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The Interaction Impacts of Breeder Flock Genotype and Egg Shapes on Quantitative and Qualitative Chick Quality

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ABSTRACT

Background: Chick quality is influenced by several important factors, including the genotype of the breeder flock, incubation conditions, egg storage duration and conditions, as well as post-hatch handling. To assess chick quality, researchers use both quantitative and qualitative methods. Quantitative assessments involve morphological measurements such as chick weight, length and leg length. Qualitative evaluations are based on visual scoring methods, among these, the Tona method has become increasingly common in recent studies to measuring chick quality. The goal of this study was to investigate the interaction impacts of breeder flock genotype and egg shapes on quantitative and qualitative chick quality.

Methods: In this experiment, a total of two hundred and seventy hatching eggs, were randomly assigned to a 2 × 3 factorial design involving two breeder flock genotypes (Hy-Line White and Hy-Line Brown) and three egg shapes (normal shape, abnormal shape and rough shell). Egg weight, fertility and hatchability percentages, chick quality evaluation was assessed based on both quantitative and qualitative parameters.

Result: The results showed that breeder genotype exerts a stronger influence on quantitative chick quality, whereas egg shapes primarily affects fertility, hatchability and qualitative chick quality (Tona score). Interaction effects showed that egg weight, chick weight, shank length were significantly influenced by interaction between genotype and egg shapes. The interaction between breeder genotype and egg shape can help poultry producers improve hatchery performance and chick quality. Specifically, it highlights that selecting appropriate breeder strains and managing egg shapes during collection and incubation could enhance fertility, hatchability and overall chick quality.

Key words: Chick quality, Egg shapes, Genotype, Interaction.

INTRODUCTION

The global rise in poultry production can be attributed to the widespread availability of affordable products, which has been enabled by the genotype improvement and enhancements in environmental conditions of the birds (Tixier-Boichard *et al.,* 2012). In the field of poultry production, the production of good-quality chicks remains the fundamental objective of modern hatcheries (Mukhtar *et al.,* 2013). Starting poultry production with high-quality chicks helps reduce losses in industry and enhances profitability across production cycle. Most research assessing chick quality, using both quantitative and qualitative methods, focuses on how some factors impact performance traits and phenotypic relationships between chick quality and these traits. Chick quality is influenced by a combination of genetic and environmental elements (Tona *et al.,* 2005; Aydemir, 2020).

A high-quality chick is expected to exhibit optimal growth during incubation, maintain a strong survivability, show normal post-hatch development and meet the defined quality criteria (Molenaar *et al.,* 2010). After hatching and drying, a healthy chick is expected to possess bright and clear eyes, no physical deformities, a fully closed navel and a completely absorbed yolk sac, free from any remaining membranes or shell fragments. The chick must respond to external stimuli, show no signs of swelling or edema and be alert and responsive to its surroundings. Based on these physical features, chicks are categorized accordingly (Tona *et al.,* 2003[a]). Both qualitative and quantitative approaches are used to evaluate the quality of chicks. Quantitative methods for assessing chick quality often include morphological measurements like body weight and length. Although chick weight is commonly used as an evaluation parameter, it may not always provide an accurate reflection of quality since the measurement can be influenced by the presence of residual yolk (Narinç and Aydemir, 2021). Even so, previous findings indicate a significant positive correlation between egg weight and chick body weight at hatch (Tona *et al*., 2005; Ulmer-Franco *et al.,* 2010), making it challenging and sometimes misleading

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to evaluate chick quality based solely on body weight. Chick length is determined by placing the chick along a ruler and measuring from the tip of the beak to the end of the middle toe. Previous research has demonstrated that this trait is positively associated with yolk-free body weight and serves as a useful predictor of later performance (Deeming, 2005; Wolanski *et al.,* 2006). Another commonly applied measure of quality is the Tona score, a 100-point qualitative system used to evaluate day-old, fully dried chicks. This scoring method takes into account several features, including activity level, overall physical appearance, residual yolk content and eye condition, closure of the navel, leg quality, the presence of membranes and the extent of yolk retraction. Detailed descriptions of the criteria applied in this system are provided by Tona *et al.* (2003); Narinç *et al.* (2016).

