COMPARATIVE ANALYSIS OF EGG QUALITIES OF ISA-BROWN LAYING BIRDS COLLECTED FROM THREE HOUSING SYSTEMS

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ABSTRACT

This study was carried out to investigate the egg qualities of eggs collected from Isa-Brown laying birds under three systems. 90 birds were allotted to three systems of three replicates and 10 birds per replicate in a completely randomized design. External and internal egg qualities were examined at every 28 days, while the egg storage effects were examined at day 7, 14 and 21. Results showed that significant differences (p<0.05) existed between the systems and egg qualities. Highest egg weight (63.22 ± 0.93 g) was recorded in eggs collected from cage, while lowest egg weight (56.71 ± 1.11 g) was recorded in eggs collected from outdoor. Highest shell thickness (0.18 ± 0.01 mm) was observed in egg collected from outdoor, while lowest shell thickness (0.12 ± 0.01 mm) was observed in eggs from cage. Lowest pH (7.37 ± 0.05) was recorded on day seven, while highest pH (8.10 ± 0.04) was observed on day 21 in eggs collected from deep litter and outdoor systems, respectively. The results on egg qualities in relations to the rearing systems reveal that external and internal egg qualities were better in battery cage rearing system. On the storage period, egg consumers should strictly consider seven days storage period at room temperature in order to prevent nutritional and economic loss.

Keywords: Egg qualities, pH, Rearing systems, Battery cage, Outdoor, Deep litter, Laying birds

INTRODUCTION

The housing system is an external factor that influences both the performance of hens and the egg quality characteristics. Conventional cages have been banned in the European Union since 2012, and the housing of laying hens is permitted only in enriched cages or in alternative systems, such as litter housings, aviaries or free range, to improve the welfare of the hens. Better performance of layers is achieved in conventional cage systems (Holzebosch 2006; Voslářová *et al.*, 2006; Valkonen *et al.,* 2010), including more eggs, improved feed consumption and feed conversion ratios and lower mortality. The ban on housing hens in conventional cages has led to a search for suitable housing systems. In terms of the welfare of hens, alternative housing systems are preferable to cages. Duncan (2001) analysed advantages and disadvantages of battery cage systems. He considered the low incidence of diseases, low incidence of social frictions, and the absence of problems resulting from litter as the main advantages. The disadvantages were found to be a lack of both physical and psychological space for laying hens, lack of space for daily activities and nesting and dust bathing opportunities, and a higher incidence of foot lesions. The chicken egg is one of the finest foods, offering men an almost complete balance of essential nutrients with proteins, vitamins, minerals and fatty acids of great biological value (Gunnars, 2018). In addition to being one of the foods with the lowest cost, eggs increases the consumption of food with high nutritional value by the low-income population (Abive-Bortsi *et al.*, 2022). Egg producers have increased their net income by utilizing available housing facilities at maximum capacity (Jalal *et al*., 2006). The egg quality characteristics are better in eggs produced in cages when compared to alternative systems. Opinions on egg weights are ambiguous. Leyendecker *et al.* (2001a) observed higher egg weights from hens that were housed in cages, whereas Tůmová and Ebeid (2005) and Pištěková *et al.* (2006) reported heavier eggs from litter systems. However, the influence of the housing system on egg quality still needs more investigations. Therefore, this study was conducted to look at the quality of eggs, expressed as the physical egg quality characteristics and the storage period on the quality of eggs from battery cage, deep litter and outdoor rearing systems.

MATERIALS AND METHODS

Experimental Site: The field work for this study was carried out at a private farm (Oluade Farm in Ilara-Mokin), Ifedore Local Government, Ondo State Nigeria, while the laboratory analyses were done at the Microbiology Laboratory, Department of Animal Production and Health, Federal University of Technology, Akure, Ondo State, Nigeria. The towns are located within Latitude 7º 20" N and Longitude 5º 12" E, the rainfall zone of the humid tropics which is characterized by hot and humid climate. The annual rainfall is 1800 mm and the rain period is bimodal with a short break in August. The altitude is about 323.03 m above the sea level, the annual humidity is less than 70% and the annual temperature ranges between 22 – 30ºC (Ashaolu and Adebayo, 2014)

Birds' Arrangement and Feeding Trial: One hundred (100) Isa-Brown laying birds of 47 weeks old were procured and were housed in battery cages for two weeks to ascertain the ones producing among the birds to be used for this study. At the end of the two weeks, 90 producing birds were selected and used for this study. The birds were divided into three treatments replicated thrice and ten (10) birds per replicate and they were marked using different coloured permanent marker to ascertain each group in a completely randomized design. The formulation of the diets met the NRC (1994) requirements for laying hens. Each bird was given 115 g feed per day and the trial lasted for 84 days, while water was provided *ad libitum* throughout the experimental periods. The experimental period was further divided into three phases of 28 days per phase.

