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Comparative Evaluation of Some Properties of Chicken and Japanese Quail Eggs Subjected to Different Storage Methods

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Abstract

This study investigated the potential effects of egg quality indices at 95% confidence level in order to minimize quality loss during different storage conditions. The chicken and quail eggs' quality indices including weight, albumen index, yolk index, Haugh index in fresh eggs as well as after storing in moist sawdust, oil, and refrigerator were measured for six weeks. The results revealed that storage conditions significantly influenced the eggs quality indices. Eggs' weight, albumen index, yolk index, Haugh unit, pH, and total plate counts varied respectively from 59.41 to 66.12g, zero to 0.12, zero to 0.52, zero to 88.19, 7.31 to 8.52, and zero to 2.56×10^6 cfu/mL in chicken eggs while it was 9.25 to 10.39g, zero to 0.16, zero to 0.47, zero to 91.86, 7.28 to 9.42, and zero to 2.56×10^6 cfu/mL for quails. Based on the various eggs storage quality indices evaluated on eggs stored under different conditions, quail eggs stored in oil were able to retain their interior quality than in other storage conditions, while chicken eggs stored in the refrigerator had better retention of quality than in other storage conditions at the end of the six-week storage period.

Introduction

Bird eggs and egg products are essential part of the food chain, containing many essential nutrients needed for vital life processes (Abanikannda *et al.,* 2007). Eggs are good sources of energy, proteins, and other beneficial substances needed for human growth and well-being (Braun, 2000; Carrillo *et al.*, 2012). Their low caloric values and good digestibility make them an important ingredient for many dietary regimes (Keener *et al.,* 2006). In addition to their nutritional significance, they are major ingredients in egg products where they function in many ways to give the food product with desirable characteristics. Egg yolk is mainly used in the food industries as an emulsifier, because of its emulsion stability, foaming stability and good thermal gelation (Miranda *et al.*, 2015). It is highly versatile and easily available as foods for all categories of people (Akter *et al.*, 2014). Egg products include liquid egg products, frozen egg products and dried eggs which are utilized in preparing egg based products. However, perishability of eggs limits their storability (Caner and Cansiz, 2007), and the main difference between fresh and stored eggs is in the pH and quality of the egg white (albumen) (Walsh *et al.*, 1995). Humidity and temperature of the storage environment, storage time, poor nutrition, air movement and handling are other degradation factors for egg (Samli *et al.*, 2005). Usually, these factors determine the final quality of eggshell and internal quality of table eggs (Roberts, 2004), hence, they are of concern to egg industry globally. It is therefore important to enhance the efficiency of eggs natural protection

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barriers, shell, as well as controlling the storage environment in order to ensure freshness and extension of shelf life. This can be achieved using appropriate storage technology which will assist in retaining both the quality of the egg shell and internal quality thereby making it suitable for human consumption even during prolonged storage.

Consumer acceptability and functional properties of eggs are quality dependent (Joseph and Ogundele, 1996; Berardinelli *et al*., 2008), hence, good knowledge and understanding of different factors that affect eggshell quality and internal egg quality will not only ensure production of high quality eggs but also promote longer shelf-life. Generally, poultry eggs have similar nutritional compositions and usage in food industries (Dudusola, 2010; Carrillo *et al.*, 2012), but literature on poultry eggs quality and usage has been restricted mostly to chicken eggs (Dudusola, 2010). Therefore, the objective of this study is to evaluate the storage stability of Japanese quail and chicken eggs during six week storage period. This study also reports the interior eggs' quality as storage progresses.

Materials and Methods

Experimental birds

Japanese quail (*Coturnix coturnix japonica*)

Three hundred laying birds (20 weeks old), which were reared at the University of Ibadan research farm were used for the study. Laying birds were housed in a cage system having 16 hours lighting per day (normal day light) and at a feeding rate of 40g per bird daily. Feed formulation recommended by NRC (1994) was used. A total of 120 unfertilized eggs were collected at once for the experiment. Fresh eggs were weighed prior to storage at four different storage conditions.

