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Analysis of Egg Production Curves Using Three Mathematical Models and the Variation in Egg Quality between Commercial (Hy-Line Brown) Layer Hens and Sentul Hens

Research Article

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ABSTRACT

Egg production is a crucial economic trait in poultry, with heritability challenges. The study investigated egg production and quality in commercial (Hy-Line Brown) and local (Sentul) chicken strains through mathematical modeling and detailed egg quality assessments. Utilizing 100 hens from each strain for up to 80 weeks, mathematical models: Gamma Wood, Quadratic, and Quartic, were applied to analyze egg production curves. The Quartic model exhibited outstanding accuracy, surpassing other models with significantly higher coefficients of determination (R2) for both Hy-Line Brown (R2=89.67%) and Sentul (R2=89.92%) hens showing the Quartic model's superior ability to precisely represent the persistence in egg production curves over time. Correlation analysis identified multiple linkages shaping egg quality, notably positive relationships of egg weight with shell strength, yolk color, yolk weight, albumen weight and shell weight as well as a trade-off between egg weight and Haugh units. Egg quality parameters were systematically compared. Commercial hens demonstrated significantly (P<0.005) higher values in several quality parameters, including egg weight (62.35±5.02 g), shell strength (0.42±0.10), albumen weight (32.5±2.71 g), Haugh Unit (95.99±7.94), and shell weight (8.16±0.86 g), compared to local hens. Positive correlations were identified between egg weight and shell strength (0.224**), yolk color (0.033), yolk weight (0.968**), albumen weight (0.993**), and shell weight (0.488**). Conversely, a negative correlation is noted between egg weight and Haugh Unit (-0.040), indicating a trade-off between egg size and freshness. The Identified correlations between egg weight and quality parameters showed the multifaceted nature of egg characteristics, shaped by genetic and management factors. These findings provide comprehensive insights into the genetic and environmental influences on egg production and quality, offering a foundation for selective breeding strategies and management practices permitting productive strategies to ensure animal welfare in diverse chicken populations. This research notably illuminates untapped potential of the Quartic model for forecasting laying persistence amidst environmental fluctuations, while also suggesting hybridization opportunities to infuse specialized commercial vigor and consistency into local gene pools. With global demand for affordable, quality nutrition expanding amidst climate change, these unified insights to bolstering egg quantity and quality through predictive modeling and strategic breeding carry far-reaching implications for sustaining poultry production.

KEY WORDS egg production and quality, genetic variation, Hy-Line Brown hens, mathematical models, selective breeding, Sentul Hens.

INTRODUCTION

Egg production is a key indicator for measuring the performance of laying hens and is a characteristic with high economic value. Egg production plays a crucial role in meeting consumer needs as a source of animal protein, along with meat and milk (Gautron *et al.* 2022), making it an important indicator for efficiency in the poultry industry (Awada *et al.* 2021). However, egg production is a quantitative trait with low heritability (Goto and Tsudzuki, 2017), lower than that of growth traits (Niknafs *et al.* 2012), making it challenging to improve through direct selection (Wolc *et al.* 2011). The heritability of early egg production is reported to be 0.36 (Biscarini *et al.* 2010).

Mathematical models can be used to evaluate genetic value by predicting overall performance based on partial egg production records, as this prediction plays a crucial role in early selection (Al-Samarai *et al.* 2008). Mathematical models have been employed to study changes in egg production over time. The application of new approaches at the genetic level will enhance the possibility of discovering new quantitative trait loci (QTL) that have a significant impact on the shape of the egg production curve using mathematical models (Alshaheen, 2017). Mathematical models can provide a descriptive overview of the egg production curve, especially at peak times and during declines, as well as its persistence (Schaeffer *et al.* 2000). The egg production curve illustrates the laying pattern of a chicken population over time (Savegnago *et al.* 2012).

Several mathematical models that can be utilized include Gamma Wood, quadratic, and quartic (Sharifi *et al.* 2022). Mathematical models using egg production curves can provide a clear picture of the partial performance of laying hens. This allows farmers or researchers to identify hens with better egg production potential without waiting for the actual egg production results until culling. By employing mathematical models, the selection of hens based on specific egg production parameters (such as the number and weight of eggs produced in a given period) becomes more accurate. Mathematical models provide estimates of genetic parameters at all points along the egg production curve within the measurement intervals. Predictions of these egg production values are economically significant and can be considered when choosing laying hens.

