



Effect of Preservation and Storage Methods on Some Parameters of Egg Quality Traits of Exotic Chickens

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Abstract

This study was carried out to determine the effect of egg preservation and storage methods on the qualitative changes of both external and internal egg quality traits of exotic chickens. A total of three hundred and ninety (390) eggs were collected from three different strains of laying birds (Isa Brown, Amberlin Dekalb and Bovan nera black) reared in a reputable integrated farm in Jigawa state, Nigeria. Eggs were preserved using two preservation methods (oil coating and thermo-stabilization) and stored at refrigerator, earthen pot and room temperature. Eggs were taken periodically at 7 days' interval for total duration of 28 days of storage period (0, 7, 14, 21 and 28days). All eggs were individually evaluated for egg quality traits. The mean value for egg weight, length, width, shape index, shell thickness and weight, and percentage shell were 55.16 g, 54.60 mm, 42.84 mm, 1.28%, 0.51 mm, 5.94 g and 10.94%, respectively. The internal quality traits: albumen height, length, width, index, pH, yolk height, length, width, index and pH, albumen-yolk pH and Haugh unit have the corresponding values as 4.56mm, 97.50mm, 83.72mm, 1.17%, 8.75, 10.29mm, 50.55mm, 46.81mm, 1.09%, 8.52, 6.90 and 82.10, respectively. The findings from the present study showed that eggs stored using oil coating and refrigeration had significantly ($P<0.01$) better external and internal quality parameters compared to untreated once. It was concluded that eggs stored at room temperature without any preservatives gradually deteriorates in quality and become unfit for consumption.

keywords: Albumin pH, Egg quality traits, Storage and Preservation

Introduction

The egg is a biological structure intended by nature for reproduction and is a complete diet for the developing embryo (Jacob *et al.*, 2000). It is one of the most important sources of animal protein; which is better than other sources due to its ease of digestion, transport, storage, and marketing (Bayer and Baleh, 2000). Eggs are readily digested and can provide a significant portion of the nutrients required daily for growth and maintenance of body tissues. Belitz *et al.* (2013) reported that chicken eggs are the more important than those of other birds and are utilized in many ways both in the food industry and at home.

Relevant knowledge and information on the whole structure of egg and its components are

essential for an understanding of egg quality, fertility, embryo development and diseases of the poultry (Islam and Dutta, 2010). Quality traits of eggs determine prices directly in commercial flocks. In egg processing enterprises, the weight of eggshell, albumen and yolk that form the egg as well as their compositions affect the amount and price of the product (Altan *et al.*, 1998).

Eggs are highly perishable and can rapidly lose their quality (Kamel *et al.*, 1980). Recently, people are very concerned about the quality of eggs. The quality of eggs would deteriorate when stored for long time making them unsuitable for human consumption. As a result, appropriate technology for storage of eggs is essential to retain quality. Various factors such as egg storage period and

conditions, temperature, humidity, air movement, handling, strain and age of hens are the major important factors influencing egg quality.

Therefore, proper storage of eggs is essential to preserve quality and cooking characteristics. Poor storage conditions can reduce eggs grade within a few days. The principle degrading factors are high storage temperature and dehydration. Improper storage is reported to produce some observed changes: a change of thick albumen to watery albumen, enlargement of yolk that breaks easily when the shell is broken, enlargement of the air cell, and absorption of off odors and off-flavors if stored near pungent foods (Young, 1997).

Although refrigeration of egg is expected to result in longer shelf life and reduce spoilage, by reducing the possibility of infection of the internal portion by the spoilage- and disease-causing organisms (Miyamoto *et al.*, 1998). The knowledge of effect of temperature degree on the quality control of internal composition of eggs is essential to make comparison between eggs storage at room temperature and the refrigerator on one hand, and egg preservation on the other.

