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Quality of Eggs Under Varying Storage Periods, Conditions and Seasons in a Semi Arid Zone of Nigeria

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ABSTRACT

This study investigated the effects of storage time, season and egg weight on external and internal characteristics of chicken eggs. Two hundred and forty (240) eggs of small(51.42 g ± 0.26), medium (56.05 g ± 0.26) and large (61.01 g ± 0.29) grades were collected from the battery cage laying chickens and stored at room temperatures of 40 °C and 31 °C during the dry hot and wet seasons respectively. The corresponding averages for relative humidity were 29.38% and 65.39%. Ten (10) eggs from each of the three weight groups were examined as soon as they were collected and subsequently, 4, 8 and 12 days after storage; making a total of 120 eggs per season. The eggs were analyzed for their weight, length, width, albumen length, albumen width, albumen height, yolk length, yolk width, yolk height, shell weight, shell thickness, shape index, albumen index, yolk index and haugh unit. There was a significant effect ($p<0.01$) of egg weight on egg width, egg length, shell weight, shape index, albumen length, albumen width and albumen index. All the egg quality factors were significantly ($p<0.001$) affected by storage period except egg length, egg width, shape index and shell thickness. Albumen length, albumen width, yolk length, yolk width increased with increase in storage period, while albumen length and yolk height decreased with increase in storage period. Storage time did not affect ($p>0.05$) shell weight, shape index, egg length and egg width. The effect of season was significant ($p<0.001$) on all the egg quality factors (with effects been pronounced during dry season) except shell weight and shell thickness. The interaction effects showed that large eggs were more affected by storage period than small eggs while, seasonal effect became more pronounced with prolong storage period.

Key words: Egg, quality, season, storage

INTRODUCTION

Chicken eggs, the most commonly eaten egg in most part of Nigeria, are highly nutritious. They not only supply a large amount of complete proteins but also of high quality which contain all the essential amino acids for human and provide significant amount of several vitamins and minerals including vitamin A, riboflavin, folic acid, vitamin B_6, vitamin B_{12}, chlorine, iron, calcium, phosphorus and potassium (FAO, 1978). They are therefore classified as one of the best single food sources of complete protein (Rickett, 1981). The egg yolk also contain choline; an important nutrient for development of brain and is said to be important for pregnant and nursing women to ensure proper development of fetal brain (Jadhav and Siddiqui, 2007). Egg is easily digestible and contains unsaturated fat which inhibits heart attack progress (MAFF, 1991).

In addition to their nutritive value, eggs have important functional properties. Eggs act as leaving agent in baked foods and also as binding agent to hold other ingredients together (Orr and Murray, 1977). Eggs act as thickening agent particularly in custards and egg yolk contains emulsifiers (Kurtzweil, 1998). It is also excellent coating for cakes, breads and other bakery foods and also adds colour and richness to foods.

Acceptability of an egg is determined by its quality characteristics which can be external (shell thickness, shell weight) or internal (albumen index, yolk index and haugh units). Evaluation of these egg traits is important because of consumer preference for better quality.

There are several factors influencing the quality of an egg. Storage period and temperature appear to be the most crucial factors affecting egg quality characteristics. The albumen height, Haugh unit, albumen and yolk indices of all eggs are at maximum when the eggs are laid and decreases with increased storage time (Silverside and Villeneuve, 1994; Tilki and Inal, 2004). Vitelline membrane, characteristic which determines the microbial quality

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of eggs (Humphrey, 1994), had also been shown to depend on the length and conditions of storage (Smolinska and Trziska, 1982). In Nigeria, most of the available eggs are usually stored at room temperature which can be as low as 31 °C during harmattan and as high as 40 °C during the hot season. Prolong storage of eggs in hot dry and wet cool season reduces egg quality. For this reason, optimum storage period for different seasons should be determined as a guide for the producers and consumers of eggs.

The aim of this study was therefore to determine the quality of eggs stored under varying storage conditions at two different seasons of the year in the semi arid region of Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at the University of Maiduguri, Maiduguri, Borno state Nigeria. Maiduguri falls within the Sahel region which is characterised by short (June- Sept) raining and a long (October –June) dry periods. Ambient temperature could be as high as 40^0C or more in April while relative humidity could be as low as 5% between December and January (Fada and Rayar, 1988).