Chicken eggs serve not only as a reproductive tool but also as a protein source for humans. Eggs are widely accepted worldwide without any religious or traditional restrictions (Alkan *et al.* 2015). Eggs are extensively consumed due to their economical animal protein source (Da Silva Pires *et al.* 2020). Both external and internal egg quality are crucial characteristics observed by consumers. Noteworthy aspects of egg quality include cleanliness, freshness, surface area, mass, eggshell quality, yolk index, albumen index, and Haugh unit (Narushin, 1997). Internal quality is based on air cell size, albumen quality, yolk quality, and the presence of blood spots and meat spots. Egg quality is influenced by the age and genotype of the chicken, nutrition, the type of husbandry system, and the timing of oviposition (Ahmadi and Rahimi, 2011; Yang *et al.* 2014).

The Hy-Line Brown chicken is a type of laying hen produced by the company Hy-Line International, headquartered in the United States. The Hy-Line Brown chicken is a popular breed due to its high egg production and good egg quality (Hy-Line International, 2023). The Sentul chicken is a local breed native to Ciamis, West Java, Indonesia, officially recognized by the Minister of Agriculture of the Republic of Indonesia through Decree No. 689/Kpts.PD410/2/2013 as a local Indonesian breed originating from Ciamis. The Sentul chicken remains a native genetic resource from Ciamis that has been preserved until now (Food Security and Livestock Office, 2021). The advantages of the Sentul chicken include relatively fast growth and high egg production (Masito *et al.* 2019; Teguh *et al.* 2023). It is well-known that several genes, including prolactin (PRL) (Bai *et al.* 2019), insulin-like growth factor-2 (IGF-2) (Ye *et al.* 2017), melatonin receptor (MTNR) (Feng *et al.* 2018), follicle-stimulating hormone receptor (FSHR) (Xu *et al.* 2017), and growth differentiation factor 9 (GDF9) (França *et al.* 2018), have significant impact on egg production.

The phenotypic value of a trait is the result of the genetic combination (genotype) and the influence of the environment, as well as the interaction between genotype and environment experienced by the livestock. This indicates that the phenotypic value does not directly reflect its genetic potential because it is always influenced by the environment and the interaction between genotype and environment (Hill and Mackay, 2004). Egg production is a quantitative trait influenced by both genetics and the environment. Differences in strains or genotypes have an impact on egg production and quality, necessitating the creation of a mathematical model for the analysis of egg production curves and differences in egg quality between two chicken strains (commercial stock versus local). This research aimed to obtain a mathematical model with high precision for estimating egg production and determining egg quality in commercial (Hy-Line Brown) and local (Sentul) hens.

MATERIALS AND METHODS

All procedures used in this research have been approved by the Animal Research Ethics Committee of the Institute for Research and Community Service, Universitas Jenderal

Soedirman (128/E5/PG.02.00.PL/2023), Indonesia. The study utilized 20 weeks old Hy-Line Brown (commercial) and Sentul (local) hens which are raised until 80 weeks of age, with each group consisting of 100 hens. The research was conducted in a closed house facility owned by the Faculty of Animal Husbandry, Universitas Jenderal Soedirman, Purwokerto, Central Java, Indonesia. The housing system used was battery cages (length 0.35×width0.45×height 0.40 m), each accommodating two hens with unrestricted access to drinking water. The lighting program provided 17 hours of light per day. The nutritional content of the chicken feed for the production period (PT. New Hope Indonesia) with feed code L83-1A is presented in Table 1.

Table 1 Nutrient content of feed L83-1A

Nutrients[1]	Nutrient content
Water	12%
Proteins	16.5 %
Fat	3.0%
Crude fiber	5.5 %
Ash	13.5 %
Calcium	3.25 %
Total phosphorus	0.64 %
Urea	Undetected
Total aflatoxin	50 µg/kg
Amino acids	
Lysine	0.80 %
Methionine	0.40 %
Methionine + cystine	0.67 %
Tryptophan	0.18 %
Threonine	0.55 %
Metabolisable energy (ME)	2750 kcal/kg

[1] Proximate analysis of PT. New Hope.

