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Interactive Effects of Layer Breeder Strain and Egg Shape on Hatching Egg and Eggshell Characteristics

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ABSTRACT

Background: Understanding how breeder strain and egg shape interact to influence hatching egg and eggshell characteristics and hatchability is essential for improving incubation efficiency. The objective of this study was to investigate influence of layer breeder strain, egg shape and their interactions on hatching egg and eggshell characteristics.

Methods: In this experiment, two strains and three egg shapes were studied. Individual egg weights were recorded before incubation using a precision electronic balance (±0.01 g). The same eggs were reweighed on day 18 of incubation to calculate weight loss during the incubation period. Egg volume (EV), total pores per egg (TP), shape index (SI), shell weight (SW), shell percentage (SP), shell index (SHI) and hatchability percentage were also recorded.

Result: Percentage of egg weight loss was significantly greater in rough-shelled (10.76%) and abnormally shaped eggs (10.25%) than in normal ones, which showed the lowest loss (8.98%). In terms of interaction effects, all possible interactions significantly influenced egg weight at both day 0 and day 18 of incubation, as well as absolute and relative egg weight loss during incubation. Breeder strain had a significant effect on egg volume (EV), total pores per egg (TP), shell percentage (SP) and shell index (SHI). White eggs exhibited a higher number of pores (7258) compared with brown eggs (6979) and abnormally shaped eggs also had more pores overall. In contrast, brown eggs showed significantly higher shell percentage and shell index values than white eggs. Among egg shapes, normal eggs had the highest shell percentage and shell index, while eggs with rough shells demonstrated the lowest hatchability rates in both brown and white strains.

Key words: Breeder strain, Egg shape, Eggshell characteristics, Hatching egg.

INTRODUCTION

The characteristics and quality of hatching eggs are critical, as eggs offer both physical protection and essential nutrients for the developing embryo. Eggshell quality, including factors such as pores number, regulates gas exchange and moisture loss during incubation. Eggs with suboptimal shell quality tend to experience greater moisture loss, which can negatively affect hatchability (Peebles *et al*., 2001; Narushin and Romanov, 2002).

Egg shape is influenced by the hen's anatomical characteristics, particularly the structure of the oviduct, the arrangement of internal organs and the configuration of pelvic bones (King'ori, 2012). Egg shape index, determined by the ratio of the egg's maximum width to its length (Narushin and Romanov, 2002), provides quantitative measure of egg form.

Factors concerning breeder can influence hatchability, including the strain of the breeder, egg size, egg quality, the age of the breeder and the length of time eggs are stored (Tona *et al*., 2005). Several studies (Harun *et al*., 2001; Narushin and Romanov, 2002; King'ori, 2011) have indicated eggs with a normal shape generally exhibit better hatchability than those with abnormal forms. This improvement is linked to the embryo's axial orientation in normally shaped eggs during the later phases of development (Ainsworth *et al*., 2010). In eggs of chickens, by approximately day 14 of incubation, embryo's head shifts toward the blunt end, aligning its body parallel to the longitudinal axis of the egg. Comprehending how breeder strain and egg shape interact to influence hatching egg and eggshell characteristics and hatchability is essential for improving incubation efficiency. Therefore, this study aimed to examine the effects of layer breeder strain, egg shape and their interaction on hatching egg and eggshell characteristics.

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MATERIALS AND METHODS

Egg sampling and study design

A collection of two hundred and seventy hatching eggs, comprising 135 from White and 135 from Brown Hy-Line breeder strains, were obtained from 46-week-old commercial

layer breeders. The eggs were kept under conditions of 15°C and 80% relative humidity for 3 to 7 days prior to incubation. Upon arrival at the hatchery, eggs were sorted into three morphological categories: normal shape, abnormal shape and rough shell. Each category included 45 eggs for each strain, resulting in a 2 × 3 factorial design involving two strains and three egg shapes. Incubation was carried out at 37°C with a relative humidity of 65%. This study was conducted in June 2025, in a specialized hatchery situated at EL-Mansouria area - October Governorate.

Egg weight and weight loss

Each egg was individually weighed before incubation using electronic balance (± 0.01 g). The same eggs were then weighed again on the 18th day of incubation to determine the amount of weight lost during incubation. Percentage of egg weight loss was determined according to the following equation:

$$\text{Egg weight loss (\%)} = \frac{\text{Initial egg weight - Egg weight at day 18}}{\text{Initial egg weight}} \times 100$$

Egg and eggshell characteristics

Length and width of each egg were measured separately using digital caliper. Egg shape index (SI), egg volume (EV), total pores per egg (TP), shell index (SI) and shell percentage (SP) were calculated using the formulas shown in Table 1.