Several physical and chemical modifications take place in an egg during storage, this includes thinning of the albumin and flattening of the yolk. Egg is generally subject to damage, and its quality can be lost rapidly during the period between storage and consumption being affected by condition such as temperature, moisture and storage period (Scott and Silversides, 2001). Therefore, the aim of this research aims was to evaluate the effect of different preservation and storage methods on the changes that occur in the egg (quality and biochemical parameters).

Materials and Methods

Description of the study area

The eggs for the study were collected from a reputable poultry farm in Birnin Kudu. Birnin Kudu L.G.A. is situated between latitude 11° N and longitude 9° 30' E, at an altitude of 485 m above sea level. The area is characterized by mean annual rainfall ranges from 750 to 1000 mm with a peak in August. The average minimum and maximum temperature and relative humidity ranges are 28 to 40° and 40 to 78°, respectively. Lowest temperature occurs during harmattan (November-February) and highest from March to June. However, the region is characterized by a long dry season of 7-8 months. The average temperature and relative humidity were 35° and 51° during the period of eggs collection. The eggs were collected on the same day in the morning and transported to the Department of Animal Science Laboratory, Federal University Dutse, Jigawa State.

Collection of eggs

A total of three hundred and ninety (390) eggs were collected from three different strains (Isa Brown, Amberlin Dekalb and Bovan nera black) of laying birds from a reputable integrated farm in Birnin Kudu L.G.A. of Jigawa state. The birds were 52 weeks of age at the time of egg collection (mid lay). On arrival of the fresh eggs at the Animal Science laboratory, they were kept according to their strains, comprising of 130 eggs each. All eggs were kept at room temperature and assessed individually for the evaluation of egg quality traits. Soft, cracked and very small eggs were not used in the experiment. Eggs were preserved using two preservation methods (oil coating and thermo-stabilization) and stored at refrigerator, earthen pot and room temperature. Eggs were taken periodically at 7 days interval for total duration of 28 days of storage period (0, 7, 14, 21 and 28 days).

Data collection

Eggs (g) were weighed individually using electronic scale. Egg length (mm) which is the

broader circumference and width (mm) representing the narrow circumference of the egg were measured by digital vernier caliper. Egg Shape index (%) was calculated as the ratio of egg width to egg length (%) by method of Anderson *et al.* (2004).

$$\text{Shape Index} = \frac{\text{Width of egg}}{\text{Length of egg}} \times 100$$

After taking the external measurements of the eggs, they were broken at the middle with the blunt end of a knife, the content poured on a flat glass sheet. The albumen and yolk height were then measured. The height of the albumen was taken on the thick albumen surrounding the yolk using a tripod spherometer. The length and width of both the albumen and yolk were measured with the aid of a digital vernier caliper and recorded in millimeter. Albumen index (%) was determined using the ratio of the height and width of the albumen according to Alkan *et al.* (2010).

$$\text{Albumin Index (\%)} = \frac{\text{Hight of thick albumin (mm)}}{\text{Mean diameter of thick albumin (mm)}} \times 100$$

Yolk Index (%) was calculated after measuring the height and diameter of the yolk according to Funk (1948) using micrometer screw gauge.

$$\text{Yolk Index} = \frac{\text{Yolk height (mm)}}{\text{Mean yolk diameter (mm)}} \times 100$$

The Haugh units were calculated for individual eggs from the albumen height and egg weight according to the Haugh, (1937) equation

$$\text{HU} = 100 \log (H + 7.57 - 1.7W^{0.37})$$

Where: H= observed albumen height (mm) and

$$W = \text{egg weight (g)}$$

After measuring the length, width and length of the albumen and yolk. The albumen was separated from the yolk. The thin and thick albumen were mixed thoroughly prior to measuring the pH with a pH paper. pH paper was also used to measure the pH of the albumen and yolk concentration. Albumen and yolk concentration were thoroughly mixed and then pH taken with the aid of pH paper.

Egg shell was isolated after emptying its contents by washing it to ensure that all the remains of albumen were completely removed. The washed shells were then labelled and left to dry in the open air for twenty hours after which they were individually weighed (g) with the weighing balance (Gilbert *et al.*, 1978). Shell thickness (mm) was measured from the narrow end, broad end and equator. The average shell thickness was obtained and recorded, with the aid of micrometer screw gauge at 0.01mm precision (Chowdhury, 1987).