The collection of egg production data was conducted daily, including the number of eggs, egg weight, Hen Day Production (HDP=total number of eggs laid by the flock in each period divided by the product of the number of days and the number of hens alive on each of these days), and Feed Conversion Ratio (FCR=feed intake (g)/egg production (g)). External and internal egg quality was observed three times at weeks 25, 35, and 45 representing the onset, peak, and decline of production. Fifty randomly selected eggs were immediately tested for quality. Egg quality testing was carried out promptly after collection to prevent the influence of storage time and environmental temperature (EFSA, 2014). The observed egg quality parameters included egg weight, shell strength, yolk color (Alig *et al.* 2023), yolk weight, egg white weight, Haugh unit (Cheng *et al.* 2020), and shell weight. All eggs were individually weighed using an electronic scale with a precision of 0.1 grams and then cracked to determine other quality parameters. Broken eggshells were washed, dried, and then weighed to measure shell weight. Yolks were separated and individually weighed to determine yolk weight. Albumen weight was calculated by subtracting the weight of the wet yolk and shell from the individual egg weight (Iqbal *et al.* 2017).

The egg production curve data were analyzed based on strains using mathematical models, employing the nonlinear Gamma Wood function (Wood, 1967), the quadratic linear function, and a polynomial function of degree n (Sharifi *et al.* 2022).

Gamma Wood: $Yt= at \exp(-bt)$
Quadratic: $Yt= B_0 + B_1X + B_2X^2$
Quartic: $Yt= B_0 + B_1 X + B_2X^2 + B_3X^3 + B_4X^4$

Where:
Y_t: egg production at time t (weeks).
exp: exponential function.
at: initial production.
bt: rate of production decline from its peak.
B_0, B_1, B_2, B_3, B_4: coefficients for the quadratic and polynomial functions.
X: time in weeks.

The accuracy of using mathematical models was tested based on the regression coefficient values (R^2) calculated using the Statistical Package for Social Sciences (SPSS, 2011). The highest R^2 value indicates the mathematical model that best approximates the real egg production conditions.

RESULTS AND DISCUSSION

Mathematical models of egg production curve

Mathematical models have been employed across various disciplines to illustrate and interpret data obtained through observation or measurement, as well as to reveal cause-and-effect relationships. One commonly used type is empirical models that depict the motion of dependent variables without attempting to diagnose and explain the underlying reasons. The most widely accepted empirical models include both linear and nonlinear models (Narinc *et al.* 2014).

Egg production modeling is less common compared to the modeling of growth in broiler hens, perhaps due to the extended time required to track egg production. Egg production commences at sexual maturity, rapidly reaching peak levels, following a linear trend for a while, then declining.

Hence, it bears more resemblance to milk production, as some functions used in egg production modeling can also be applied to the lactation curve of dairy cows (Gavora *et al.* 1982).

Analysis of egg production curves in Hy-Line Brown and Sentul hens using mathematical models

The egg production curves of Hy-Line Brown and Sentul hens, analyzed using the Gamma Wood, Quadratic, and Quartic mathematical models, are illustrated in Figures 1 and 2.

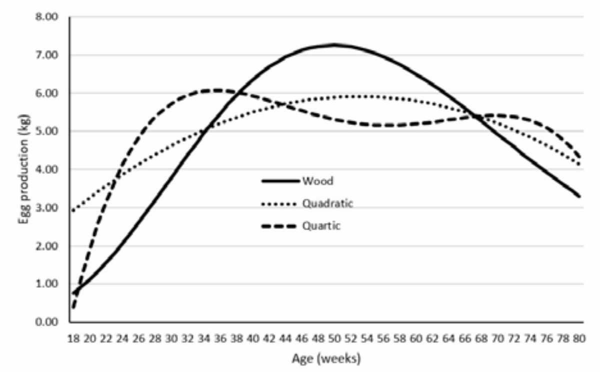

Figure 1 Gamma Wood, Quadratic, and Quartic models in Hy-Line Brown hens

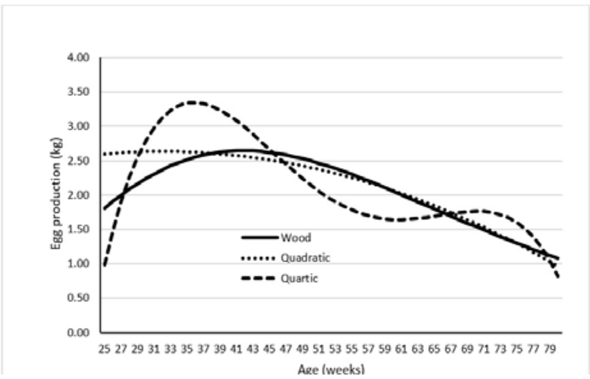

Figure 2 Gamma Wood, Quadratic, and Quartic models in Sentul hens

Hy-Line Brown hens (Figure 1)