Statistical analysis

Data were analyzed using a two-way analysis of variance (ANOVA) to determine the effects of strain, egg shape and their interaction. The General Linear Model (GLM) procedure in SAS (2004) was used and the statistical model was structured as follows:

$$Y_{ijk} = \mu + S_i + E_j + (S*E)_{ij} + e_{ijk}$$

Where

Y_{ijk} = Represents the measured trait.

ì = Overall mean.

S_i = Strain effect (i= 1, 2).

E_j = Egg variant effect (j= 1, 2, 3).

$(S*E)_{ij}$ = Denotes the interaction between strain and egg variant.

e_{ijk} = Experimental error.

When significant differences were detected, mean comparisons were performed using Duncan's multiple range test.

RESULTS AND DISCUSSION

Influence of layer breeder strain, egg shape and their interactions on egg weight and weight loss are presented in Table 2. Egg weight was significantly influenced by breeder strain, with white layer hens laying notably heavier eggs than brown hens. This difference in egg weight was observed both at the start of incubation and on day 18. Rayan *et al*. (2023) reported that egg weight was significantly influenced by strain, breeder age and incubation duration. Brown layer breeders produced noticeably heavier eggs than white ones. Moreover, egg weight declined throughout the incubation period, which is an expected outcome resulting from the natural moisture loss that occurs during incubation. The data showed no significant variations between the strains in either absolute or relative egg weight loss. The same trend was observed by Murshed and Qaid (2024); Murshed *et al*. (2024) found that egg weight loss did not differ significantly between brown and white shelled eggs. Regarding the effect of egg shape, eggs with abnormal shapes were the heaviest at both day 0 and day 18 of incubation (62.95 g and 56.57 g, respectively), while eggs with rough shells were the lightest (59.48 g and 53.72 g, respectively). Egg weight loss (%) was highest in rough-shelled (10.76%) and abnormally shaped eggs (10.25%), whereas normal eggs had the lowest weight loss (8.98%) (Fig 1). Interaction effects revealed that all potential combinations significantly influenced egg weight at both day 0 and day 18, as well as absolute and relative weight loss over the incubation period. Notably, abnormal eggs from the white breeder strain had the greatest weight at both time points (64.76 g at day 0 and 60.04 g at day 18). While, rough shell eggs from the brown breeder strain showed the lightest egg weight (57.91 and 51.44 g, respectively). In the other hand, Abnormal eggs from the brown breeder strain recorded the highest absolute and relative egg weight loss (8.16g and 13.25%, respectively), while normal eggs from the brown breeder strain showed the lowest egg weight loss (3.72g and 6.28%, respectively) (Table 2).

Influence of layer breeder strain, egg shape and their interactions on egg and eggshell characteristics are summarized in (Table 3). Egg volume (EV), total pores per egg (TP), breeder strain had a significant influence on both shell percentage (SP) and shell index (SHI). The same trend was observed by Shafey (2002), who indicated that the genetic composition or strain affects the eggshell characteristics. The results showed that eggs from white layer hens had a significantly greater egg volume (EV) than

Table 1: Formulas used for egg and eggshell measurements.

Measurement	The formula
Egg shape index (SI)	= egg width ÷ egg length ×100 (Gwaza and Elkanah, 2017; Alkan, 2023).
Egg volume (EV)	= 0.496 × L × B² Where L is egg length and *B* is egg breadth (Narushin, 1997).
Total pores per egg (TP)	= 304 × M^0.767 *M* represents the egg's weight (Rahn and Paganelli, 1990).
Shell index (SI), g/100 cm²	= shell weight ÷ shell surface area ×100 (Sauveur, 1988).
Shell percentage (SP)	= wet shell weight ÷ egg weight ×100. (Yang and Luu, 2009; Alkan, 2023).