Data collection and analysis

A total of 240 fresh eggs used for the study was obtained from chickens reared at the Livestock and poultry Teaching and Research Farm of the university of Maiduguri, Maiduguri, Borno state. Each half of the 240 eggs used in each season (wet/dry season) were sorted into large (average: 61.01 g), medium (average: 56.05 g) and small (average: 51.42 g) weight groups. The eggs were stored at room temperature of 30 °C - 40 °C in the dry season and 30 - 31 °C in the wet season. The corresponding relative humidity figures were 14.00 - 42.00% and 56.00 - 77.00%. Eggs in each group were stored for specific number of days (one day, 4, 8 and 12 days) and, at the end, 30 eggs were examined for internal and external quality characteristics. The egg quality characteristics measured were egg weight, albumen height, albumen width, yolk length, yolk width, yolk height, shell weight, shell thickness, egg length and egg width. Eggs were weighed with electronic weighing balance; the length and width of eggs were measured with the vernier caliper while, the shape index was determined according to Reddy et al. (1979). The egg shape index was calculated thus:

$$\text{Egg shape index} = \frac{\text{Width of egg}}{\text{Length of egg}} \times 100$$

Procedure

The egg content was carefully poured on a flat surface where the height, length and width of the albumen and yolk were measured using vernier caliper calibrated in mm. The shells were dried at room temperature for 3 days and weighed according to Scott and Silversides (2000) method. The thickness of each egg shell was determined using a micrometer screw gauge calibrated in mm. Accuracy of shell thickness was ensured by measuring shell samples at the broad end, middle portion and narrow end of the shell. The average shell thickness was then recorded in mm. The values obtained from albumen length, height and width, yolk length, height and width were used in calculating albumen index and yolk index according to Tilki and Inal (2004) method as follows.

$$\text{Albumen index} = \frac{\text{Albumen height}}{\text{Albumen width + albumen length}} \times 100$$

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk diameter}} \times 100$$

The haugh unit was determined from albumen height and egg weight according to Haugh (1937) as follows:

$$Hu = 100 \log (H\text{-}1.7W^{0.37} + 7.6)$$

where, HU = haugh unit, H = observed height of albumen and W = weight of egg.

All data were analyzed using the General Linear Model of SPSS (2006) with storage period, weight and season as fixed factors. Significant means were separated by the Duncan's Multiple Range test. The statistical model adopted is as follows.

$$Y_{ijKl} = U + Y_i + S_j + P_{K} + (YS)_{ij} + (YP)_{iK} + (SP)_{jK} + e_{ijKl}$$

where, Y_{ijKl} = observation on an egg parameter of i^{th} storage period, J^{th} weight group and K^{th} season. U=population mean, Y_i = effect of i^{th} storage period, S_j = effect of the j^{th} weight, P_k = effect of K^{th} season, YS_{ij}, YP_{iK} and SP_{jK} are two way interactions of storage period × weight group, storage period x season and weight group × season respectively, and e_{ijKl} = random error.

RESULTS AND DISCUSSION

Effects of weight group on egg quality factors

The least-square means and standard error for the external and internal egg quality factors for the three weight groups are presented in Table 1. The mean egg weights were 51.42 g, 56.05 g and 61.05 g for weight groups 1, 2, and 3, respectively. There was significant effect of weight of egg on all the egg quality factors except yolk width, yolk height, shell thickness and yolk index. Generally, where significant differences were observed, larger eggs had better qualities. This is in agreement with the work of Silverside and Scott (2001) who attributed differences in albumen qualities of Isa Brown and Isa White eggs to differences in their egg size. Washburn (1990) summarized literature to show that the relationship between egg weight and albumen weight is higher than those between egg weight and shell or yolk weight. Flecher *et al.* (1983) showed that as egg size increases, so does the percent of albumen.

Table 1. Least squares means of external and internal egg quality factors according to weight groups.