Data analysis

The data collected were subjected to Analysis of variance (ANOVA) using the General Linear Model procedure of the Statistical Package for Social Science (SPSS) Version 12.0. Differences between means were separated using Duncan's Multiple Range Test.

The statistical model adopted was:

$$Y_{ij} = \mu + B_i + G_j + e_{ij}$$

Where:

Y_{ij} = observation on the ij^{th} egg traits

μ = the overall mean common to all observation

B_i = effect of i^{th} storage ($i=1, 2$)

G_j = effect of j^{th} preservation methods ($k=1, 2, 3$)

e_{ij} = Random errors effect peculiar to each observation.

Results and Discussion

The descriptive statistics of the external and internal egg quality characteristics are shown in Table 1. The mean egg weight obtained in the present study was 55.16 ± 0.35 g which is within the range 53.4 to 56.0 g reported by Wolanski *et al.* (2007) in ten breeder strains of chickens at ages between 46 and 57 weeks. The egg length and width obtained in the present study have overall mean values of 54.60 ± 0.17 mm and 42.84 ± 0.14 mm, respectively. This corroborates the work of Lall (2014) who reported 56.40mm for egg length and 43.5 mm for egg width. Mean shape index was 1.28 ± 0.00 which was higher than 0.77 reported by Mpieri (1984). This could be attributed to many factors, mainly genetic and feed effects. Egg length and width was reported to vary with genotypes and other non-genetic factors (Isadahomen *et al.*, 2014). The shell weight, thickness and percentage shell have mean values of 5.94 ± 0.05 g, 0.51 ± 0.00 mm and $10.94 \pm 0.11\%$, respectively. The overall mean albumen length and width obtained were 97.50 ± 0.79 mm and 83.72 ± 0.74 mm, respectively. More so, the overall mean value of the albumen index was 1.17 ± 0.01 which is higher than the 0.54% recorded by Boldman *et al.* (1995). Jones (2006) reported that strain of birds plays a role in albumin quality, with some strain consistently producing eggs with thin albumen. Similarly, the albumen height was 4.56 ± 0.08 mm in the present study, which is in agreement with the 4.94 mm reported by Lall (2014) in chickens at the age of 50 weeks. Furthermore, the yolk length and width have mean values of 50.55 ± 0.37 mm and 46.81 ± 0.34 mm, respectively. The Yolk index was found to have an overall mean of 1.09 ± 0.14 , whereas the Yolk height was

10.29 ± 0.19 mm. The mean value of the Haugh Unit was 82.10 ± 0.45 . The pH values 8.75 ± 0.72 , 8.52 ± 0.84 and 6.90 ± 1.29 were recorded for Albumen, Yolk and combination of both (Albumen-Yolk) respectively. The Albumen pH in the present study agrees with reports of Shin *et al.* (2005) that showed a range from 8.3 to 9.0.

The effect of preservation methods on external egg quality traits are presented in Table 2. There was highly significant ($P < 0.001$) effect of preservation method on egg weight. Weight of eggs was higher in oil coated eggs (59.76 ± 0.64) and refrigerated (58.85 ± 0.72). the earthen pot, room temperature and thermostabilization were 53.03 ± 0.63 , 52.99 ± 0.69 and 52.06 ± 0.80 g respectively. These findings are in agreement with those of Walsh *et al.* (1995), Samli *et al.* (2005) and Siyar *et al.* (2007). Wells and Belyavin (1987) observed that egg weight reduces with increase in environmental temperature. Obanu and Mpieri (1984) reported that evaporation of water and loss of CO_2 from the albumen through the pores lead to an overall weight loss of whole egg. This could be the reason, keeping eggs under refrigeration (5°C) and oil coating methods reduces this moisture loss. Low humidity and less shell pores reduce moisture evaporation and hence, egg weight loss and deterioration.