those from brown hens. Egg shape also had a significant effect, with abnormally shaped eggs exhibiting the largest egg volume. Conversely, normal eggs had the lowest value of egg volume. With regard to interaction effect, abnormal eggs from the white breeder strain recorded the highest egg volume (61.24) compared to their counterparts. In avian eggs, gas exchange between developing embryo and external environment occurs through diffusion across the chorion-allantoic membrane, which contains thousands of microscopic pores (Wagner-Amos and Seymour 2002, 2003; Nys *et al.,* 2004). Concerning Total pores per egg, White eggs had a significantly greater number of total pores per egg (7258) than brown eggs (6979). Additionally, abnormally shaped eggs showed the highest total pore count (7282), while rough shell eggs had the lowest value of total pores per egg (6973). Rough shell eggs from the brown breeder strain showed the lowest total pores per egg. No significant differences were observed to effect of layer breeder strain or egg shape on the shape index and shell weight. According to Rayan *et al.* (2020), egg shape index (%) did not differ significantly between layer breeder strains; however, shell weight was significantly influenced by strain. Murshed *et al.* (2024) shows that there are no significant differences between brown eggs and white-shell eggs in the percentage of shell weight. Concerning interaction effect, rough shell eggs from the white breeder

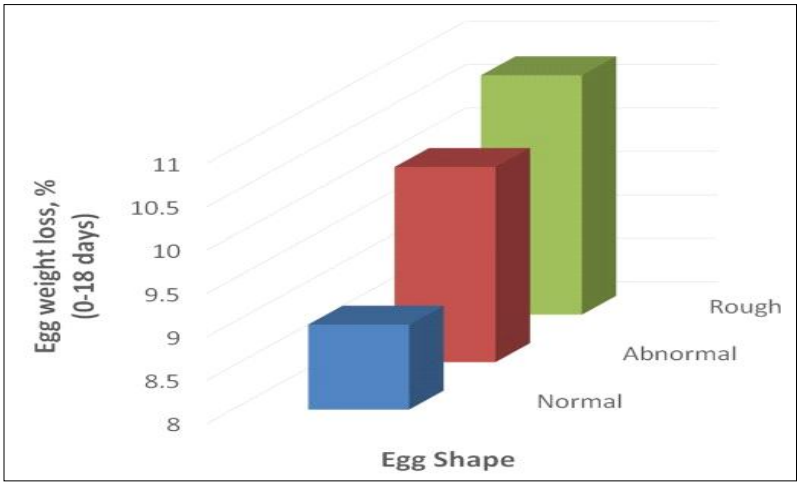


Fig 1: Influence of egg shape on the percentage of egg weight loss during incubation (0-18 days).

Table 2: Influence of layer breeder strain, egg shape and their interactions on egg weight and weight loss (Means ± SE).

Items	Trait			
	Egg weight, g (0 day)	Egg weight, g (18 days)	Egg weight loss, g (0-18 days)	Egg weight loss, % (0-18 days)
Breeder strain (S)				
Brown	59.52^{b}	53.47^{b}	6.16	10.27
White	62.66^{a}	56.87^{a}	6.03	9.65
Egg shape (E)				
Normal (N)	60.99^{b}	55.31^{ab}	5.48^{b}	8.98^{b}
Abnormal (A)	62.95^{a}	56.57^{a}	6.45^{a}	10.25^{ab}
Rough (R)	59.48^{b}	53.72^{b}	6.43^{a}	10.76^{a}
Interaction effect				
Brown - N	59.82^{cd}	55.69^{b}	3.72^{d}	6.28^{c}
Brown - A	60.96^{bc}	52.84^{cd}	8.16^{a}	13.25^{a}
Brown - R	57.91^{d}	51.44^{d}	6.95^{ab}	11.87^{ab}
White - N	62.17^{b}	54.95^{bc}	7.16^{ab}	11.56^{ab}
White - A	64.76^{a}	60.04^{a}	4.87^{cd}	7.47^{c}
White - R	61.05^{bc}	55.72^{b}	5.98^{bc}	9.79^{b}
Probability				
S	<.0001	<.0001	0.4806	0.1666
E	0.0001	0.0045	0.0311	0.0299
S*E	<.0001	<.0001	<.0001	<.0001

$^{a, b, c \text{ and } d}$ Means within the same main effects with different letters are significantly differed, NS= Non-significant.

strain showed the highest shape index, while normal eggs from the white breeder strain showed the lowest shape index. Normal eggs from the brown breeder strain showed the highest shell weight (6.13 g). As noted by Mertens *et al.* (2006), the shell percentage can be used as a measure of eggshell quality. The results indicated that eggs from the brown strain had significantly higher shell percentage and shell index than those from the white strain. A comparable outcome was found by Rayan *et al.* (2020) and (2023) who noted brown eggs exhibited a significantly greater shell percentage than white eggs. Normal eggs exhibited significantly greater shell percentage and shell index values in comparison with the other egg shapes. The interaction between breeder strain and egg shape (S×E) had a significant effect on both shell percentage and shell index. The highest values of shell percentage and shell index was recorded of normal eggs from the brown breeder strain (10.41 and 8.93, respectively) (Table 3).