Layer Chicken: (Rhode Island Red hen (*Gallus gallus*))

A thousand laying hens at about 20 weeks in lay were used. Laying hens were housed in a deep litter housing with 16 hours lighting (normal day light) and at a feeding rate of 125 g per bird daily. Feed formulation recommended by NRC (1994) was used. A total of 120 eggs were collected at once for the experiment within 2 hours of being laid. The eggs were weighed prior to storage at four different storage conditions.

Egg storage

At first, the eggs were washed with sanitizers using warm water and air dried. Then, eggs were divided to four groups and each group was stored for six weeks as following:

1) Refrigeration storage: for this purpose eggs were placed in crates and refrigerated at 4-7^{0}C.

2) Vegetable oil storage: the eggs were dipped one by one into vegetable oil for 5 seconds and placed in sieves to facilitate oil drainage. The coated eggs with oil then kept at room temperature.

3) Moist Sawdust storage: eggs were placed in baskets containing moistened sawdust and they were stored at room temperature.

4) Room Temperature Storage (Control): the eggs were placed in egg trays and kept at room temperature.

Egg analyses

The pH of mixtures of albumens and yolks were measured using a pH meter (HANNA ELECTRONIC pH meter) weekly at room temperature. Yolk index was determined weekly by separating the yolk from the albumen before measuring the yolk height and width (USDA, 2000) using Vernier callipers. Then yolk index was calculated by dividing yolk height (mm) to yolk width (mm). Albumen index was determined weekly by measuring albumen height and width on flat glass surface (petri dish) using Vernier callipers. Then albumen index was calculated by dividing height of the albumen to the width of the albumen (USDA, 2000). Haugh Unit was determined by the following formula (USDA, 2000):

$$HU=100\log\ (H-(\sqrt{G}(30W^{0.37}-100))/100+1.9)$$

Where H= albumen height (average; mm)

G= gravitational constant (32.2)

W= weight of the egg (g)

Microbial Analysis

The media (Nutrient agar) was prepared according to the manufacturer's instruction and sterilized in an autoclave at 121^{0}C for 15 minutes. Sample (1 mL) was aseptically pipetted from egg contents (yolk and albumen) mixed together using pour plate method, one millimetre of each of the serially diluted (up to 10^{-6}) samples was aseptically introduced into sterilized petri-dishes. Aliquot of the prepared sterile nutrient agar medium was added to the samples in the petri-dish and swirled clock wisely. The mixture was allowed to set and upon solidification, the plates were inverted and incubated at 37^{0}C for 24 hours. The colonies on the incubated plates were counted using a colony counter and calculated as colony forming units per gram (RobertsandGreenwood, 2008).

Statistical Analysis

Data derived from this study were analyzed using SPSS version 14.0, Chicago.

Results and Discussion

Effect of storage conditions on egg weight

Table 1 shows the results of effect of storage conditions on eggs weight. The weight of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from 63.61 to 60.03g, 63.11 to 60.99g, 61.12 to 59.41g, and 66.12 to 65.79g, respectively. While the weight of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from10.39 to 9.61g, 10.01 to 9.58g, 10.11 to 9.25g, and 10.02 to 9.72g. The average percentage losses observed in chicken eggs stored at ambient condition (control), moist sawdust, refrigerator and those that were dipped in oil were 5.63%, 3.36%, 2.80%, and 0.50%, respectively. While the average percentage losses observed in quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil were 7.51%, 4.30%, 8.5%, and 2.99%, respectively. The storage conditions significantly influenced the weight of both chicken and quail eggs at 95% confidence level. It was observed that as the storage period progressed the eggs weight decreased. The weight loss might be as a result of respiratory activities of the eggs, which releases water vapour, carbon dioxide, ammonia, nitrogen and hydrogen sulphide gas during storage (Alsobayel and Albadey, 2011; Jin *et al*., 2011).