Egg Quality Evaluation: Eggs were collected on the last three days to the end of each phase; all the eggs collected from each replicate were marked for the determination of external and internal egg quality parameters. Egg quality parameters assessed include egg weight, egg length and width, shell thickness, shell weight, percentage shell weight, albumen height, albumen weight, albumen width, yolk weight, yolk length, yolk height, Haugh unit and pH.

Egg Weight: Collected eggs were weighed using a sensitive digital balance (g). The weight of the egg was recorded and then the eggs were marked with a permanent marker.

Eggshell Weight: Shell weight was determined according to the procedures described by Kul and Seker (2004). After removing the yolk and the albumen from the shell, the shells were oven-dried for one hour at 40^{O}C using laboratory oven, (TT-9053, Technel and Technel, USA) and weighed using a digital sensitive balance scale.

Percentage Shell Weight: The percentage shell weight was calculated by dividing the shell weight by the weight of the egg and multiplying by 100 (Chowdhury and Smith, 2001).

Percent shell (%) = $\frac{\text{Weight of shell (g)}}{Weig \quad of\ egg\ (g)}\, x100$

Eggshell Thickness: After weighing the dried shell, part of the shell was cut and the inner layer removed to measure the thickness of the eggshell using micrometer screw gauge. The shell thickness was measured at three different points at the equatorial shell region and the average of the three was used as a trait.

Albumen Weight: Each egg was gently crack to expose the interior portion. The egg yolk was manually separated from the albumen with use of tablespoon. The albumen weight was then measured using a sensitive digital scale.

Haugh Unit: Albumen quality is measured in terms of Haugh units (HU) calculated from the albumen height and the weight of the egg. Haugh unit = 100 log (AH + 7.57 - 1.7 x $EW^{0.35}$), Where AH = Albumen height, EW = Egg weight, 7.57, 1.7 and 0.35 are constants (Haugh, 1937)

Egg pH: The egg albumen and yolk contents were mixed thoroughly. After this, the whole egg pH was measured using a digital pH meter (DpH-2 ATAGO).

Storability Evaluation: The eggs were stored at room temperature at different storage periods to assess the quality of the eggs from the three different rearing systems. During the last three days of each experimental phase, a total of 12 fresh eggs were collected from each replicate and labeled with a permanent marker and the weight of these eggs were recorded. The eggs collected were stored for 7, 14 and 21 days. At the 7th day, the weights of all the eggs for the three batches were taken. The eggs meant for 7th day storage were broken to reveal the internal contents upon which the quality of the eggs was assessed. This was repeated at the 14th and 21st day.

Percentage Loss in Egg Weight: The variations in the weight of the eggs across the storage periods were calculated by subtracting the initial weight from the final weight divided by the initial weight then multiplied by one hundred.

$$\text{\% weight loss} = \frac{\text{Initial weight} - \text{fina weight}}{\text{Initial weight}} \times 100$$

Statistical Analysis: All data were subjected to one-way Analysis of Variance (ANOVA) using SPSS version 23.0 (SPSS Software products, Marketing Department, SPSS Incorporated, Chicago, Illinois, USA) and where there were significant differences, Duncan Multiple Range Test (DMRT) of the same package was used to compare the mean values.