Egg length which is the height of the egg varied significantly ($P < 0.001$) with preservation and storage methods. The length of eggs preserved using oil coating, thermostabilization earthen pot and refrigeration were 55.47 ± 0.28 , 55.35 ± 0.31 , 55.40 ± 0.30 and 55.10 ± 0.31 mm respectively. Eggs stored at room temperature had the least length (52.50 ± 0.44 mm). This result is similar to the findings of Lall (2014) that egg length kept at room temperature was found to be 50.30 mm. the higher egg length in earthen pot, refrigeration, oil coating and thermostabilized eggs might be due to reduction in degenerative

changes in thick albumen due to heat treatment.

Highly significant ($P < 0.001$) variation in egg width with preservation methods showed that refrigerator, thermostabilization, oil coating and earthen pot were similar (43.60 ± 0.18 , 43.58 ± 0.18 , 43.47 ± 0.19 and 43.46 ± 0.20 mm respectively), while those stored at room temperature were least (40.91 ± 0.41 mm). The result is in agreement with the reported of Lall (2014) for egg width. The author concluded that variation in egg width might be due to eggs of variable sizes taken for experimental purpose. The shape index was found to be significantly ($P < 0.05$) different. Eggs stored at room temperature have the highest shape index (1.29 ± 0.01). Although similar with those stored in earthen pot, oil coating and thermostabilization with values 1.28 ± 0.01 , 1.26 ± 0.01 and 1.27 ± 0.01 respectively. Similar results (1.43) were reported by Rath (2015) in eggs stored at room temperature.

Similarly, shell weight was found to differ significantly ($P < 0.05$) with preservation methods. Eggs stored in earthen pot and thermo-stabilization have almost similar shell weight (6.10 ± 0.11 and 6.04 ± 0.11 g, respectively), while those stored in refrigerator and room temperature also had similar shell weight of 5.94 ± 0.12 and 5.93 ± 0.09 g respectively. Jin *et al.* (2011) reported similar shell weight of eggs preserved using oil coating (5.35 g). However, there was no variation in shell thickness with preservation methods. Farooq *et al.* (2001) had earlier reported that smaller eggs have stronger shell than larger ones as hens have a definite capacity to deposit calcium in the shell and as a result the same amount of calcium is spread over a larger area. For the percentage shell, eggs preserved in refrigerator, earthen pot, thermostabilization and oil coating differ ($P < 0.001$) significantly with values 10.16 ± 0.21 , 11.62 ± 0.25 , 11.74 ± 0.25 and 9.56 ± 0.21 respectively. This result was in

agreement with the earlier reports of Anderson *et al.* (2004). Moreover, rapid cooling of shell eggs increases the internal quality of eggs and enhanced the microbiological integrity since most microbes cannot survive under such cold conditions.

The effects of preservation method on internal egg quality characteristics are presented in Table 3. There was highly significant difference ($P < 0.001$) in albumen length under different preservation and storage methods. Eggs stored in refrigerator, earthen pot, oil coating and thermo-stabilization methods had albumen lengths as 97.66 ± 1.51 , 102.02 ± 1.22 , 102.26 ± 1.46 and 100.28 ± 2.05 mm, respectively, while those stored at room temperature had the least (88.88 ± 1.79 mm). Similar results were reported by Samli *et al.* (2005), who observed that albumen of refrigerated eggs was higher (91.36 ± 1.21 mm) than eggs stored at room temperature and other storage methods. Therefore, Mountney (1976) concluded that the differences which arouses between refrigeration and other storage methods in maintaining egg quality could be due to their varying ability to retard carbon dioxide loss and breakdown of carbonic acid to carbon dioxide, which help egg albumen to maintain its quality during refrigeration.