Egg quality factors	Weight groups			Level of significance
	1	2	3	
Egg weight (g)	51.42 ± 0.26^{c}	56.05 ± 0.26^{b}	61.05 ± 0.29^{a}	***
Egg length (mm)	5.60 ± 0.02^{b}	5.56 ± 0.02^{b}	5.8 ± 0.02	***
Egg width	4.13 ± 0.01^{c}	4.26 ± 0.01^{b}	4.38 ± 0.01^{a}	***
Albumen length	8.86 ± 0.09^{b}	8.89 ± 0.09^{b}	9.27 ± 0.09^{a}	***
Albumen width	7.36 ± 0.12^{b}	7.19 ± 0.12^{b}	7.81 ± 0.13^{a}	***
Albumen height	0.39 ± 0.13^{b}	0.42 ± 0.13^{a}	0.40 ± 0.13^{ab}	*
Yolk length	4.14 ± 0.03^{b}	4.22 ± 0.036^{a}	4.19 ± 0.01^{ab}	*
Yolk width	4.11 ± 0.03	4.16 ± 0.03	4.18 ± 0.04	NS
Yolk height	1.11 ± 0.02	1.11 ± 0.02	1.11 ± 0.02	NS
Shell thickness	0.27 ± 0.00	0.27 ± 0.00	0.26 ± 0.00	NS
Shell weight	4.97 ± 0.06^{c}	5.27 ± 0.06^{b}	5.81 ± 0.06^{a}	***
Shape index	74.05 ± 0.39^{b}	76.72 ± 0.39^{a}	74.76 ± 0.41^{b}	***
Albumen index	2.60 ± 0.09^{ab}	2.80 ± 0.09^{a}	2.40 ± 0.10^{b}	**
Yolk index	28.3 ± 0.57	27.7 ± 0.58	27.8 ± 0.61	NS
Haugh unit	59.47 ± 0.46^{ab}	59.99 ± 1.47^{a}	55.35 ± 1.55^{b}	*

Means on the same row with different superscripts are statistically significant; *** = (p<0.001),***= (p<0.01),* = (p<0.05), NS = not significant

Effect of storage period on egg quality factors

The effect of storage time on external and internal egg quality factors was significant (p<0.05) for all the factors except egg length, egg width, shell weight and shape index (Table 2). Egg weight decreased with increase in storage period. This is in agreement with the work of Monira *et al.* (2003) who reported that egg weight decreased from 63.00 g to 56.00 g when stored for 14 days. This is probably due to evaporation of water and loss of minor quantity of gases like Carbon dioxide through the shell pores (Oluyemi and Robert, 2000). Reduction of albumen height and increase of albumen width could also be attributed to weakness of the ovomucin layer which is responsible for firmness of thick albumen. The thick albumen slowly becomes thin and spread over wide range of area in abnormal manner when egg is broken causing increase in albumen length and width (Jadhav and Siddiqui, 2007). This result is in agreement with the findings of Scott and Siverside (2000) who observed a decline in albumen quality with increase in storage time and that of Monira *et al.* (2003) who reported that albumen height decreased from 7.62 mm to 1.41 mm when stored for 14 days. Increased storage period also had negative effect on Haugh unit as it had on both egg weight and albumen height perhaps, because egg weight and albumen height are positively correlated with haugh unit (Kul and Seker, 2004). This result is in agreement with the work of Monira *et al.* (2003) and Tilki and Inal (2004) who reported decreased haugh unit with increase in storage period. However, dramatic increase in yolk length, yolk width and decreased yolk height with increase in storage peroid may be as a result of weakness of chalazae and vitelline layers that hold the yolk in position and absorb any shocks and jerks

Table 2. Least squares means of external and egg quality factors according to period of storage

Egg quality factors	Storage period (days)				Level of significance
	0	4	8	12	
Egg weight (g)	57.2 ± 0.29^{a}	57.2 ± 0.29^{a}	55.5 ± 0.29^{b}	54.8 ± 0.32^{b}	***
Egg length	5.69 ± 0.02	5.67 ± 0.02	5.67 ± 0.02	5.65 ± 0.03	NS
Egg width	4.26 ± 0.01	4.27 ± 0.01	4.25 ± 0.01	4.24 ± 0.02	NS
Albumen length	7.97 ± 0.11^{c}	8.89 ± 0.11^{b}	9.57 ± 0.11^{a}	9.59 ± 0.12^{a}	***
Albumen width	6.62 ± 0.14^{bc}	7.17 ± 0.14^{c}	7.76 ± 0.14^{b}	8.25 ± 0.15^{a}	**
Albumen height	0.58 ± 0.01^{a}	0.42 ± 0.01^{b}	0.30 ± 0.02^{c}	0.31 ± 0.02^{c}	***
Yolk length	3.78 ± 0.04^{bc}	4.01 ± 0.04^{c}	4.33 ± 0.04^{b}	4.62 ± 0.04^{a}	***
Yolk width	3.68 ± 0.04^{bc}	4.02 ± 0.04^{c}	4.32 ± 0.04^{b}	4.61 ± 0.04^{a}	***
Yolk height	1.46 ± 0.02^{a}	1.19 ± 0.02^{b}	0.96 ± 0.02^{c}	0.86 ± 0.03^{bc}	***
Shell weight	5.27 ± 0.07	5.32 ± 0.07	5.38 ± 0.07	5.45 ± 0.08	NS
Shell thickness	0.29 ± 0.00^{a}	0.28 ± 0.00^{a}	0.26 ± 0.00^{b}	0.26 ± 0.01^{b}	**
Shape index	75.0 ± 0.45	75.4 ± 0.45	75.2 ± 0.45	75.2 ± 0.49	NS
Albumen index	4.08 ± 0.11^{a}	2.68 ± 0.11^{b}	1.82 ± 0.11^{c}	1.78 ± 0.12^{c}	***
Yolk index	39.80 ± 0.66^{a}	29.10 ± 0.66^{b}	22.7 ± 0.66^{bc}	19.32 ± 0.73^{c}	***
Haugh unit	74.46 ± 1.68^{a}	60.90 ± 1.68^{b}	48.46 ± 1.69^{c}	48.26 ± 1.85^{c}	***