Table 1. Effect of storage condition on eggs weight (g)

Eggs	Week	Control	Moist Sawdust	Refrigeration	Oil
Chicken	0	63.61+1.72^{a}	63.11 + 2.19^{a}	61.12±1.95^{a}	66.12±1.82^{a}
	1	63.16±1.71^{a}	62.70±2.31^{a}	60.97±1.91^{a}	66.09±1.83^{a}
	2	62.61±1.69^{a}	62.55±2.26^{a}	60.42±1.91^{a}	65.93±1.82^{a}
	3	61.74±1.66^{a}	62.20±2.25^{a}	60.27±1.90^{a}	65.92±1.82^{a}
	4	61.25±1.65^{a}	62.09±2.25^{a}	60.03±1.86^{a}	65.88±1.85^{a}
	5	60.54±1.63^{ab}	61.37±2.33^{ab}	59.68±1.87^{b}	65.84±1.83^{a}
	6	60.03±1.62^{ab}	60.99±2.30^{ab}	59.41±1.86^{b}	65.79±1.82^{a}
Quail					
	0	10.39±0.27^{a}	10.01±0.37^{a}	10.11±0.35^{a}	10.02±0.30^{a}
	1	10.20±0.31^{a}	9.99±0.38^{a}	9.96±0.35^{a}	10.00±0.29^{a}
	2	10.10±0.31^{a}	9.93±0.36^{a}	9.85±0.37^{a}	9.97±0.30^{a}
	3	9.96±0.31^{a}	9.73±0.36^{a}	9.67±0.38^{a}	9.92±0.29^{a}
	4	9.86±0.32^{a}	9.68±0.36^{a}	9.54±0.37^{a}	9.90±0.29^{a}
	5	9.72±0.30^{a}	9.64±0.37^{ab}	9.38±0.35^{b}	9.84±0.28^{a}
	6	9.61±0.29^{ab}	9.58±0.37^{b}	9.25±0.35^{c}	9.72±0.28^{a}

Data reported as (±SD) Means followed by the same super scripts in rows are not significantly different at $P < 0.05$.

Effect of storage conditions on egg albumen index

The results of the effect of storage conditions on the albumen index are shown in Table 2. The albumen index of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil decreased from 0.10 to 0.08, 0.12 to zero, 0.09 to 0.05, and 0.11 to 0.06, respectively. While the albumen index of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil decreased from 0.16 to zero, 0.13 to zero, 0.15 to 0.09, and 0.15 to 0.06. The storage conditions influenced the eggs albumen index significantly at 95% confidence level. However, the dimensional appreciation of albumen offers important information about the freshness of eggs (Jones and Musgroove, 2005). The values obtained for the fresh eggs before storage (chicken as well as quail eggs) fell within the range (0.09-0.12) reported by Jones and Musgroove (2005). Furthermore, gradual decline in the values of the albumen index of eggs during storage was evident in eggs stored under refrigeration and in oil. In contrast, albumen index of eggs stored under ambient condition and in moist sawdust could no longer be evaluated after three weeks of storage, as in the case of chicken eggs. For quail eggs, it was observed that the albumen index could not be determined at 5th and 4th week of storage under ambient condition and in moist sawdust, respectively. Otles and Hisil (2004) reported that room temperature storage of eggs led to albumen mottling. Storage temperatures in this study surpassed 18^0C except storage under refrigeration, thus favoured metabolic activities which led to albumen quality reduction. Refrigerated eggs had the least reduction in albumen index at the end of storage period. Water movement from albumen to yolk is reduced due to lower storage temperature, leading to good quality albumen (Brake *et al.,* 1997).

Table 2. Effect of storage condition on eggs albumen index (g)