The genotype of the breeder flock is one of the factors affecting chick quality. Two separate investigations, Wolanski *et al.* (2004, 2006) evaluated chick quality measurements in 26 different flocks using quantitative measures such as chick weight and length and observed that these traits were strongly influenced by genotype. Regarding egg shapes, King'ori (2012) noted that egg shapes is primarily determined by the hen's anatomy, with key roles played by the oviduct, pelvic bone structure and distribution of internal organ. Several studies (Farooq *et al.,* 2001; Narushin and Romanov, 2002; King'ori, 2011) found eggs with regular shapes generally exhibit superior hatching outcomes compared to those with abnormal forms. This advantage is linked to the shift in the embryo's axial position within normally shaped eggs during later phases of development (Ainsworth *et al.,* 2010). The techno-economic importance of egg type extends beyond hatch numbers, as it significantly influences overall production efficiency and chick quality. Further studies are needed to explore additional factors that may impact hatchability and the quality of day-old chicks (Benatallah *et al*., 2025).

The aim of this study was to investigate the interaction impacts of breeder flock genotype and egg shapes on quantitative and qualitative chick quality.

MATERIALS AND METHODS

In this study, two commercial laying breeder strains (Hy-Line W-36 and Hy-Line Brown) were utilized for fertile egg production. The feed quantity in each house was regulated according to the number of birds. The birds were fed a mash layer breeder ration containing 16.5% crude protein, 2800 kcal metabolizable energy per kilogram, 3.1% calcium and 0.35% phosphorus. Management practices and housing conditions were identical for both breeder flocks, which were kept in open-sided houses under standard management conditions. At the onset of production (20 weeks of age), a male-to-female ratio of 1:8 was maintained. Water was provided ad libitum and natural daylight was supplemented with artificial lighting to achieve the desired photoperiod. The duration of light exposure was gradually extended with age until it reached 17 hours per day. All breeder flocks exhibited -normal egg production rates throughout the laying period.

Egg collection and experimental design

A total of Two hundred and seventy hatching eggs from different genotypes (135 White and 135 Brown) were collected from two Hy-Line commercial layer breeder at 46 weeks of age. The eggs were stored at 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 genotype, resulting in a 2×3 factorial design involving two genotype s and three egg shapes. Incubation was carried out at 37°C with a relative humidity of 65%.

Hatching eggs traits

Individual egg weights were recorded prior to incubation using a precision electronic balance (±0.01 g). Candling was performed on day 7 of incubation to determine fertility. Fertility (%) was determined by dividing the number of fertile eggs by the total settable eggs and multiplying by 100, whereas hatchability (%) was obtained by expressing the number of chicks hatched as a percentage of the fertile eggs (Ori, 2011).

Chick quality evaluation

Upon hatching, at 21.5 days of incubation, the chicks were taken out and evaluated for quality based on both quantitative and qualitative parameters.

Quantitative factors

- Chick weight was recorded on the first day.
- Shank length (from the leg pad to the tarsus bone) was measured using a digital caliper.
- Chick length (from the beak to the middle top of the leg, excluding the nail) was measured with a ruler (Willemsen *et al.* 2008).

Qualitative factors (Tona score)

Each chick was examined visually to assess physical characteristics that are linked to chick quality. The assessment followed the criteria set by Tona *et al.* (2003), categorizing the chicks into good, average, or poor quality based on their physical appearance.

This study was conducted in June 2025, in a specialized hatchery in Egypt.

Statistical analysis

Data were examined using a two-way analysis of variance (ANOVA) to assess the effects of genotype, egg shape and their interaction. The analysis was conducted with the General Linear Model (GLM) procedure in SAS (2004). The statistical model employed was as follows:

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

Where

Y_{ijk} = Represents the measured trait.

μ = Overall mean.

S_i = Genotype effect (i= 1, 2).
E_j = Egg shapes effect (j= 1, 2, 3).
$(S*E)_{ij}$ = Denotes the interaction between genotype and egg variant.
e_{ijk} = Experimental error.