Egg production initiates at week 18. According to the Gamma Wood model, production increases from week 18, reaching its peak at week 50 with a production of 7.26 kg, then gradually declining to 3.3 kg by week 80. The Quadratic model indicates an increase reaching its peak at week 53 with a production of 5.92 kg, followed by a decrease to 4.14 kg by week 80. Using the Quartic model, production increases, reaching its first peak at week 35 with a production of 6.07 kg. There is a subsequent increase at weeks 69-70, resulting in 5.41 kg. The Quartic model shows a production of 4.34 kg at week 80, higher than the Gamma Wood and Quadratic models. Overall, the Quartic model provides a better representation of persistence, exhibiting a relatively small decline in production from week 33 to 74. Production persistence is crucial in egg production, with an increase to a peak, sustained for several weeks before declining with age (Alshaheen, 2017).

Sentul hens (Figure 2)

Egg production starts at week 25, seven weeks later than commercial laying hens. According to the Gamma Wood model, egg production peaks at weeks 39-43, with an average production of 2.63 kg, followed by a decline to 1.08 kg by week 80. The Quadratic model indicates an increase, peaking at weeks 29-35 with a production of 5.92 kg, then decreasing to 0.96 kg by week 80. Using the Quartic model, production increases, reaching its peak at week 36 with a production of 3.35 kg. There is a subsequent decrease and increase at weeks 69-72, resulting in 1.76 kg. The Quartic model shows a production of 4.34 kg at week 80, higher than the Gamma Wood and Quadratic models. Generally, the Quartic model provides a reasonably good representation of persistence in both commercial (Hy-Line Brown) and local (Sentul) hens.

Comparison of egg production

Figure 3 illustrates the comparison of egg production in 100 commercial (Hy-Line Brown) and 100 local (Sentul) hens, showing a substantial deviation.

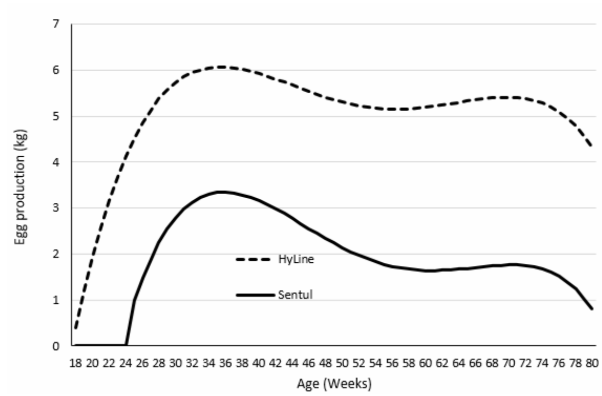

Figure 3 Quartic model estimation of egg production in Hy-Line Brown and Sentul hens

The total egg production at week 80 for commercial hens is 319.48 kg, while local hens yield 119.82 kg. The deviation at the peak of production is 2.72 kg. Commercial chicken production increases, peaking at week 35 with a production of 6.07 kg, while local chicken production reaches its peak at week 36 with a production of 3.35 kg. The peaks in production for commercial and local hens occur at a relatively similar age of 35-36 weeks, despite local hens reaching sexual maturity at an older age of 24 weeks. The age of sexual maturity can influence the total egg production. These performance differences are suspected to be due to genetic variations in the studied strains.

Sentul hens are local hens not yet selectively bred for egg production, whereas Hy-Line Brown hens are commercial hens specifically selected for egg production. Such variations in production performance are influenced by the genetic diversity present in each individual and the environment in which they are raised (Hill and Mackay, 2004; Johnston and Gous, 2007).