Eggs	Week	Control	Moist Sawdust	Refrigeration	Oil
Chicken					
	0	0.10±0.00^a	0.12±0.01^a	0.09±0.01^a	0.11±0.01^a
	1	0.09±0.01^a	0.09±0.01^a	0.09±0.01^a	0.10±0.01^a
	2	0.09±0.01^a	0.08±0.01^a	0.09±0.00^a	0.09±0.01^a
	3	0.08±0.00^a	0.08±0.00^a	0.09±0.01^a	0.09±0.01^a
	4	0.08±0.01^a	0.00±0.00^b	0.08±0.00^a	0.09±0.01^a
	5	0.08±0.01^a	0.00±0.00^b	0.07±0.00^a	0.08±0.00^a
	6	0.08±0.01^a	0.00±0.00^b	0.05±0.00^a	0.06±0.01^a
Quail					
	0	0.16±0.072^a	0.13±0.01^a	0.15±0.05^a	0.15±0.00^a
	1	0.15±0.01^a	0.12±0.02^a	0.14±0.01^a	0.14±0.01^a
	2	0.13±0.01^a	0.04±0.16^b	0.13±0.01^a	0.13±0.01^a
	3	0.12±0.02^a	0.00±0.00^b	0.12±0.01^a	0.13±0.01^a
	4	0.09±0.01^a	0.00±0.00^b	0.11±0.01^a	0.11±0.01^a
	5	0.00±0.00^b	0.00±0.00^b	0.11±0.01^a	0.09±0.02^a
	6	0.00±0.00^c	0.00±0.00^c	0.09±0.01^a	0.06±0.00^b

Data reported as Mean±SD
Values followed by the same superscripts in rows are not significantly different at $P < 0.05$.

Effect of storage conditions on egg yolk index

Table 3 shows the effect of storage conditions on egg yolk index. The egg yolk index of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from 0.43 to 0.19, 0.43 to zero, 0.52 to 0.33, and 0.50 to 0.36, respectively. While the egg yolk index of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from 0.47 to zero, 0.47 to zero, 0.47 to 0.39, and 0.47 to 0.31, respectively. The storage conditions had a significant influence on the egg yolk index ($P < 0.05$). Considerable reductions in egg yolk index were noticed in eggs stored under refrigeration and in oil as the storage period increased. Eggs yolk index of chicken eggs stored at ambient condition and in moist sawdust were difficult to evaluate at three weeks of storage. The egg yolk index in quail eggs were becoming difficult to examine after four weeks of storage. Yolk index is a measure of egg quality and it is based on the state of the yolk membrane, which shows the integrity between 0.33 and 0.5 for fresh eggs (Stadelman *et al.*, 1996; Popoola *et al*., 2015). Ageing reduces the shape the yolk, weakens the yolk membrane and reduces the value of the egg yolk index (Keener *et al*., 2006). However, reduction in egg yolk index as the storage period progressed might be as a result of ageing or it might be due to movement of CO_2 and moisture through the eggs shells which cause changes in albumen, yolk and egg weight (Stadelman *et al.*, 1996; Stadelman and Cotterill, 2005). It might also be as a result of breaking down of the fibrous glycoprotein ovomucin in the egg (Dudusola, 2009). It was observed that storage of eggs in oil had least reduction in yolk indices, this claim was in agreement with the findings of Kester and Fennema (1986), who reported on the ability of oiling of eggs in slowing down albumen and yolk quality degradation.

Table 3. Effect of storage condition on eggs yolk index (g)

Eggs	Week	Control	Moist Sawdust	Refrigeration	Oil
Chicken					
	0	0.43±0.03[a]	0.43±0.03[a]	0.52±0.02[a]	0.50±0.01[a]
	1	0.38±0.04[a]	0.39±0.00[a]	0.50±0.02[a]	0.49±0.01[a]
	2	0.37±0.01[a]	0.37±0.04[a]	0.45±0.00[a]	0.46±0.06[a]
	3	0.37±0.03[a]	0.37±0.06[a]	0.43±0.03[a]	0.45±0.01[a]
	4	0.22±0.05[b]	0.00±0.00[c]	0.38±0.03[a]	0.45±0.05[a]
	5	0.22±0.02[b]	0.00±0.00[c]	0.33±0.09[ab]	0.43±0.03[a]
	6	0.19±0.04[b]	0.00±0.00[c]	0.33±0.04[ab]	0.36±0.07[a]
Quail					
	0	0.47±0.04[a]	0.47±0.04[a]	0.47±0.04[a]	0.47±0.04[a]
	1	0.41±0.01[a]	0.37±0.04[a]	0.45±0.01[a]	0.42±0.05[a]
	2	0.31±0.02[a]	0.32±0.03[a]	0.44±0.08[a]	0.39±0.02[a]
	3	0.27±0.03[b]	0.00±0.00[c]	0.41±0.02[a]	0.37±0.04[a]
	4	0.25±0.00[b]	0.00±0.00[c]	0.41±0.03[a]	0.35±0.02[a]
	5	0.00±0.00[c]	0.00±0.00[c]	0.40±0.00[a]	0.34±0.02[b]
	6	0.00±0.00[b]	0.00±0.00[b]	0.39±0.01[a]	0.31±0.06[a]

Data reported as Mean±SD
Values followed by the same super scripts in rows are not significantly different at $P < 0.05$.