Duncan's multiple range test was applied to differentiate means when significant differences were observed.

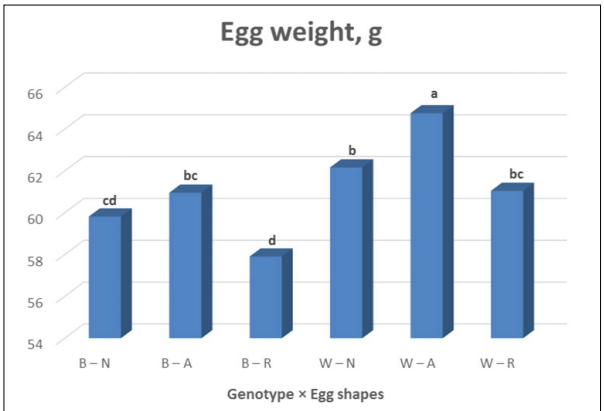
RESULTS AND DISCUSSION

Impact of the interaction between genotype and egg shapes on egg weight at day 0 of incubation is shown in Fig 1. Egg weight was significantly influenced by this interaction. Specifically, the lowest egg weight at day 0 was observed in rough shell eggs from the brown genotype (57.91 g), while the highest weight was recorded in abnormal shape eggs from the white genotype (64.76 g). Suarez *et al.* (1997) conducted a study comparing the weights of newly hatched chicks from breeder flocks of various genotypes. The findings revealed significant statistical differences in the average weights of one-day-old chicks among the six genotypes examined. Owolabi *et al.* (2024) indicated that genotype had a significant effect (P<0.05) on chick weight.

The fertility and hatchability percentages for different genotypes and egg shapes are presented in (Fig 2 and 3). Normal eggs from the white genotype exhibited the highest fertility percentage, while rough shell eggs from the brown genotype showed the lowest fertility, followed by rough shell eggs from the white genotype. Hatchability of fertile eggs was lowest in rough-shelled eggs for both brown and white genotypes relative to other egg shapes. Conversely, normal eggs from both genotypes had the highest hatchability percentages, with abnormal shape eggs from each genotype showing intermediate values. Harun *et al.* (2001) observed a similar pattern and King'ori (2011) reported that eggs with normal shapes generally result in higher hatching success compared to those with abnormal forms.

Quantitative chick quality

Effect of genotype, egg shapes and their interactions on quantitative day-old chick quality are summarized in Table 1. Chicks from the white genotype exhibited significantly higher body weight at hatch (42.36 g) compared to those from the brown genotype (36.84 g). This increased chick weight in white breeder hens may be attributed to their production of heavier eggs relative to the brown genotype.



B - N (Brown - Normal), B - A (Brown - Abnormal), B - R (Brown - Rough), W - N (White - Normal), W - A (White - Abnormal), W - R (White - Rough).

Fig 1: Effect of interaction between genotype and egg shapes on egg weight.

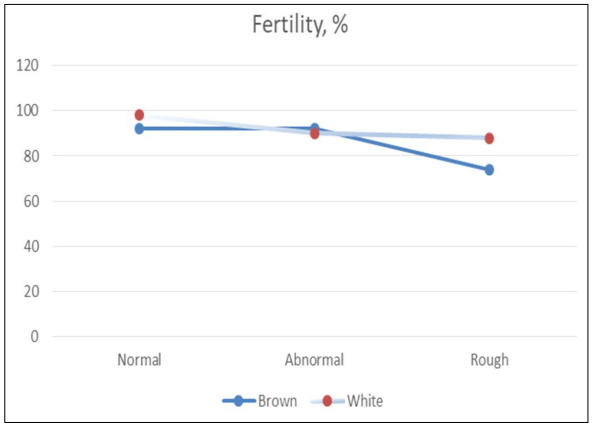


Fig 2: Fertility percentage for different genotypes and egg shapes.

