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INTERNAL EGG QUALITY TRAITS OF CHICKEN: STORAGE DURATION AND STRAIN EFFECTS

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ABSTRACT

The experiment aimed at studying the effect of length of storage and chicken strain on the internal egg qualities of chickens. Eggs from 51-week-old Isa-brown, Isa-white, and Lohmann brown were analyzed using a 4 x 3 factorial arrangement for their internal egg qualities. The strain was studied under three levels and storage duration under four levels. A total of three hundred and sixty (360) eggs (120 from each strain) were collected from the hens, labeled according to the strain, and 30 eggs from each strain were analyzed for their internal quality traits at the point of lay (day 1), day 7, day 14 and day 21. Data collected were subjected to two-way analysis of variance, and differences between treatments means were separated using LSD. Most studied traits showed no differences between the Isa-brown, Isa-white and Lohmann brown chickens. However, the eggs laid by Lohmann brown strain were superior to those laid by Isa strains in egg weight, albumen weight, and yolk weight. A prolonged holding period affected some egg quality traits such as albumen weight and height, Haugh unit, and yolk weight. Hence, the study displayed that the longer the egg is stored, the lesser the nutritive value of the egg and eggs from some strains of poultry may stay longer than that of others without deleterious effects on their internal egg qualities.

***Keywords*:** Correlation, Egg quality traits, Storage duration, Strain

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1. INTRODUCTION

According to Matt et al. (2009), the egg is the most excellent source of non-expensive animal protein with well-balanced nutrients for mankind. The egg is generally acceptable and has no cultural or religious taboo against its consumption. Its natural presentation or disposition appeals to people of all ages and classes; however, the major drawback in egg production and consumption is its rapid deterioration, leaving it offensive. Bekele et al. (2022) listed the factors that affect egg quality deterioration to include variation in environment, the composition of feed, and management practices of the hen. Rizzi (2020) reported that genotype and age affect most egg quality traits, and Goto et al. (2022), working with Japanese quail and Brown layer chickens, observed genotype effect on the amino acids contents of egg yolk and albumen.

According to Bekele et al. (2022), egg weight correlates positively with egg length and breadth. However, Okonkwo (2014) and Sadaf et al. (2021) reported little or no genetic correlation between egg quality traits, and the relationship remains fairly constant even as laying age progressed. This implies that neither the nutritive value of an egg nor the breeding value of a hen from color or other external characteristics. The period of egg storage may be increased by keeping them under the refrigerator between 5°C and 13°C (Hagan and Eichie 2019; Okonkwo et al. 2021). Other preventive measures for successful storage of eggs include proper cleaning without wetting, using new, clean, and odorless materials for packing. Also, reducing temperature to minimize water evaporation, avoiding tainting materials in the storage room, maintaining proper air circulation, constant temperature and humidity in the storage room (FAO 2003; Hagan and Eichie 2019; Okonkwo et al. 2021).

Egg quality traits are a function of the management and nutrient contents of the hen's feed (Yaman et al. 2012; Bekele et al. 2022). This is so because hens are efficient feed converters and transform only available nutrients into eggs. Feeding layers deficient in some essential nutrients will entail the production of eggs poor in such critical nutrients. However, a good number of environmental factors like temperature, humidity, the presence of CO2 and storage time influence egg quality traits mostly during handling and storage (Silversides and Villeneuve 1994; Walsh et al. 1995; Scott and Silversides 2000; Samli et al. 2005; Hagan and Eichie 2019). Abioja et al. (2021), working with FUNAAB-α chickens, reported that extended storage duration resulted in a decline in egg quality, high embryo mortality and low hatchability of eggs.

Furthermore, protracted periods of storage, according to Scott and Silversides (2000), results in a diminution in the strength of the vitelline membrane, thereby making it possible for microorganisms to enter the yolk and albumen

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(Scott and Silversides 2000; Jones and Musgrove 2005; Keener et al. 2006; Mollazade et al. 2021). Thus, it has been established that these environmental factors are critical in determining the quality of eggs getting to consumers and eggs hatchability. Though Ansari et al. (2021), working with egg quality indices of Uttara chicken breed, maintained that eggshell and yolk weight were higher in crown type than the comb ecotype, there is a lack of literature report on strain differences on egg quality traits as storage time increased. Hence, this experiment was designed to determine the influence of strain storage duration and their interaction on the internal egg quality traits of chicken.