Effect of storage conditions on haugh index

The effect of storage conditions on eggs haugh index are shown in Table4.The haugh index of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from 81.38 to 64.46, 87.30 to zero, 79.24 to 43.64, and 88.19 to 45.79, respectively. While the haugh index of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil reduced from 86.48 to zero, 86.48 to zero, 86.48 to 64.00, and 91.86 to 49.58, respectively. The storage conditions significantly influenced eggs haugh index at 95% confidence level. Haugh index is used to determine the suitability of eggs for incubation and consumption, as it defines the quality of eggs based on dense albumen index and eggs Weight (Berardinelli *et al*., 2008). Among the storage conditions considered, storage under refrigeration had limited effect on the haugh index of both eggs, and this might be as a result of their storage at reduced temperature (4^{o}C) which limited metabolic activities. A similar finding was reported by Gavril and Usturol (2011) who research on effects of temperature and storage time on hen eggs quality. However, eggs having haugh index of 30 and below are not suitable for consumption (USDA, 2000). The haugh index obtained after six weeks storage were above 30, but varied according to the storage periods and conditions employed. High values obtained after storage in oil and refrigeration indicated that eggs could be stored under those conditions for over six weeks.

Table 4. Effect of storage condition on eggs haugh index

Eggs	Week	Control	Moist Sawdust	Refrigeration	Oil
Chicken					
	0	81.38±2.35[a]	87.30±3.32[a]	79.24±6.68[a]	88.19±7.20[a]
	1	74.67±8.63[a]	73.40±6.04[a]	75.46±4.84[a]	84.30±9.95[a]
	2	75.25±5.75[a]	70.23±4.54[a]	74.69±0.93[a]	75.19±4.02[a]
	3	73.40±6.04[a]	64.00±4.19[a]	73.40±6.04[a]	73.92±6.65[a]
	4	70.08±2.58[a]	0.00±0.00[b]	69.06±4.40[a]	73.40±6.04[a]
	5	67.92±11.75[a]	0.00±0.00[b]	59.81±3.93[a]	70.99±2.05[a]
	6	64.46±8.47[a]	0.00±0.00[b]	43.64±4.71[a]	45.79±14.43[a]
Quail					
	0	86.48±4.25[a]	86.48±4.25[a]	86.48±4.25[a]	91.86±4.91[a]
	1	74.57±0.90[b]	82.62±6.33[ab]	85.00±1.20[ab]	88.48±2.87[a]
	2	73.65±2.45[a]	66.18±17.51[a]	84.58±2.42[a]	86.48±4.25[a]
	3	68.08±19.19[a]	0.00±0.00[b]	77.14±9.34[a]	85.19±2.54[a]
	4	61.22±19.25[a]	0.00±0.00[b]	76.54±3.92[a]	75.36±3.22[a]
	5	0.00±0.00[b]	0.00±0.00[b]	74.38±3.83[a]	67.66±5.88[a]
	6	0.00±0.00[b]	0.00±0.00[b]	64.00±16.53[a]	49.58±9.27[a]

Data reported as Mean±SD
Values followed by the same super scripts in rows are not significantly different at $P < 0.05$.