Means on the same row with different superscripts are statistically significant; *** = ($p<0.001$),** = ($P<0.01$),* = ($p<0.005$), NS = not significant to eggs. The yolk loses its round shape and becomes fragile and flattened at the extreme stage of deterioration (Jadhav and Siddiqui, 2007). Vittelline membrane of yolk gets ruptured with complete flattening of yolk and, further, albumen and yolk got mixed emitting bad smell. This is in line with the work of Jones and Musgrove (2006). The decrease in yolk index with increasing storage period is in accordance with the work of Tilki and Saatci (2004).

Effect of season on egg quality factors

The least square means and standard errors for external and internal egg quality factors in dry hot and wet season is presented in Table 3. There was a significant ($p<0.0001$) effect of season on all the egg quality parameters except albumen width, shell weight, shell thickness and shape index. Where significant effect was observed, eggs collected during the wet season were of better quality than those in the dry hot season. This observation was due to difference in variation of temperature in dry and wet seasons (40^0C and 30^0C, respectively).

Table 3. Least square means of external and internal egg quality factors according to season

Egg quality factors	Season		Level of significance
	Dry	Wet	
Egg weight (g)	55.5±0.22	56.9±0.21[a]	***
Egg length	5.64±0.02	5.71±0.02	**
Egg width	4.25±0.01	4.28±0.01	*
Albumen length	9.12±0.08	8.83±0.08	*
Albumen width	7.59±0.10	7.32±0.09	NS
Albumen height	0.38±0.01	0.44±0.01	***
Yolk length	4.37±0.03	4.00±0.03	***
Yolk width	4.37±0.03	3.95±0.03	***
Yolk height	1.00±0.02	1.23±0.02	***
Shell weight	5.38±0.05	5.32±0.05	NS
Shell thickness	0.27±0.00	0.28±0.00	NS
Shape index	75.34±0.33	75.02±0.32	NS
Albumen index	2.37±0.08	2.80±0.07	***
Yolk index	24.3±0.49	31.6±0.47	***
Haugh unit	55.4±1.24	61.20±1.10	***

*** = ($p<0.001$),** = ($p<0.01$),* = ($p<0.05$), NS = not significant

Temperatures higher than 30°C which prevail in the dry hot season have negative effects on egg qualities (Oluyemi and Roberts, 2000). This result is in agreement with the work of Samli *et al*. (2005) who reported that albumen and yolk quality decreased with increase in temperature.

The egg weight loss in the dry season could be as a result of evaporation of water and loss of gases like carbon dioxide through the shell pores which fluctuate with temperature. It has been reported that temperatures higher than 32°C - 38°C depress feed intake and increase water consumption of the laying hens and, consequently, result to decrease in egg weight and shell thickness since the hen will be unable to supply the required nutrient for egg formation (Oluyemi and Roberts, 2000).

Storage period and weight group interaction

The interaction between weight group and storage period of egg quality factors is presented in Table 4. Variation of albumen index, albumen height, yolk index, yolk height, shape index and haugh unit was more among medium size eggs than small or heavy eggs, when eggs were stored at different storage periods. However, higher variation was recorded for yolk length and yolk width among medium and heavy egg though, small eggs varied more in shell weight and albumen width. Changes in external characteristics were similar when eggs of different weights were stored for different number of days.