Accuracy assessment of mathematical models

The precision of using mathematical models is typically evaluated based on the coefficient of determination (R^2) obtained from the equations derived from these models. R^2 is a widely used metric for assessing the performance of regression models, serving as a measure of "goodness-of-fit" (Onyutha, 2020). The use of R^2 as a standard accuracy assessment is recommended for evaluating the fit of regression lines (Chicco *et al.* 2021).

Different mathematical models depict the shape of the egg production curve and the accuracy of their predictions varies depending on the R^2 values (Atta *et al.* 2010). For Hy-Line Brown hens, the highest R^2 value is obtained for the Quartic model at 89.67% (Table 2), followed by Gamma Wood (49.29%) and Quadratic (49.02%). In the case of Sentul hens, the highest R2 value is observed for the Quartic model at 89.92%, followed by Gamma Wood (53.68%) and Quadratic (49.02%). The estimated parameter values (a, b, c, and d) differ among the three mathematical models, influencing the graphical representation of the egg production curve for the studied hens. Variations in parameter values affect the persistence of individual genetic abilities in egg production. According to Grossman *et al.* (2000), measuring persistence in laying hens is crucial for genetic selection, as prolonged peak production benefits farmers. If the model is intended solely for predicting total egg production from partial data, a linear model should be considered due to its simplicity and lower cost (Narinc *et al.* 2014).

Egg quality

Eggs are natural substances that can be stored at room temperature, but gas exchange between the inner part of the egg and the atmosphere will alter the properties of the egg white, which also plays a crucial role in the egg's natural defense against bacteria. Storage at room temperature rapidly changes the antibacterial defense system in the egg white (Rehault-Godbert *et al.* 2010), and lower temperatures will slow down the rate of bacterial growth (Yadav and Vadehra, 1977). In this study, the quality of eggs was tested on freshly collected eggs from the coop. The results of the egg quality test are presented in Table 3.

Egg weight is a characteristic commonly used as a selection criterion. The weight of eggs varies depending on the age of the chicken; as the chicken ages, the egg weight tends to increase (Iqbal *et al.* 2017; Nys *et al.* 2018). Egg weight is categorized into four groups: small (S) if the weight is less than 53 g; medium (M) for sizes ranging from 53 to 62 g; large (L) for eggs with a weight of 63–72 g; and extra large (XL) for eggs weighing more than 73 g. The M and L categories are the most commonly sold as they align with consumer demand (Gautron *et al.* 2022).

Table 2 Estimation of coefficient of determination (R^2) for each model

Model	Parameter	Value	R^2
Hy-Line Brown hens			
Gamma Wood	A	2.29E-07	
	B	5.939	49.29
	C	0.119	
Quadratic	A	-0.927	
	B	0.258	49.02
	C	-0.002	
Quartic	A	-35.004	
	B	3.435	
	C	-0.104	89.67
	D	-6.146E-06	
Sentul hens			
Gamma Wood	A	0.00025	
	B	3.388	53.68
	C	0.081	
Quadratic	A	1.888	
	B	0.047	49.02
	C	-0.00073	
Quartic	A	-52.657	
	B	4.574	
	C	-0.134	89.92
	D	0.00166	

The table presents the estimated values of coefficients (A, B, C, D) and the corresponding coefficient of determination (R^2) for each mathematical model applied to the egg production data of Hy-Line Brown and Sentul hens.

Table 3 Egg quality of Hy-Line Brown and Sentul laying hens

Variable	Hy-Line Brown hens	Sentul hens
Egg weight (g)	62.35±5.02[a]	50.68±3.94[b]
Shell strength	0.42±0.10[a]	0.35±0.09[b]
Yolk color	8.55±0.86	8.60±1.18
Yolk weight (g)	21.53±1.89[a]	17.34±2.59[b]
Albumen weight (g)	32.5±2.71[a]	26.51±3.44[b]
Haugh Unit (HU)	95.99±7.94[a]	86.21±8.86[b]
Shell weight (g)	8.16±0.86[a]	6.83±0.73[b]

The means within the same row with at least one common letter, do not have significant difference (P>0.05).