Effect of storage conditions on pH of eggs

The pH of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil varied from 7.28 to 9.42, 7.28 to 9.10, 7.28 to 8.97, and 7.28 to 7.96, respectively (Figure 1). While the pH of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil varied from 7.31 to 7.87, 7.31to 8.52, 7.31 to 8.47, and 7.31 to 8.14, respectively (Figure 2). During storage, it was observed that the pH of eggs stored under aforementioned conditions increased as the storage period increased, except for eggs stored in oil, whose pH dropped at the fourth week (6.02±0.27) and then rose again gradually at the fifth week (6.33±0.27) till the end of the storage period. Highest pH value of 8.52±0.3 was recorded for the moist sawdust treatment. The increase in pH at ambient condition (control) might be as a result of the storage temperature (32°C) which aided loss of CO_2 through the eggshell pores and thus increased the alkalinity of albumen and yolk (Rocculi *et al*., 2009). It could also be attributed to high temperature catalytic effect of carbonic anhydrase enzyme, which dissociated H_2CO_3 into H_2O and CO_2 that left the eggs through the eggshell pores, thereby increasing internal egg pH (Stadelman and Cotterill, 2005; Keener *et al*., 2006). The highest pH recorded in this study were still below the maximum limit (9.3) reported by Chen *et al.* (2014). Egg whose pH is above the recommended limit is unfit for consumption (Keener *et al*., 2006). However, alkalisation of egg had been associated with albumen liquefaction, flaccidity of the yolk membrane and yolk disruption (Alleoni and Antunes, 2005).

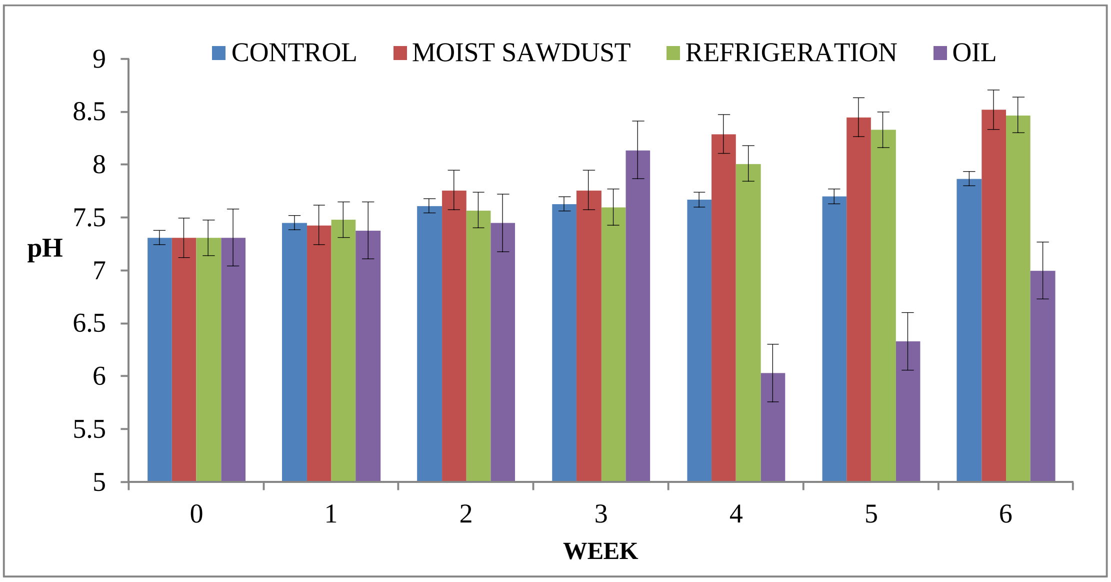

Figure 1. Effect of storage condition on chicken eggs pH. Data reported as Mean± SE

Effect of storage conditions on total bacteria count (TBC) of eggs

The results of total bacterial counts of chicken eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil varied from zero to 2.56×10^6 cfu/mL, zero to 2.33×10^6 cfu/mL, zero to 2.00×10^6 cfu/mL, and zero to 1.89×10^6 cfu/mL, respectively (Figures 3). While the total bacterial counts of quail eggs stored at ambient condition (control), moist sawdust, refrigerator, and those that were dipped in oil varied from zero to 5.8×10^5 cfu/mL, zero to 1.16×10^6 cfu/mL, zero to 1.46×10^6 cfu/mL, and zero to 8.8×10^5 cfu/mL, respectively (Figures 4). Eggs stored in moist sawdust had the highest total bacterial counts, while eggs stored under refrigeration had the lowest total bacterial counts at the end of storage period. The initial microbial load observed in fresh eggs was an indication that contamination of eggs contents might occur either before the eggs were laid or shortly after, as it was reported in the findings of Jones *et al.* (2004) on eggs microbial quality. High viable counts observed in eggs stored in moist sawdust might be due to higher relative humidity of the medium, which favours microbial proliferation in egg during storage as reported by Joseph and Ogundele (1996). A decline in viable counts was observed between the fourth week and the fifth week in all the storage conditions, but it was more pronounced in the control and in eggs stored in moist sawdust. The decline in counts might be due to eventual use up of nutrients by the organisms. The refrigeration condition limited the proliferation of microorganisms below 4.0×10^7 cfu/g throughout the storage period. Similar findings were also reported by Joseph and Ogundele (1996), Shin *et al.* (2012) and Wahba *et al*. (2014) who researched on storage of eggs under refrigeration.