Also revealed was the statistical ($P < 0.001$) difference in albumen width with different preservation methods. Refrigerated and room temperature eggs have the lowest albumen width of 82.94 ± 1.10 and 75.46 ± 1.76 mm, respectively. These results contradicted the assertion that albumen width stored in refrigeration was higher (Lall, 2014). However, the means of albumen width recorded for oil coating, thermostabilization and earthen pot was 89.02 ± 1.25 , 87.05 ± 1.78 and 87.57 ± 1.33 respectively. Albumen index was found not to differ significantly with storage and preservation methods.

Different preservation methods were found to have significant effect ($P < 0.001$) on the

albumen height. Eggs stored in the refrigerator had the highest albumen height (5.76 ± 0.22 mm), those stored at room temperature had a value of 4.50 ± 0.15 mm, followed by oil coating (4.41 ± 0.12 mm), earthen pot (4.14 ± 0.14 mm) and thermo-stabilization (3.99 ± 0.13 mm) being the least. The eggs stored at room temperature and oil coating had slightly the same albumen height. Research has shown that the mean value of albumen height for local chicken eggs was lowest (2.52 mm) in controlled egg (room temperature) and highest (4.65 mm) in refrigeration (Islam *et al.*, 2001). The present finding agrees with the results of Wan *et al.*, (2001) and Tayeb (2012). The authors further reported that a decrease in albumin height with increase in temperature and also purported that albumen height was found to be higher in refrigerated eggs (4.79) than other methods.

Yolk length was significantly ($P < 0.001$) affected by the different preservation methods. Thermo-stabilization had the highest yolk length followed by earthen pot, oil coating, room temperature and refrigeration with the values 55.57 ± 0.82 , 53.92 ± 0.67 , 50.83 ± 0.65 , 48.55 ± 0.77 and 44.43 ± 0.47 mm respectively. Yolk width was highly significant ($P < 0.001$) at different preservation methods. Thermo-stabilization had the highest yolk width followed by earthen pot with values of 50.98 ± 0.67 and 49.16 ± 0.75 mm, respectively. Eggs stored in refrigerator had the least yolk width value 41.76 ± 0.75 mm. However, yolk index was not significantly affected.

Furthermore, there was highly significant ($P < 0.001$) variation in yolk height at different preservation methods. Eggs stored in refrigerator had the highest yolk height followed by those kept at room temperature 14.08 ± 0.3 and 10.98 ± 0.41 mm respectively. Thermo-stabilization showed the least (9.99 ± 0.25 mm). The reason for this could be due to the fact that migration of water from the albumen to the yolk is a function of storage

temperature with faster rate of migration occurring at higher temperature.

Haugh unit is an expression relating egg weight and the height of the thick albumen. Haugh unit was highly significant ($P < 0.001$) at different preservation methods. Refrigeration made the eggs to have highest haugh unit (88.07 ± 1.13) than those of other preservation methods. This result is in agreement with the report of Menezes *et al.* (2009) who reported significant difference between haugh unit of eggs stored in both refrigeration and room temperature. Samli *et al.* (2005) reported that storage period and temperature adversely affected Haugh unit. This is due to the fact that there is an increase in whiteness. It is generally accepted that the higher the Haugh unit, the better the quality of the eggs (Curtis *et al.*, 2015). Therefore, the present finding falls within the optimum range of values reported by Sreevani and Kumar (1994).

Shown in Table 4 is the effects of storage and preservation methods on biochemical parameter (pH). Albumen pH which is an indicator of albumen quality of eggs was found to be significantly ($P < 0.05$) affected by preservation methods. Eggs preserved in earthen pot had the highest albumen pH, followed by those preserved under thermo-stabilization, room temperature, refrigeration and oil coating with the corresponding values of 8.82 ± 0.09 , 8.82 ± 0.06 , 8.75 ± 0.08 , 8.72 ± 0.08 and 8.54 ± 0.07 , respectively. Previous researchers, (Obanu and Mpiari, 1984; Biladeau and Keener, 2009) had reported that pH value varied with storage and preservation methods. They concluded that the decrease in albumen pH in oil coated eggs which is similar with the present study may be due to the continuing breakdown system. However, Okoli and Udedibie (2000) reported that oiling of eggs helped to reduce CO₂ losses, thus help to maintain internal egg quality but not a substitute for cool storage.