According to Table 3, there is a significant difference in the egg weight of commercial and local hens (P<0.05). The egg weight of commercial hens is 62.35 ± 5.02 g, while that of local hens is 50.68 ± 3.94 g, with a deviation of 11.67 g. This high deviation is likely related to the genetic abilities of the hens. Sentul hens are locally raised in a simple manner to meet the protein needs of families, producing around 19.28 eggs per bird (Sudrajat and Isyanto, 2018a; Sudrajat and Isyanto, 2018b), whereas commercial hens undergo extensive selection specifically for egg production. In other studies, the lowest recorded egg weight for Hy-Line Brown hens was 61.50 ± 0.67 g (Thanapal *et al.* 2021), ranging from 59.73 to 66.72 g (Biesiada-Drzazga *et al.* 2022).

There is a significant difference in shell strength between commercial and local hens (P<0.05). The shell strength of commercial hens is 0.42 ± 0.10, while that of local hens is 0.35 ± 0.09. Eggs with stronger shells are more resistant to cracking. The crucial factor in determining shell strength is not the production system but rather the genetics and feed given to the hens (Gautron *et al.* 2022). Dietary calcium is necessary for the eggshell formation process (Dijkslag *et al.* 2021; Wang *et al.* 2021). Shell strength does not change during egg storage (Guyot *et al.* 2016), and towards the end of the production cycle, the shells become more brittle (Nys *et al.* 2018).

The yolk color between commercial and local hens is relatively similar (P>0.05). The average yolk color using the scale is 8.55 ± 0.86 for commercial hens and 8.60 ± 1.18 for local hens. In this study, both commercial and local hens were given the same feed containing the same nutrients. Yolk color did not differ because yolk color is related to the feed given. Different feed compositions can cause changes in color (Hammershøj and Johansen, 2016). The husbandry system influences the composition of eggs, including yolk color, which is inconsistent and highly variable. This variation does not affect the nutritional content of eggs (Gautron *et al.* 2022), but yolk color does influence consumer perception (Berkhoff *et al.* 2020).

For the albumen weight, the data indicates a significant difference (P<0.05) in the weight of egg whites (albumen) between Hy-Line Brown and Sentul hens. The average weight of albumen is higher in Hy-Line Brown hens (32.5±2.71 g) compared to Sentul hens (26.51±3.44 g). Past research has shown that egg weight, yolk weight, and percentage, as well as Haugh Units, increase with the hens' age in all genotypes, while albumen and eggshell percentage decrease. Additionally, eggshell thickness and strength improve with age (Zita *et al.* 2009). This could imply that the differences observed in albumen weight between the two chicken breeds may be influenced by their age and genotype.

Furthermore, the Haugh Unit (HU) is a measure of egg freshness and quality. A higher HU value indicates better egg quality. In this study, Hy-Line Brown hens have a significantly higher (95.99±7.94) HU compared to Sentul hens (86.21±8.86), suggesting better egg quality in terms of freshness. Previous studies have also highlighted the relationship between eggshell quality and the age of the hens, with histological changes in the uterus endometrium associated with increasing hen age (Park and Sohn, 2018).

There is also a significant difference (P<0.05) in the weight of eggshells between Hy-Line Brown and Sentul hens. The average weight of eggshells is higher in Hy-Line Brown hens (8.16±0.86 g) compared to Sentul hens (6.83±0.73 g). This could indicate differences in eggshell thickness and strength, with Hy-Line Brown eggs having a relatively higher eggshell weight. Research has shown that the physical quality of eggs, including shell thickness, is influenced by the breed of the hens, with certain strains exhibiting better results for specific egg quality traits (Almeida *et al.* 2021). This suggests that genetic variations and breed differences may contribute to the observed variations in eggshell weight between Hy-Line Brown and Sentul hens.

Correlation of egg weight with egg quality

Table 4 reveals a positive correlation between the egg weight of commercial hens and various quality parameters such as shell strength, yolk color, yolk weight, egg white weight, and shell weight, denoted by values of 0.224, 0.033, 0.968, 0.993, and 0.488, respectively. Conversely, there is a negative correlation with Haugh Unit (HU) at -0.040. This suggests that an increase in egg weight corresponds to an increase in these measured variables.