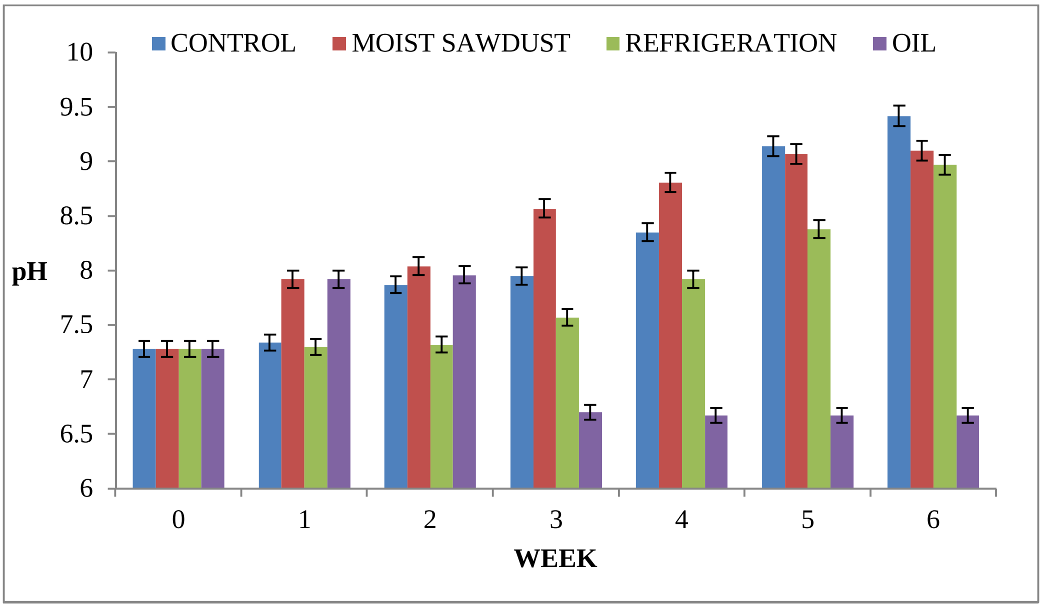

Figure 2. Effect of storage on quail eggs pH.
Data reported as Mean± SE

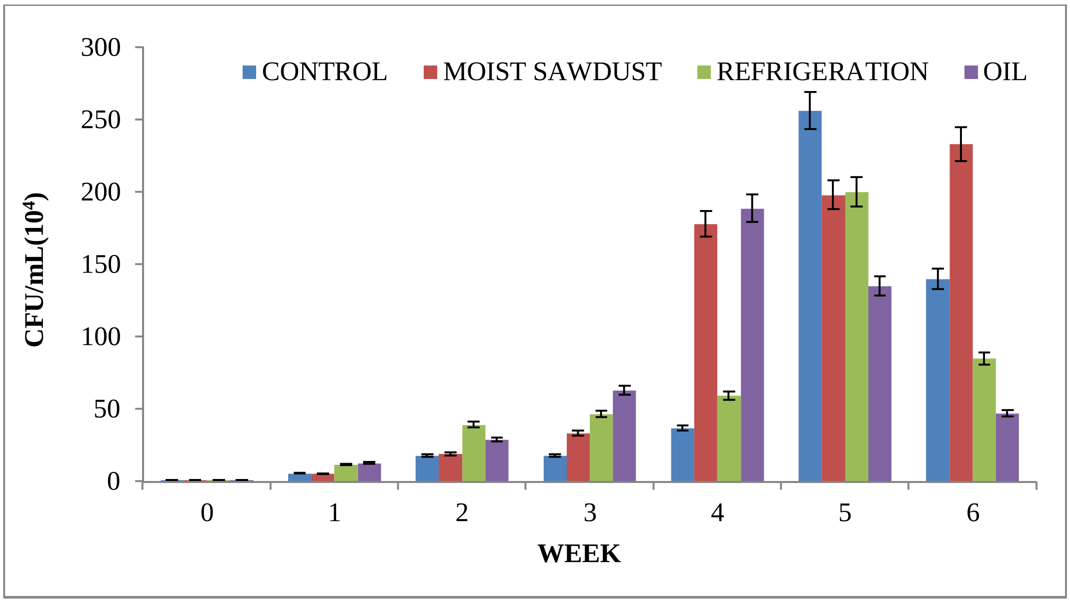

Figure 3. Effect of storage condition on chicken eggs bacterial count.
Data reported as Mean± SE

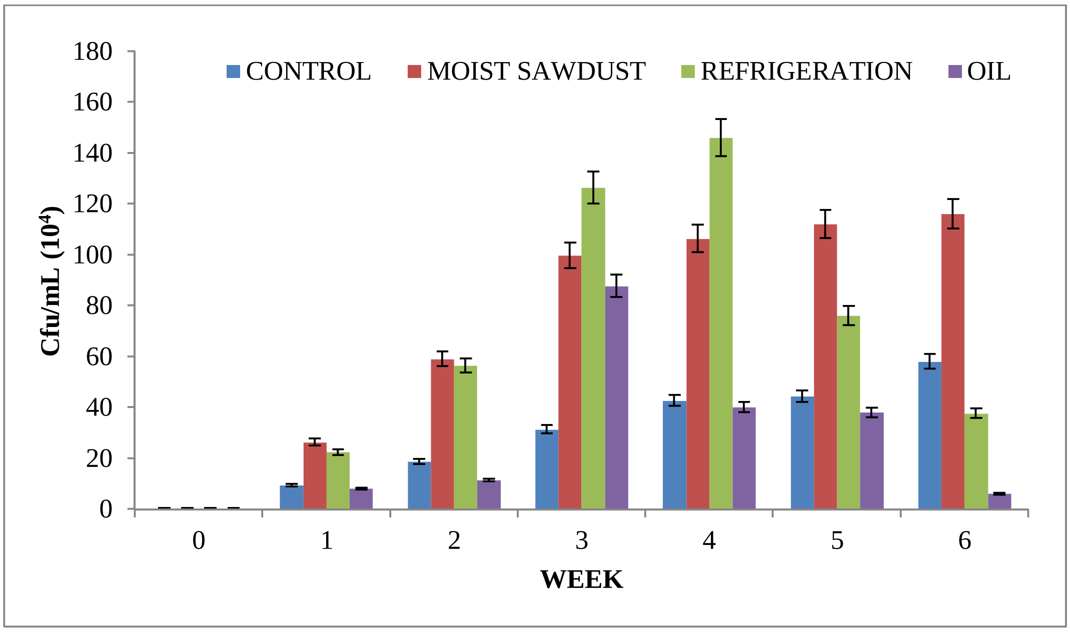

Figure 4. Effect of storage condition on quail eggs bacterial count. Data reported as Mean± SE

Conclusions

The findings show that the method and length of storage affect eggs quality. Rapid quality deterioration in eggs kept at room temperature make them unfit for consumption after three weeks storage, especially the quail eggs. Eggs storage under refrigeration prevents quality deterioration when compared to storage at ambient temperature. In tropical countries, where ambient temperatures ranged from 25-30°C, storage of eggs should not be more than two weeks before consumption in order to ascertain eggs fresh quality. Considering the various quality parameters evaluated, quail eggs were better preserved by oil treatment than chicken eggs, while refrigeration treatment preserved chicken eggs better compared to quail eggs.

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