RESULTS

Among all the external egg quality parameters measured, the egg weight, egg height, egg width and shell thickness were significantly ($p<0.05$) influenced by the three different rearing systems. Highest egg weight (63.22 ± 0.93 g), highest egg height (4.72 ± 0.04 cm) and highest egg width (3.50 ± 0.02 cm) were recorded in eggs collected from the battery cage rearing system, while lowest egg weight (56.71 ± 1.11 g), lowest egg height (4.53 ± 0.05 cm) and lowest egg width (3.36 ± 0.03 cm) were recorded in eggs collected from outdoor rearing system (Table 1). Highest shell thickness (0.18 ± 0.01 mm) was observed in egg collected from outdoor rearing system, while lowest shell thickness (0.12 ± 0.01 mm) was observed in eggs from battery cage rearing system. Numerically, highest shell weight (6.03 ± 0.14 g) was recorded in egg collected from battery cage rearing system, while lowest shell weight (5.93 ± 0.14 g) was recorded in egg collected from deep litter rearing system. Highest % shell weight (10.65 ± 0.32 %) was recorded in egg collected from outdoor rearing system, while lowest % shell weight (9.55 ± 0.25 %) was recorded in egg collected from battery cage rearing system.

Among all the internal egg quality parameters measured, albumen weight, yolk weight, albumen height, albumen width and yolk length were significantly influenced ($p<0.05$) by the three different rearing systems. Highest albumen weight (38.80 ± 1.07 g), highest yolk weight (15.68 ± 0.40 g), highest albumen width (7.36 ± 0.25 mm), and highest yolk length (4.43 ± 0.04 cm) were recorded in eggs collected from battery cage rearing system, while lowest albumen weight (34.41 ± 0.89 g), lowest yolk weight (13.69 ± 0.30 g), lowest albumen width (6.66 ± 0.16 mm) and lowest yolk length (4.13 ± 0.06 cm) were observed in eggs collected from outdoor rearing system.

Table 1: External egg quality of Isa-Brown laying birds under different rearing systems

Parameters	Battery Cage	Deep Litter	Outdoor
Egg weight (g)	63.22 ± 0.93^{b}	59.88 ± 1.81^{ab}	56.71 ± 1.11^{a}
Egg height (cm)	4.72 ± 0.04^{b}	4.59 ± 0.07^{ab}	4.53 ± 0.05^{a}
Egg width (cm)	3.50 ± 0.02^{b}	3.40 ± 0.04^{ab}	3.36 ± 0.03^{a}
Shell thickness (mm)	0.12 ± 0.01^{a}	0.15 ± 0.01^{b}	0.18 ± 0.01^{c}
Shell weight (g)	6.03 ± 0.14	5.93 ± 0.14	6.01 ± 0.11
% Shell Weight	9.55 ± 0.25	9.97 ± 0.27	10.65 ± 0.32

a, b, c – Means on the same row with different letter superscripts are significantly different (p<0.05)

Table 2: Internal egg quality of Isa-Brown laying birds under different rearing systems

Parameters	Battery Cage	Deep Litter	Outdoor
Albumen weight (g)	38.80 ± 1.07^{b}	37.00 ± 1.41^{ab}	34.41 ± 0.89^{a}
Albumen height (mm)	8.70 ± 0.24^{b}	8.71 ± 0.16^{b}	8.01 ± 0.13^{a}
Albumen width (mm)	7.36 ± 0.25^{b}	7.10 ± 0.15^{ab}	6.66 ± 0.16^{a}
Yolk weight (g)	15.68 ± 0.40^{b}	14.87 ± 0.40^{b}	13.69 ± 0.30^{a}
Yolk length (cm)	4.43 ± 0.04^{b}	4.36 ± 0.05^{b}	4.13 ± 0.06^{a}
Yolk height (mm)	1.24 ± 0.03	1.31 ± 0.03	1.33 ± 0.04
Haugh unit	88.22 ± 1.47	87.76 ± 0.77	85.92 ± 0.86
Egg pH	7.27 ± 0.10	7.38 ± 0.12	7.53 ± 0.15

a, b, c – Means on the same row with different letter superscripts are significantly different (p<0.05)

Highest Haugh unit (88.22 ± 1.47) and lowest egg pH (7.27 ± 0.10) were recorded in eggs collected from battery cage rearing system while lowest Haugh unit (85.92 ± 0.86) and highest pH (7.53 ± 0.15) were observed in eggs collected from outdoor rearing system (Table 2).