It was further stated that freshly laid eggs have an albumen pH of 7.6-8.7 (Goodwin *et al.*, 1962; Rhim *et al.*, 2004). Albumen pH increased with the loss of CO₂ from the egg. An increase in pH and dry matter has been reported by Scholtyseek (1981). It was also found that the pH of untreated eggs increased significantly faster than oil treated eggs (Schwall *et al.* 1961). More so, albumen- Yolk pH was highly significant (P<0.01) with different preservation and storage methods. Eggs kept/stored at room temperature had the highest albumen-yolk pH (7.22±0.15), although similar with that of thermo-stabilization (7.02±0.16). Oil coating was the least (6.67±0.13).

However, pH is an important environmental factor used in determining the changes in albumen quality during storage and preservation. Albumen pH increases with the loss of carbon dioxide from eggs (Scholtyseek, 1981). The values recorded in the present study agrees with the report of Sami *et al.* (2005) and Akyrek and Okur (2009), and falls within the acceptable range.

Conclusion

In conclusion, the present study indicated that eggs stored at room temperature without any preservatives gradually deteriorates in quality very fast and become unfit for consumption. In the absence of refrigeration facilities eggs can be stored and protected by oil coating, thermo-stabilization and earthen pot preservation methods at room temperature to avoid rapid deterioration.

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Table 1: Descriptive Statistics for External and Internal Quality Characteristics of Chicken Eggs

Traits	Mean	Minimum	Maximum	Standard Deviation
External egg quality traits				
Egg weight (g)	55.16	31.0	77.0	6.98
Egg length (mm)	54.60	39.4	62.0	3.36
Egg width(mm)	42.84	27.3	49.3	2.77
Shape index (%)	1.28	1.0	1.6	0.06
Shell weight (g)	5.94	4.0	8.0	0.95
Shell thickness (mm)	0.51	0.2	0.8	0.10
Shell ratio (%)	10.94	5.8	19.0	2.27
Internal egg quality traits				
Albumin length (mm)	97.50	10.2	135.2	15.69
Albumin width (mm)	83.72	11.4	119.5	14.54
Albumin index (%)	1.17	0.8	2.0	0.17
Albumin height (mm)	4.56	1.1	11.1	1.51
Yolk length (mm)	50.55	31.6	92.6	7.36
Yolk width (mm)	46.81	24.0	81.5	6.70
Yolk index (%)	1.09	0.5	2.0	0.14
Yolk height (mm)	10.29	2.8	20.0	3.76
Haugh unit	82.10	53.0	112.0	8.96
Albumin pH	8.75	6.0	10.0	0.72
Yolk pH	8.52	6.0	10.0	0.84
Albumin yolk pH	6.90	5.0	10.0	1.29

Table 2: Effects of storage and preservation methods on external egg quality traits

Variables	EW (g)	EL(mm)	EW(mm)	SI	SW(g)	ST(mm)	%shell
Preservation methods	***	***	***	*	*	NS	***
Oil coating	59.76±0.64 ^a	55.47±0.28 ^a	43.47±0.19 ^a	1.28±0.01 ^{ab}	5.67±0.12 ^b	0.50±0.01	9.56±0.21 ^b
Thermo stabilization	52.06±0.80 ^b	55.35±0.31 ^a	43.58±0.18 ^a	1.27±0.01 ^{ab}	6.04±0.11 ^a	0.52±0.01	11.74±0.25 ^a
Storage periods							
Room temperature	52.99±0.69 ^b	52.55±0.44 ^b	40.91±0.41 ^b	1.29±0.01 ^a	5.93±0.09 ^{ab}	0.51±0.01	11.43±0.25
Earthen pot	53.03±0.63 ^b	55.40±0.30 ^a	43.46±0.20 ^a	1.28±0.01 ^{ab}	6.10±0.11 ^a	0.52±0.01	11.62±0.25 ^a
Refrigeration	58.85±0.72 ^a	55.10±0.31 ^a	43.60±0.18 ^a	1.26±0.01 ^b	5.94±0.12 ^{ab}	0.53±0.01	10.16±0.21 ^b