Table 4 Correlation of egg weight with egg quality

Egg laying hens	Egg weight correlation
Hy-Line Brown hens	
Shell strength	0.224**[1]
Yolk color	0.033
Yolk weight	0.968**
Albumin weight	0.993**
Haugh Unit (HU)	-0.040
Shell weight	0.488**
Sentul hens	
Shell strength	0.236**
Yolk color	-0.064
Yolk weight	0.382**
Albumin weight	0.751**
Haugh Unit (HU)	0.212**
Shell weight	0.644**

** (P<0.005).

The positive correlation implies that egg weight indirectly influences eggshell strength, while the thickness of the eggshell has a direct connection with egg weight (Choi *et al.* 1983; Stadelmann, 1995). Previous studies, including Nowaczewski *et al.* (2008), have also highlighted the positive correlation between egg weight and eggshell thickness, observing a decrease in eggshell thickness as egg weight increases (Poggenpoel, 1986; Ketelaere *et al.* 2002). These observations align with findings from earlier research.

In the context of this study, egg weight exhibits positive associations with various egg quality indicators, including shell strength, yolk color, yolk weight, egg white weight, and shell weight, while demonstrating a negative correlation with Haugh Unit (HU). This consistency with past research supports the idea of a positive relationship between egg weight and eggshell thickness (Alfonso-Carrillo *et al.* 2021). Furthermore, the inverse relationship between egg weight and eggshell thickness has been substantiated in experiments exploring the impact of strain and age on egg quality parameters (Kocevski *et al.* 2011).

Beyond this, investigations into the relationship between bone quality and egg production or eggshell quality have unveiled intriguing patterns. Hens exhibiting high egg production and robust eggshell quality often display diminished bone quality (Ketta and Tůmová, 2017). This complex interplay suggests intricate dynamics between egg production, eggshell quality, and bone quality in laying hens. Additionally, the microstructure of eggshells laid by hens of varying ages has been found to influence shell strength, showcasing the multifaceted nature of eggshell quality (Chang, 2021).

Moreover, genetic factors have been scrutinized concerning eggshell quality, with studies delving into quantitative trait loci influencing eggshell quality and examining the impact of myostatin mutation on egg size and eggshell thickness (Rodríguez-Navarro *et al.* 2002; Lee *et al.* 2021). These genetic insights shed light on the underlying mechanisms contributing to variations in eggshell quality among different genotypes and mutations. Additionally, housing systems have emerged as interacting factors with genotypes in relation to internal and external egg quality parameters, showing the need to consider environmental factors alongside genetic factors when evaluating egg quality (Gous *et al.* 2019). Furthermore, investigations into the effect of breeder age on eggshell thickness, surface temperature, hatchability, and chick weight emphasize the consequential impact of age on eggshell quality (Ketta and Tůmová, 2018).

CONCLUSION

The mathematical models applied in this study, including the Gamma Wood, Quadratic, and Quartic models, effectively captured the egg production curves of Hy-Line Brown and Sentul hens. The Quartic model exhibited superior performance, providing a more accurate representation of persistence in egg production for both commercial and local hens. The age of sexual maturity influenced the total egg production, with a relatively similar peak production age of 35-36 weeks for both strains. Egg quality parameters, including egg weight, shell strength, yolk color, yolk weight, albumen weight, Haugh Unit (HU), and shell weight, were systematically compared between the Hy-Line Brown and Sentul hens. The quality of the eggs of the Hy-Line Brown is higher than Sentul hens. Egg weight, a crucial selection criterion, exhibited a positive correlation with shell strength, yolk color, yolk weight, albumen weight, and shell weight in both Hy-Line Brown and Sentul hens. This positive association showed the interconnectedness of egg weight with various egg quality indicators. Notably, the negative correlation with Haugh Unit (HU) suggests that increased egg weight corresponds to a decrease in egg freshness. Furthermore, the comparison of egg quality parameters highlighted the genetic variations between commercial (Hy-Line Brown) and local (Sentul) chicken strains. Commercial hens demonstrated significantly higher egg weight, shell strength, albumen weight, Haugh Unit (HU), and shell weight compared to their local counterparts. These findings showed the impact of selective breeding for specific traits in commercial strains. The results of this study contribute valuable insights into the egg production dynamics and egg quality characteristics of different chicken strains. The identified correlations between egg weight and quality parameters emphasize the multifaceted nature of egg production and quality, influenced by genetic, environmental, and management factors. These findings provide a foundation for further research on selective breeding strategies and management practices to optimize egg production and quality in diverse chicken populations.

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