2. MATERIALS AND METHODS

2.1. Study Site

The study was conducted at the Department of Animal Science and Technology laboratory unit, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

2.2. Sample Collection

Obtained 360 eggs (120 from each breed) from ISA-Brown, ISA-White and Lohmann Brown, at Eagle food Nigeria limited and Pinga agro investment limited. Collected eggs were from the same day from a 51-week-old layer (ISA-Brown and ISA-White) and 51 weeks old Lohmann brown breed. The eggs were properly labeled for easy identification and stored for a varied number of days {one (1), seven (7), fourteen (14), and twenty-one (21) days)} after being laid under room temperature (26.6°C).

2.3. Experimental Design

used three x four (3x4) factorial design to carry out the study. Three strains, namely Isa-brown, Isa-white, and Lohmann Brown, were tested, and four storage periods, one (1), seven (7), fourteen (14) and twenty-one (21) days after being laid, were examined together with the interaction between strain and storage on internal egg quality traits. The strain was tested on three levels with an equal replicate of 120 eggs per strain, while the storage duration was tested on four levels with 90 eggs per level. Thus, plugged the data collected into the model:

$Yijk = \mu + \beta i + \mathbb{D}j + \beta i\, \mathbb{D}j + \mathcal{E}ijk$

Where:

Yijjk- is the observed egg quality traits

μ- the population mean

βi- the effect of ith strain, 1, 2, 3

$\mathbb{D}j$ - the effect of jth storage duration, 1, 2, 3, 4

$\beta i\mathbb{D}j$ - is the strain x storage interaction

$\mathcal{E}ijk$ - error that may occur in relation to the experimentation

2.4. Analytical Procedure

Ninety (90) eggs, thirty (30) from each strain were analyzed for their internal quality characteristics on the 1st, 7th, 14th and 21st days of lay as follows:

2.4.1. Albumen Height and Width (mm)

Using the blunt end of a knife, cracked the egg from the middle after the egg weight had been individually measured using a laboratory scale. Emptied The egg contents on a flat plate positioned on a leveled bench. Then, the Albumen Height and Width were taken using a Spherometer.

2.4.2. Albumen Index (%)

The percentage albumen (Albumen index) was calculated as the ratio of the albumen height (mm) to the average of width (mm) and length (mm) of the albumen multiplied by 100, using a spherometer and a Vernier caliper.

2.4.3. Albumen Weight (g)

This is measured as the egg weight minus shell weight and yolk weight as described by Gilbert and Wurdak (1978) and Maddheshiya et al. (2020).

$$\text{Albumen Weight (g)} = \text{Egg weight} - (\text{Shell weight} + \text{Yolk weight})$$

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2.4.4. Yolk Height (cm)

The Yolk Height was measured using a micrometer screw gauge. After measuring the thickness of the Petri dish with a micrometer screw gauge, separated the yolk from albumen into a Petri dish. Vernier caliper was employed to measure the height of the yolk placed just below and above the Petri dish.

2.4.5. Yolk Index (%)

The yolk index was determined as the ratio between the yolk height and yolk diameter.

2.4.6. Yolk Weight (g)

After carefully separating the yolk from the albumen, the yolk weight was measured by placing the yolk and Petri dish on a laboratory scale.

2.4.7. Albumen Percent

This was calculated as the albumen weight (g) divided by the weight of the whole egg and multiplied by 100.

2.4.8. Yolk Percent

This was calculated as the yolk weight (g) divided by the weight of the whole egg and multiplied by 100.

2.4.9. Haugh Unit

Haugh Unit was calculated using the Haugh unit equation.

$$HU = 100 \log (H + 7.57 - 1.7w0.37)$$

Where:
HU = Haugh Unit
H = Observed height of albumen (mm)
W = Weight of egg (g)

2.5. Statistical Analysis

Data obtained were subjected to a two-way analysis of variance (ANOVA) to test the effect of strain and storage duration on egg quality traits. GenStat was used and LSD was used to separate treatment means at a 5% significance level.

3. RESULTS

Table 1 presents the effect of strain on the internal egg quality traits studied. Strain differences (P<0.05) were observed for albumen index, length and width, yolk diameter and yolk weight. In contrast, strain wielded no substantial (P>0.05) influence on albumen height, albumen ratio, yolk index, yolk ratio and Haugh unit.

Table 1: Strain effect on internal egg characteristics

Strains	Albumen						Yolk					
	Height (mm)	Index (%)	Length (cm)	Ratio (%)	Weight (g)	Width (cm)	Diameter (cm)	Height (cm)	Index (%)	Ratio (%)	Weight (g)	Haugh unit
Isa-brown	4.93	6.34a	8.68a	65.46	39.16a	6.99a	3.96b	1.41ab	35.79	24.62	14.65a	65.92
Isa-white	4.81	6.23a	8.68a	65.68	38.93a	7.14a	4.17a	1.48a	35.85	24.98	14.79b	64.95
Lohmann Brown	4.82	5.85b	9.03b	65.42	40.82b	7.65b	4.14a	1.46a	35.45	24.77	15.31c	63.95
LSD	0.16	0.24	0.16	0.63	0.99	0.15	0.05	0.02	0.69	0.50	0.28	1.73
P-value	0.282	<0.001	<0.001	0.694	<0.001	<0.001	<0.001	<0.001	0.475	0.362	<0.001	0.085

Means bearing different alphabets in the column differ significantly (P<0.05).