All the parameters measured on the effect of storage on egg qualities were significantly (p<0.05) influenced by the storage periods. Considering the final weight, highest egg final weight (56.72 ± 3.19 g) was observed in egg stored for 21 days under the deep litter rearing system while the lowest egg final weight (48.02 ± 1.40 g) was observed in egg stored for 21 days under outdoor rearing system. For egg weight loss at 7th day storage period, highest egg weight loss (1.48 ± 0.13 g) was recorded in egg collected from deep litter rearing system, while lowest egg weight loss (1.13 ± 0.04 g) was recorded in egg collected from outdoor rearing system. At 14th day, highest egg weight loss (3.58 ± 0.13 g) was recorded in egg collected from battery cage rearing system, while lowest egg weight loss (2.72 ± 0.30 g) was recorded in eggs collected deep litter rearing system. Highest % weight loss (5.98 ± 0.25%) was observed in egg collected from battery cage rearing system and stored for 14 days, while lowest % weight loss (4.69 ± 0.42%) was observed in egg collected from deep litter rearing system and stored for 14 days. For the 7th day, highest pH (7.40 ± 0.00) was recorded in egg collected form battery cage rearing system, while lowest pH (7.37 ± 0.05) was recorded in egg collected from deep litter rearing system. For day 14, highest pH (7.60 ± 0.07) and lowest pH (7.42 ± 0.02) were recorded in eggs collected from battery cage rearing system and outdoor rearing systems, respectively. On day 21, highest pH (8.10 ± 0.04) and lowest pH (7.75 ± 0.06) were observed in eggs collected from outdoor rearing system and battery cage rearing systems, respectively (Table 3).

DISCUSSION

From the findings of this study, it was observed that overall result showed significant effect on the egg quality trait and the three rearing systems, which was consistent with findings of Leyendecker *et al.* (2001a). The egg weight was highest in egg collected from birds raised on battery cage rearing system but not statistically different from the value recorded for eggs collected from birds raised on deep litter rearing system, while birds on outdoor rearing system had the lowest value of egg weight; this was in

Table 3: Storage effect on egg quality of Isa-Brown laying birds under different rearing systems

Treatments	Battery Cage			Deep Litter			Outdoor		
Storage Period	Day 7	Day 14	Day 21	Day 7	Day 14	Day 21	Day 7	Day 14	Day 21
Initial weight (g)	59.63 ± 1.51^{ab}	60.35 ± 2.65^{b}	60.68 ± 1.93^{b}	59.77 ± 2.56^{ab}	57.37 ± 2.12^{a}	63.32 ± 2.80^{b}	54.68 ± 1.41^{a}	60.60 ± 2.29^{b}	53.55 ± 1.46^{a}
Final weight (g)	58.20 ± 1.53^{b}	56.77 ± 2.59^{ab}	55.33 ± 1.84^{b}	58.28 ± 2.48^{b}	54.65 ± 1.88^{ab}	56.72 ± 3.19^{ab}	53.55 ± 1.41^{ab}	57.27 ± 2.11^{b}	48.02 ± 1.40a
Egg weight loss (g)	1.43 ± 0.11^{a}	3.58 ± 0.13^{b}	5.35 ± 0.26^{c}	1.48 ± 0.13^{a}	2.72 ± 0.30^{b}	6.60 ± 0.79^{d}	1.13 ± 0.04^{a}	3.33 ± 0.23^{b}	5.53 ± 0.15^{c}
% Weight loss	2.41 ± 0.20^{a}	5.98 ± 0.25^{b}	8.83 ± 0.40^{c}	2.47 ± 0.17^{a}	4.69 ± 0.42^{ab}	10.66 ± 1.57^{d}	2.08 ± 0.10^{a}	5.48 ± 0.24^{b}	10.35 ± 0.27^{d}
Shell weight (g)	6.50 ± 0.23^{b}	6.50 ± 0.33^{b}	6.35 ± 0.21^{b}	6.53 ± 0.28^{b}	6.27 ± 0.31^{b}	6.53 ± 0.28^{b}	5.63 ± 0.27^{a}	6.27 ± 0.26^{b}	5.58 ± 0.30^{a}
pH	7.40 ± 0.00^{a}	7.60 ± 0.07^{a}	7.75 ± 0.06^{a}	7.37 ± 0.05^{a}	7.50 ± 0.04^{a}	8.09 ± 0.04^{b}	7.38 ± 0.05^{a}	7.42 ± 0.02^{a}	8.10 ± 0.04^{b}
Shell thickness mm)	0.16 ± 0.01^{b}	0.16 ± 0.01^{b}	0.16 ± 0.01^{b}	0.15 ± 0.02^{a}	0.15 ± 0.02^{a}	0.18 ± 0.03^{c}	0.20 ± 0.03^{d}	0.20 ± 0.01^{d}	0.21 ± 0.02^{e}