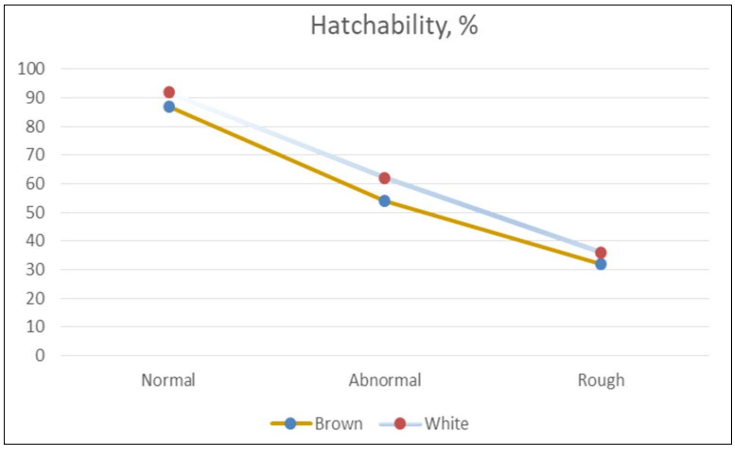


Fig 3: Hatchability percentage for different genotypes and egg shapes.

Table 1: Effect of genotype, egg shape and their interactions on quantitative day-old chick quality.

Trait	Items		
	Chick weight, g (CHW)	Shank length, mm (SL)	Chick length, mm (CL)
Genotype (G)			
Brown	36.84^{b}	27.08^{b}	16.63
White	42.36^{a}	28.52^{a}	16.65
Egg shapes (E)			
Normal (N)	39.17	28.23	16.81
Abnormal (A)	40.64	27.44	16.56
Rough (R)	40.15	27.72	16.55
Interaction effect			
Brown - Normal	37.71^{c}±0.45	27.64^{ab}±0.30	16.89±0.31
Brown - Abnormal	34.87^{d}±0.91	26.40^{c}±0.23	16.17±0.17
Brown - Rough	37.74^{c}±1.14	27.20^{bc}±0.35	16.83±0.19
White - Normal	40.48^{b}±0.51	28.83^{a}±0.40	16.72±0.33
White - Abnormal	45.48^{a}±1.02	28.48^{a}±0.52	16.94±0.26
White - Rough	42.18^{b}±1.51	28.25^{ab}±0.46	16.28±0.32
Probability			
G	<.0001	<.0001	0.9336
E	0.2956	0.1342	0.5707
G*E	<.0001	0.0006	0.2047

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

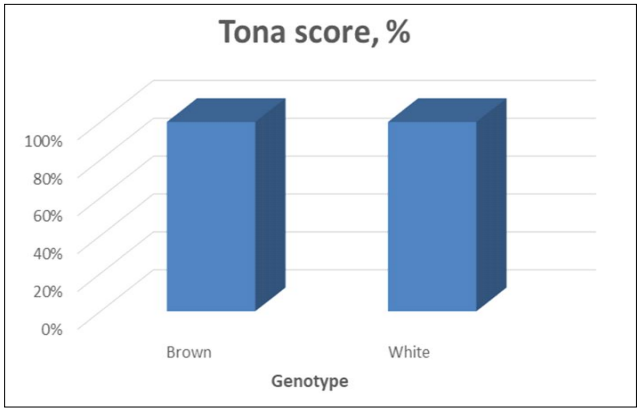


Fig 4: Effect genotype on qualitative chick quality (Tona score).

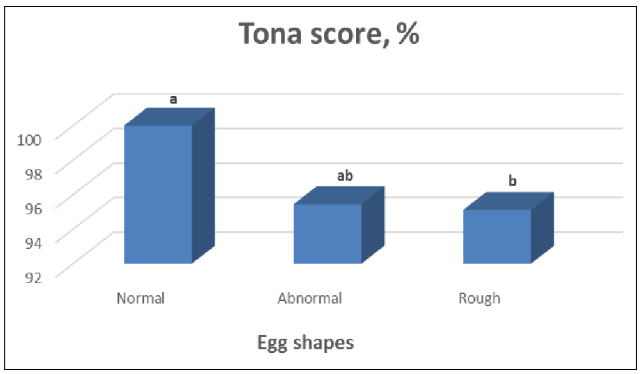


Fig 5: Effect of egg shapes on qualitative chick quality (Tona score).