Influence of breeder strain and egg shape on hatchability percentage is shown in (Fig 2). Eggs with rough shells exhibited the lowest hatchability in both brown and white strains compared with other egg shapes. In contrast, normally shaped eggs from both strains showed the highest hatchability rates, while those with abnormal shapes displayed intermediate values. Similar findings were reported by Harun *et al.* (2001) and King'ori (2011)

Table 3: Influence of layer breeder strain, egg shape and their interactions on egg and eggshell characteristics (Means ± SE).

Items	Trait					
	Egg volume (EV)	Total pores per egg (TP)	Shape index (SI)	Shell weight, g (SW)	Shell percentage (SP)	Shell index (SHI)
Breeder strain (S)						
Brown	56.26^{b}	6979^{b}	79.65	5.95	10.08^{a}	8.64^{a}
White	58.45^{a}	7258^{a}	80.31	5.82	9.27^{b}	8.3^{b}
Egg shape (E)						
Normal (N)	55.52^{c}	7113^{b}	79.59	5.98	9.93^{a}	8.71^{a}
Abnormal (A)	59.31^{a}	7282^{a}	80.15	5.73	9.16^{b}	8.12^{b}
Rough (R)	57.37^{b}	6973^{c}	80.22	5.80	9.57^{ab}	8.27^{b}
Interaction effect						
Brown - N	55.56^{c}	7007^{cd}	80.00^{abc}	6.13^{a}	10.41^{a}	8.93^{a}
Brown - A	57.20^{bc}	7107^{bc}	79.64^{bc}	5.57^{b}	9.39^{bc}	8.07^{bc}
Brown - R	56.10^{c}	6833^{d}	79.30^{bc}	6.03^{ab}	10.14^{ab}	8.66^{ab}
White - N	55.47^{c}	7218^{b}	79.18^{c}	5.85^{ab}	9.50^{bc}	8.51^{abc}
White - A	61.24^{a}	7441^{a}	80.61^{ab}	5.86^{ab}	8.96^{c}	8.16^{bc}
White - R	58.64^{b}	7114^{bc}	81.13^{a}	5.61^{b}	9.09^{c}	7.94^{c}
Probability						
S	0.0003	<.0001	0.0764	0.2786	0.0006	0.0515
E	<.0001	0.0001	0.3229	0.0808	0.0042	0.0030
S*E	0.0149	<.0001	0.0116	0.0429	<.0001	0.0027

$^{a, b \text{ and } c}$ Means within the same main effects with different letters are significantly differed, NS = Non-significant.

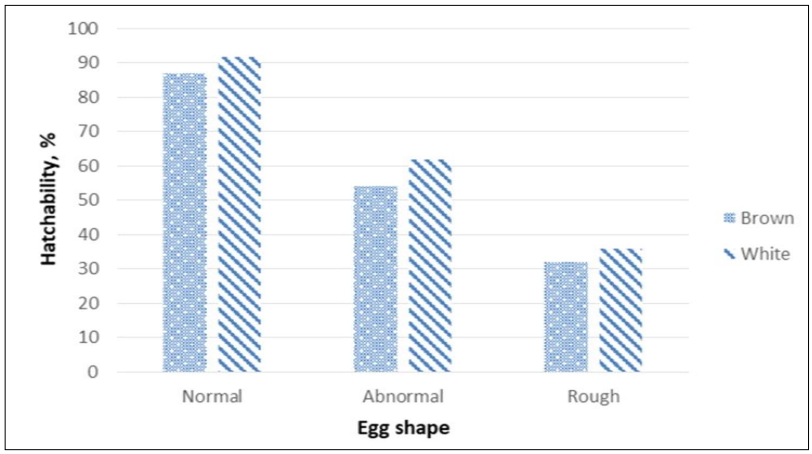


Fig 2: Influence of breeder strain and egg shape on hatchability percentage.

also noted normally shaped eggs tend to achieve greater hatching success than abnormally shaped ones.

CONCLUSION

The results of this study demonstrate that both breeder strain and egg shape have significant effects on egg weight loss, eggshell characteristics and hatchability. Rough and abnormally shaped eggs exhibited greater weight loss during incubation and lower hatchability compared to normal eggs. Moreover, strain differences were evident, as white-shelled eggs had a higher number of total pores, whereas brown-shelled eggs showed superior shell quality, reflected by higher shell percentage and shell index values.

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Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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