a, b, c, d, e = means within the same row with different letter superscripts are significantly different (p<0.05)

agreement with the reports of Rizzi *et al.* (2006) and Leyendecker *et al.* (2001b) who observed higher egg weight from hens housed in cages. Also, when comparing quality traits of Isa-Brown layers raised in two systems (deep litter and battery cage), Voslářová *et al.* (2006) found that heavier eggs were produced by caged layers. Also, Đukić-Stojčić *et al.* (2009) compared the quality of eggs from caged layers and those from restricted and free-range layers and found that heavier eggs were laid by caged hens. A higher quality of egg shell and albumen was found in battery cage rearing system. Meanwhile, Tůmová and Ebeid (2005) and Pištěková *et al.* (2006) recorded heavier eggs on deep litter rearing system.

Tůmová and Ebeid (2003) reported higher values of Haugh unit and albumen indices from eggs collected from birds reared under battery cage system. In this present study, eggs with higher Haugh unit and albumen indices were observed in egg collected from battery cage rearing system. Also, egg shell thickness was lower in eggs that were produced in battery cage and this is in agreement with the report of Tůmová *et al.* (2011). This shows that best egg shell qualities are more feasible from birds raised on free range over eggs from birds raised under other housing systems; this may be due to the fact that birds were able to pick calcium sources from the soil.

The albumen weight in this experiment had the highest value for birds raised in battery cage, while the lowest value was also seen in birds raised on free range system. This corresponded with the report of Rizzi *et al.* (2006). However, higher values for yolk weight in birds raised on battery cage rearing system in this study negate what was reported by Pištěková *et al.* (2006) who showed that highest albumen and yolk weight were recorded by hens in the deep litter system. Also, Van Den Brand *et al.* (2004) reported that free-range layers produced heavier eggs (56.41 g), while Rizzi *et al.* (2006) reported that birds on free range had higher values (25.69%) of yolk weight over birds on battery cage (24.80%). However, Lewko and Gornowicz (2011) reported highest value of yolk weight in birds raised on battery cage, while the values for free range was higher than the value for deep litter. Also, the albumen height and yolk length were significantly highest for birds raised in battery cage but not statistically different from values for birds raised on deep litter, while values for birds on free range were significantly lowest. This may be due to the exposure to detrimental climatic conditions, disease, welfare challenges and nutrient dilution as reported by Singh and Cowieson (2013).

The pH of fresh whole egg collected from battery cage, deep litter and outdoor rearing systems were 7.27 ± 0.10, 7.38 ± 0.12 and 7.53 ± 0.15 respectively. Storage periods had significant effect on pH of egg internal properties. From this study, the pH values increased significantly with storage period in the whole egg measured. The pH of the whole egg increased with the storage period length; which depicts deterioration of internal egg parameters measured is a function of storage period. The results of this study were in agreement with the reports of Samli *et al.* (2005), Akyurek and Okur (2009) and Jin *et al.* (2011) who observed similar results. Stadelman *et al.* (2017) reported pH of fresh eggs between 7.5 – 7.6 and noted that storage at day 7 and day 14 were within this range. Weight loss and increase of the air cell are caused by the diffusion of water through the eggshell. The permeability of the eggshell depends on the thickness of the shell, number of the pores and the quality of the cuticle. The egg weight loss recorded in this study suggested that in the humid tropic zones, freshness of egg cannot be preserved for more than 14 days at room temperature.

Conclusion: The results on egg quality traits in relations to the rearing systems reveals that the egg weight, egg height, egg width and shell weight (external egg qualities) and albumen weight, yolk weight and Haugh unit (internal egg qualities) were better in battery cage rearing system. Meanwhile, the best shell thickness was recorded in eggs collected from birds reared on under outdoor system. The main factors influencing internal egg quality are duration and temperature of storage, and there is a significant interaction between these two factors, therefore egg consumers should strictly consider the storage period at room temperature in order to prevent nutritional and economic loss.

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