Lohmann brown was lower (P<0.05) in albumen index and higher in albumen length than Isa-brown and Isa-white. In addition, Lohmann brown outscored (P<0.05) Isa-brown and Isa-white in albumen weight, albumen width, and yolk weight. Table 2 presents the influence of storage time on the egg quality indices studied. The storage length exhibited a substantial effect (P<0.05) on all the internal egg qualities studied (Table 2). As the storage duration increased from D1 to D21 (day 1 to day 21), albumen height, albumen index, albumen ratio, albumen weight decreased (P<0.05). The reverse was true for albumen length and width, yolk ratio, yolk weight (P<0.05).

The interaction between strain and storage period on these internal egg quality indices of chicken eggs studied are presented in Table 3. The interaction between strain and storage length showed noteworthy influence (P<0.05) for albumen index, albumen length, albumen ratio, albumen weight, albumen width, yolk diameter, yolk height, yolk index and yolk index ratio and yolk weight.

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Table 2: Effect of storage duration on internal egg characteristics

Storage Duration in Days	Albumen						Yolk					
	Height (mm)	Index (%)	Length (cm)	Ratio (%)	Weight (g)	Width (cm)	Diameter (cm)	Height (cm)	Index (%)	Ratio (%)	Weight (g)	Haugh unit
1	7.02d	9.14d	8.48a	66.58b	40.62b	6.95c	4.31c	1.49b	34.84a	23.79a	14.38a	83.65d
7	4.92c	6.14c	8.71b	65.86b	40.37b	7.37ab	3.96a	1.48b	37.69c	24.74b	15.17b	66.71c
14	4.05b	5.06b	8.89b	64.66a	39.15a	7.31a	3.97a	1.42a	36.04b	25.29bc	15,19b	58.25b
21	3.43a	4.22a	9.11c	64.99a	38.41a	7.41b	4.13b	1.41a	34.23a	25.34c	15.93c	51.54a
LSD	0.18	0.28	0.19	0.73	1.14	0.18	0.06	0.02	0.80	0.57	0.32	2.00
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Means bearing different alphabets in the column differ significantly (P<0.05).

Table 3: Interaction effect between strain and storage duration on internal egg characteristics

Strain/storage duration (days)		Albumen						Yolk					
		Height (mm)	Index (%)	Height (mm)	Index (%)	Height (mm)	Index (%)	Height (mm)	Index (%)	Height (mm)	Index (%)	Height (mm)	Index (%)
Isa-brown	D1	7.02	8.94d	8.86bc	65.49bc	38.95ab	6.87a	4.12c	1.35a	32.97a	24.60ab	14.54ab	83.68
	D7	5.04	6.50c	8.48a	66.43c	39.92bc	6.96b	3.70a	1.46b	39.56c	23.68a	14.15a	68.62
	D14	4.28	5.59b	8.52ab	65.17ab	40.00c	6.91ab	3.93b	1.44b	36.70b	24.92bc	15.22c	60.10
	D21	3.39	4.34a	8.86c	64.76a	37.75a	7.22c	4.08c	1.38a	33.95a	25.27c	14.69bc	51.27
Isa-white	D1	7.07	9.77d	7.98a	66.28ab	39.54bc	6.51c	4.56c	1.54c	34.02a	24.24a	14.33a	83.97
	D7	4.71	5.88c	8.72b	66.70b	40.36c	7.41b	4.09b	1.48b	36.50b	24.74ab	15.13c	64.52
	D14	4.00	5.00b	8.84bc	64.20c	37.31a	7.27a	3.92a	1.48b	37.97c	25.84c	15.00c	58.86
	D21	3.47	4.26a	9.16c	65.54a	38.52ab	7.37ab	4.10b	1.42a	34.91a	25.11bc	14.72b	52.45
Lohmann Brown	D1	6.99	8.72d	8.59a	67.96c	43.36c	7.48a	4.25b	1.59d	37.52b	22.54c	14.26a	82.10
	D7	5.00	6.03c	8.93b	64.45a	40.83b	7.73bc	4.08a	1.50c	37.00b	25.80b	16.25c	66.99
	D14	3.88	4.58b	9.29c	64.62ab	40.15ab	7.75c	4.05a	1.35a	33.46a	25.10a	15.37b	55.81
	D21	3.42	4.07a	9.31c	64.67b	38.96a	7.65ab	4.21b	1.42b	33.82a	25.64ab	15.39b	50.90
LSD		0.32	0.49	0.33	1.26	1.98	0.31	0.10	0.04	1.39	1.00	0.56	3.47
P-value		0.189	<0.001	<0.001	<0.001	0.007	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.186

Means bearing different alphabets in the column within the same strain differ significantly (P<0.05).