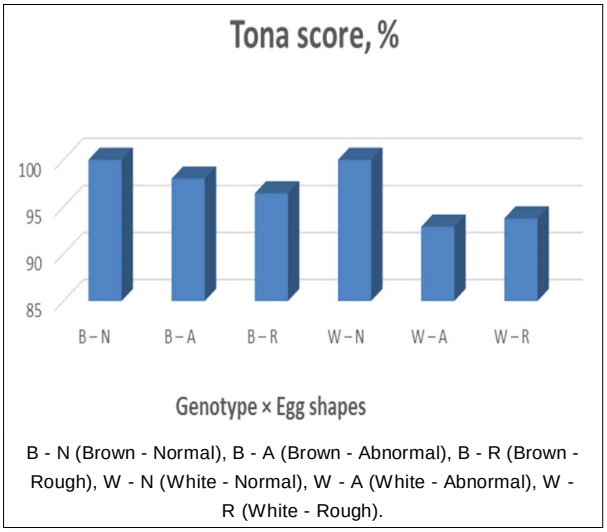
Previous studies by Iqbal *et al.* (2017) have highlighted that egg weight is a key factor influencing chick weight at hatch. Wolanski *et al.* (2006) investigated quality characteristics of chicks from 26 different flocks, using quantitative indicators like weight of chick and demonstrated that these traits were markedly affected by genotype.

Additionally, chicks of the white genotype showed significantly longer shank lengths compared to the brown genotype. This aligns with findings from recent studies. A study of Isaac (2021) on crossbred chickens reported that shank length was positively correlated with body weight across various genotypes, including those with white genotype. On the other hand, egg shapes did not have a significant effect on hatched chick weight, shank length, or chick length. Similarly, a study of Iqbal *et al.* (2023) examining the influence of egg size on chick growth reported that while egg size affected chick weight and length, egg shapes did not have a substantial impact.

Regarding the interaction effects, abnormal eggs from the white genotype produced the heaviest chicks, whereas abnormal eggs from the brown genotype yielded the lightest chicks. Similarly, both normal and abnormal eggs from the white genotype resulted in chicks with longer shank lengths, while abnormal eggs from the brown genotype produced chicks with the shortest shank lengths. There was no significant effect of the interaction between genotype and egg shape on chick length.

Qualitative chick quality (Tona score)

No significant differences in Tona score, as a measure of qualitative chick quality, were observed among the



B - N (Brown - Normal), B - A (Brown - Abnormal), B - R (Brown - Rough), W - N (White - Normal), W - A (White - Abnormal), W - R (White - Rough).

Fig 6: Effect of interaction between genotype and egg shapes on qualitative chick quality (Tona score).

genotypes (Fig 4). The same trend was observed by A similar observation was reported by Tona *et al.* (2003[b]), who examined chick quality in three commercial broiler breeder flocks and likewise found no significant variation in Tona scores among the groups. However, egg shapes significantly affects chick quality, measured using the Tona score. Normally shaped eggs consistently show the highest Tona scores, indicating better chick quality, while eggs with rough shells had the lowest Tona scores and eggs with abnormal shapes had intermediate value (Fig 5). Additionally, there was no significant interaction effect between genotype × egg shapes on the Tona score (Fig 6).

CONCLUSION

This study revealed that both genotype and egg shapes influence egg weight, fertility, hatchability and chick quality. White genotype hens produced heavier eggs and chicks with greater shank lengths than the brown genotype. Egg shapes notably affected fertility, hatchability and qualitative chick quality (Tona score), with normal eggs performing best and rough shell eggs the worst. While egg shapes did not significantly impact quantitative chick traits like weight and length, interaction effects showed that abnormal eggs from the white genotype produced the heaviest chicks, whereas those from the brown genotype produced the lightest. Overall, genotype had a greater effect on quantitative chick quality, while egg shapes more strongly influenced fertility, hatchability and qualitative traits (Tona Score).

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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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