Values (Mean ± SE) with different superscripts in a column differ significantly; *= $p < 0.05$, **= $p < 0.01$, ***= $p < 0.001$; NS= Non-significant EW= Egg Weight, EWD= Egg Width, EL=Egg Length, SI= Shape Index, AH= Albumen Height, AW=Albumen Weight, AI= Albumen Index, AL=Albumen length, YH=Yolk Height, YW= Yolk Weight, YI=Yolk Index, ST= Shell Thickness, SW= Shell Weight, %SHELL=percentage shell, YL= Yolk length, HU= Haugh Unit

Table 3: Effects of storage and preservation methods on Internal egg quality traits

Variables	AL(mm)	AW(mm)	AI	AH(mm)	YL(mm)	YW(mm)	YI	YH	HU
Preservation methods	***	***	NS	***	***	***	NS	***	***
Oil coating	100.28±2.05 ^a	89.02±1.25 ^a	1.15±0.02	4.41±0.12 ^{bc}	50.83±0.65 ^b	47.48±0.61 ^b	1.07±0.01	10.05±0.32 ^b	80.18±0.87 ^{bc}
Thermo stabilization	102.26±1.46 ^a	87.05±1.78 ^b	1.17±0.02	3.99±0.13 ^c	55.87±0.82 ^a	50.98±0.67 ^a	1.11±0.02	7.99±0.25 ^c	79.39±0.84 ^c
Storage periods									
Room temperature	88.88±1.79 ^b	75.46±1.76 ^c	1.17±0.02	4.50±0.15 ^b	48.55±0.77 ^c	45.30±0.61 ^c	1.08±0.02	10.98±0.41 ^b	82.47±0.98 ^b
Earthen pot	102.02±1.22 ^a	87.57±1.33 ^a	1.18±0.02	4.14±0.14 ^{bc}	53.92±0.67 ^a	49.16±0.75 ^{ab}	1.11±0.02	8.07±0.35 ^c	80.24±0.86 ^{bc}
Refrigeration	97.66±1.51 ^a	82.94±1.10 ^a	1.18±0.02	5.76±0.22 ^a	44.43±0.47 ^d	41.76±0.75 ^d	1.08±0.02	14.08±0.31 ^a	88.07±1.13 ^a

Values (Mean ± SE) with different superscripts in a column differ significantly; *= $p < 0.05$, **= $p < 0.01$, ***= $p < 0.001$; NS= Non-significant EW= Egg Weight, EWD= Egg Width, EL=Egg Length, SI= Shape Index, AH= Albumen Height, AW=Albumen Weight, AI= Albumen Index, AL=Albumen length, YH=Yolk Height, YW= Yolk Weight, YI=Yolk Index, ST= Shell Thickness, SW= Shell Weight, %SHELL=percentage shell, YL= Yolk length, HU= Haugh Unit.

Table 4: Biochemical parameters (pH) of eggs as affected by storage and preservation methods

Variables	Albumen pH	Yolk pH	Albumen-Yolk pH
Preservation methods	*	NS	**
Oil coating	8.54±0.07 ^b	8.47±0.11	6.67±0.13 ^b
Thermo stabilization	8.82±0.08 ^a	8.58±0.10	7.06±0.16 ^{ab}
Storage methods			
Room temperature	8.75±0.08 ^{ab}	8.39±0.09	7.22±0.15 ^a
Earthen pot	8.92±0.09 ^a	8.69±0.08	6.76±0.13 ^b
Refrigeration	8.72±0.08 ^{ab}	8.53±0.08	6.68±0.13 ^b
Overall	8.75±0.04	8.52±0.04	6.90±0.07

Values (Mean ± SE) with different superscripts in a column differ significantly; *= $p < 0.05$, **= $p < 0.01$, ***= $p < 0.001$; NS= non-significant