Generally, large eggs deteriorated faster than small or average sized eggs if stored for a prolonged period. This can be attributed to inferior qualities (albumen index and Haugh unit) of large eggs (Scott and Silversides, 2000) since eggs with inferior qualities deteriorate faster than good quality ones (Jadhav and Siddiqui, 2007).

Table 4. Storage period, season and egg weight group two (2) way interaction effects[a].

Variable	Storage period and weight group interaction*			Season and weight group interaction**			Storage period and season interaction***			
	SP × EW			S × EW			SP × S			
	1	2	3	1	2	3	0	4	8	12
Egg weight				1.80	1.50	0.89	0.60	1.10	1.40	2.60
Egg length	0.08	0.12	0.14	0.23	0.09	0.06	0.08	0.03	0.11	0.12
Egg width	0.02	0.07	0.00	0.05	0.00	0.05	0.04	0.01	0.00	0.08
Albumen length	2.29	1.81	1.37	0.25	0.28	0.69	0.12	0.69	0.10	0.85
Albumen width	1.90	1.13	1.87	0.15	0.64	0.29	0.10	055	0.28	0.33
Albumen height	0.25	0.39	0.22	0.07	0.00	0.01	0.06	0.11	0.07	0.01
Yolk length	0.70	0.89	0.89	0.43	0.26	0.41	0.01	0.35	0.39	0.75
Yolk width	0.85	0.95	0.97	0.49	0.30	0.48	0.02	0.37	0.49	0.81
Yolk height	0.58	0.76	0.49	0.24	0.20	0.23	0.00	0.31	0.29	0.30
Shell weight	0.50	0.25	0.26	0.10	0.24	0.03	0.10	0.30	0.50	0.25
Shell thickness	0.05	0.04	0.03	0.01	0.00	0.01	0.00	0.01	0.02	0.01
Shape index	1.10	1.40	1.10	2.18	1.46	0.20	0.60	0.80	1.50	0.09
Albumen index	2.22	3.09	1.75	0.43	0.16	0.72	0.39	0.87	0.43	0.04
Yolk index	19.3	24.6	17.6	8.05	5.85	8.00	0.20	10.5	9.20	9.40
Haugh unit	25.6	35.2	19.8	6.99	0.84	11.13	5.80	11.5	7.90	2.20

SP = storage period, EW= egg weight, S= Season. [a] = maximum change in variable,: * = within storage period between weight groups and between storage periods and within weight group, ** = within season between weight groups and between seasons within weight group, *** = within storage period between seasons and between storage periods within season

Season and weight group interaction

The interaction between weight group and season is presented in Table 4. Generally, albumen measurements (albumen width, length, height) and Haugh unit of heavy eggs were more sensitive to seasonal changes while egg weight and shape index of small eggs were more sensitive. However, yolk measurements (yolk width, length and height) of eggs of different sizes responded equally to seasonal changes. This season and weight group interaction explains why large eggs in the temperate zone are of better quality than those in the tropical zone (Oluyemi and Roberts, 2000). The tropical environment is noted for pronounced seasonal changes that have more severe effect on the quality of large eggs.

Storage period and season interaction

The interaction between storage period and season is presented in Table 4. Seasonal variation of egg quality factors was more with prolonged storage period. The differences in the changes that occurred between fresh eggs and those stored for different periods in different seasons revealed that four days of storage can make significant effects on quality of eggs stored in the hot season though the quality can be maintained up to 12 days during the wet season. This is attributed to temperature differences between the seasons. Additionally, humidity during the wet season inhibits loss of moisture through evaporation. The result is in agreement with the work of Samli *et al.* (2005) who reported that albumen and yolk quality deterioration depends on storage temperature. Most of these changes in egg quality can be attributed to water loss by evaporation through the pores in the shell and the escape of carbon dioxide from albumen (Robinson, 1987). Also, Samli *et al.* (2005) reported that egg stored at 29°C had lower albumen height, haugh unit and yolk index than those stored under 5°C.

CONCLUSIONS

Results of this study showed that the effects of season, egg weight and storage period on egg quality factors favored eggs of small or medium size, eggs laid in the wet season and stored for a short period. A storage period of four days can have a negative effect during the hot season; however, the quality can be maintained even up to 12 days during the wet season.

This study also showed that prolonged storage especially during the dry season promotes deterioration of large size eggs. Again, seasonal effect became more pronounced with prolong storage period. It is therefore advisable to regulate the ambient temperature during the dry season to prolong the shelf life of eggs. Egg of large size should be consumed within short period of time to prevent its deterioration.

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