al. 2013; Hrncar et al., 2016; Rehman et al., 2017; Oleforuh-Okoleh et al., 2018; Kraus et al., 2020; Özentürk & Yıldız 2020; Nwoga et al. 2021; Tadele et al. 2023). However some studies, unlike our study, it was reported that there was no difference between genotypes (Olawumi and Ogunlade, 2009; Hrnčár et al. 2015). In a study conducted in accordance with our study results, it was observed that brown commercial layers had higher egg weights than white layers (Özentürk & Yıldız 2020). In one study, it was determined that Sasso, although a slow-growing meat-type, had heavier eggs than Ethiopian local chicken breeds (Assefa et al., 2023). Similarly, in our study, it was observed that meat-types had higher egg weights than both egg-types and standard breeds including our local breed (Sultan). It should be considered that in this study standard breeds are classified as light standard breeds according to body weight.

But unlike our study, Shaker et al. (2020) conducted on Black (Domestic), Black Brown neck (Domestic), Isa Brown (Layer) and Ross (Brewer) genotypes, the lowest average egg weight was determined in the meat-type. Again similar to our study, a study conducted with local, Sasso, Bovans Brown and Koekoek genotypes, it was determined that the local genotype had the lowest average egg weight (Assefa et al. 2019). In a study conducted with Atabey, Supernick, Atak, Brownnick and Atak-S genotypes, the highest egg weight (67.60 g) was measured in the Brownnick genotype, the lowest (61.14 g) was in Atabey (Sarica et al. 2012). In this study, it was observed that commercial genotypes widely used in the world have higher egg weights compared to hybrids developed in Türkiye. In our study, it was observed that our local hybrid Atak-S (59.58 g) had the same egg weight as Lohmann Brown (59.59 g)and higher egg weight than Lohmann

Selected Leghorn (56.81 g) genotype according to egg-types. Again similar to our study, Hejdysz et al. (2024) determined that the highest average egg weight was in Hy-Line Brown eggs and the lowest in Barbud'Anvers eggs among eggs obtained from hens of the genotypes Araucana, Ayam Cemani, Barbud'Anvers, Cochin Miniature, Faverolles, Green-legged Partridge, Hy-Line Brown, Italian Chickens' Gold, Italian Chickens' Silver, Leghorn, Marans, Rhode Island Red, Sultan and Sussex. However unlike our study, Hammershøj et al. (2021) used eggs produced from four different genotypes, including two dual-purpose genotypes, a local breed and a commercial layer genotype, and the highest egg weight was obtained in local breed and the lowest in commercial layer genotype.

Egg width and length and, depending on these, shape index may vary depending on hen genotypes and yield types (Parkhurst and Mountney, 2012; Gervais et al., 2016b; Rizzi, 2020). In a study (Shaker et al. 2017), it was reported that the shape index was more homogeneous within the lines at different ages (week) and that the shape index was different between the lines, which could facilitate the estimation of eggshell quality depending on the shape index. It is stated that there are many external egg traits that allow eggs to be distinguished according to their weight and shape in two Italian local breeds. It has been determined that the eggs of the Ermellinata di Rovigo breed are more oval, while the eggs of the Pepoi breed are more spherical (Rizzi, 2020). Hejdysz et al. (2024) reported that the egg shape index in eggs obtained from hens of Araucana, Ayam Cemani, Barbud'Anvers, Cochin Miniature, Faverolles, Green-legged Partridge, Hy-Line Brown, Italian Chickens' Gold, Italian Chickens' Silver, Leghorn, Marans, Rhode Island Red, Sultan and Sussex genotypes varied among groups, but the average was 75%. Hy-Line Brown had the highest egg shape index (78.9%), while both Marans (72.1%) and Leghorn (72.2%) had the lowest index. Similar to the findings of most studies, in our study, differences were detected in terms of egg width, length, and shape index traits according to both genotypes and types (Khan et al. 2004; Rehman et al. 2017; Hussen et al. 2019; Assefa et al. 2019; Özentürk & Yıldız 2020; Rakonjac et al. 2021; Assefa et al., 2023). According to our data, the average shape index W/L and L/W were determined as 75.35% and 133.03%, respectively. In a study (Olawumi and Ogunlade, 2009) conducted with two different layer genotypes (Isa Brown and Bovan nera), no difference was found in the egg width, while it was determined that the Isa Brown genotype had a higher average in egg length and shape index. In a study conducted with normal feathered and naked-necked local breeds of Nigeria (Oleforuh-Okoleh et al. 2018), it was reported that the normal feathered genotypes had higher average in egg width and egg length than the naked-necked genotypes, but there was no difference between them in terms of shape index.

In a study (Rahn et al., 1975) conducted on over 800 bird species, there is a relationship between female body weight and the egg weight, although it varies by species. The eggs from meat-type hens were heavier and bigger (wider and longer) than the egg-type and standard breeds. Moreover, it was determined that the genotypes had differences in terms of egg weight and size. Although not in the same scope as our study, some of the studies conducted support these results (Hammershøj et al., 2021; Assefa et al., 2023; Hejdysz et al., 2024). Although egg-type hens to meat-types are smaller in body size, because heavy eggs are preferred for table use, selection has made eggs from egg-type hens heavier over time, approaching the egg sizes of larger meat-types (Thiruvenkadan et al., 2010). The observed reclassification success of eggs obtained from meat-type and standard breeds in their groups was higher (93.7% and 89.9%, respectively) than the success of egg-type in its group (22.3%). The fact that the majority (77.0%) of the eggs obtained from egg-type hens were classified in the meat-type group supports the idea mentioned above regarding the selection process of the egg-type genotypes.

## Conclusion

Our results reveal that the genotypic trend of selection programs conducted on egg quality traits in chickens caused significant positive changes in egg weight and shape. The results of this study show that discriminant analysis is a good tool to reflect or reveal shape-related egg traits of different genotypes and types. The results of this study are important for understanding the effect of selection or selective breeding on egg traits. We showed that egg weight and shape-related traits can be changed by genotype and type in this study.

## Declarations

### *Ethical Approval Certificate*

Since the research is conducted only on eggs and not on live animals, no ethics committee approval is required.

### *Author Contribution Statement*

Ahmet Uçar: Data collection, investigation, formal analysis, and writing the original draft

Yasin Kahya: Supervision, conceptualization, statistical analysis, review and editing

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