4. DISCUSSION

Many of the egg quality parameters like albumen index, albumen length, albumen weight, albumen width were influenced by strain (Table 1), which is an indication of genetic effect and agreed with some literature reports (Hartmann et al. 2003); Zhang et al. 2005; Okonkwo 2009; Wolc et al. 2012; AL-Obaidi et al. 2020; Okonkwo et al. 2021). Lohmann brown had a heavier albumen weight than Isa strains and was affected by strain, directly proportional to egg weight. These findings agreed with the works of Washburn (1990) and Okonkwo (2014). They reported a higher positive correlation between egg weight and albumen weight and a lesser correlation between egg weight and shell or yolk weight. This means that Lohmann brown produced a much heavier egg than Isa-brown and Isa-white.

The internal egg qualities are the major determinants of eggs value offered to consumers (Yaman et al. 2012; Lee et al. 2016). A meaningful decline was observed in albumen height and Haugh unit due to an increase in the duration of storage. The albumen height, one of the major internal parameters for measuring egg quality, decreased from 7.02 to 3.43mm as storage duration prolonged, albumen length and width increased as the period of storage increased and may be attributed to loss of CO2 from the albumen. A decline in the CO2 content of the albumen will make the albumen alkaline, transparent, and increasingly watery, which is in agreement with the findings reported by Okeudo et al. (2003). At higher temperatures and longer storage duration, the loss of CO2 increases and albumen quality deteriorates faster.

Albumen weight reduced from 40.62 to 38.41g (Table 2) and agrees with the reports from Scott and Silversides (2000), Jones and Musgrove (2005) and Hagan and Eichie (2019), which might be due to rapid loss of moisture by evaporation through the shell pores, to the surrounding atmosphere, as the period of storage increased.

Yolk weight increased from 14.38 to 15.93g and was influenced by increased storage time (Table 2) and agrees with the report of Jin et al. (2011), who observed an increase in yolk weight when the storage time increased. The yolk integrity depends on the strength of the vitelline membrane, which is inversely proportional to storage duration and temperature; as the yolk losses its quality, it absorbs water from the watery albumen, thereby increasing in weight. The yolk index decreased from 34.84 to 34.23% at increased storage time (Table 1) and this agrees with reports from Caner and Cansiz (2007) that reported a decreased yolk index after 4 weeks of storage. This shows that the yolk index is higher for eggs stored at cold temperatures than those stored at room temperature for longer periods.

As determined by Haugh unit, the freshness of the egg's unit, was affected by storage duration. As the storage duration increased from 7 days to 21 days, the freshness of the eggs retrogressed from 83.65% to 51.54%. The

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study evinced that after 14 days of storage, the freshness of the eggs stored at room temperature falls below 70%, which is the minimum acceptable standard as reported by (Haugh 1937). Similar reports on the decline in Haugh unit as a result of prolonged storage duration have been reported by Scott and Silversides (2000), Keener et al. (2006), Raji et al. (2009) and Okonkwo (2009). It was observed that the Haugh unit was not influenced by the interaction between the chicken strain and storage duration. A contrary report was given by Hagan et al. (2013), who observed the interaction effect between strain and storage duration on the Haugh unit. The inconsequential interaction influence obtained in this study implies that regardless of the strain from which the eggs are obtained if the eggs are stored over a long period, the value would be reduced. Equally, AL-Obaidi et al. (2020) evinced that as the age of laying hen advances, both the external and internal egg characteristics declined.

Conclusion: The chicken strain exhibited a noticeable effect on internal egg quality traits such as albumen characteristics and yolk indices, hence may determine how long an egg can be stored. All the quality traits tested were expressively affected by storage duration. As storage duration increased, the quality of the egg regressed. Thus, there is a need to devise proper preservative measure(s) as proposed by Okonkwo et al. (2021).

Author's Contribution: Okonkwo JC conceived, designed and outlined the work. He also revised the wrote up. Samuel K carried out the laboratory determination of the egg quality indices under the guidance of Nwankwo CA and Okonkwo IF. They wrote the manuscript. Ezenyilimba BN and Okafor EC are directly involved in the management of the birds and statistical analysis

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