Scholars Journal of Agriculture and Veterinary Sciences (SJAVS) **e-ISSN 2348–1854**
Abbreviated Key Title: Sch. J. Agric. Vet. Sci. **p-ISSN 2348–8883**

A Unit of Scholars Academic and Scientific Society, India
(An International Publisher for Academic and Scientific Resources)

Impact of storage duration on Quality and Proximate Content of Eggs obtained from Hens fed Three Commercial Layers' Feed

Akinola LAF, Nwabia PO
Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, Choba, Port Harcourt, P.M.B. 5323 Port Harcourt, Rivers State, Nigeria. Email: letorn.akinola@uniport.edu.ng, lafakinola@gmail

Original Research Article

***Corresponding author**
Akinola LAF

Article History
Received: 20.01.2018
Accepted: 28.01.2018
Published: 10.02.2018

DOI:
10.36347/sjavs.2018.v05i02.002

Abstract: This research was done to study the impact of storage duration on the quality and proximate content of eggs that were obtained from laying chickens fed three commercial layers' feed. ISA brown hens numbering 108 which were 34 weeks old were studied for 13 weeks. The hens were shared randomly into three treatments which were labeled as FT1, FT2, and FT3 with four replicates each. Each replicate was used to accommodate nine (9) hens. Three types of commercial layers feed commonly sold in Port Harcourt, Nigeria, were bought from a sales outlet (within the week of their supply to the shop) and offered in each treatment. The labels on the feed bags contained Crude protein, CP 16.2%, Fat/Oil 5.0%, Crude Fibre, CF 6%, metabolizable energy, ME 2500kcal/kg ME, calcium 3.6% and phosphorus 0.45% for FT1, similar feeds with CF 7% and Ca 3.5% constituted FT2 and CP 15%, CF 6.5%, ME 2400kcal/kg ME, calcium 1% and phosphorus 0.40% for FT3. Water was provided *ad libitum* while all routine activities were observed. On completion of the study, 21 eggs with similar weight were randomly collected within 72 hours from each replicate (84 eggs per treatment). Three (3) eggs were evaluated per replicate on the day that they were collected while the rest were analyzed weekly for the external, internal quality and the proximate content at 1, 2, 3, 4, 5 and 6 weeks (day 7, 14, 21, 28, 35 and 42). The result revealed that the storage duration significantly affected the weight of the eggs, shell weight, and the egg shape index. The weight of the egg was significantly greater within the first three week (21 days) for eggs obtained from FT1 and FT2 and up to 5 weeks (35 days) for FT3. The height of the albumen and HU revealed significantly greater values within the first fourteen days of storage which declined as the duration of storage increased. The proximate content of the stored eggs (protein) declined from day 28 in T1 and T2 and from day 35 in T3. It was concluded that the eggs which were collected from T3 which gave better weight during storage and retained better protein content up to day 35 could imply that feed FT3 was the best amongst the commercial layers feed that were studied.

Keywords: Egg quality, Commercial feeds, Hens, Proximate analysis, Storage.

INTRODUCTION

The avian egg serves as a source of reproduction to the bird and a source of food to man, required for good health, and human development [1]. According to [2] egg is a storehouse of nutrients such as lipids, proteins, enzymes and other biologically active materials including growth promoting factors and defense factors against disease invasion.

However, changes in the content of the egg is a serious problem associated with egg. Such changes occur in deteriorative form as some of the nutrients are altered in quantity and quality. Several factors have been identified to affect or cause changes in egg. Such factors include the strain and the breed of the layers [3] and the dietary composition, the health of the birds, the eggs environment, handling, processing and storage [4-6]. Also, there is usually the interactive effect of these major factors on the content of egg.

Higher temperature is a major factor which causes deterioration in the internal content of egg [7]. Time also causes changes in egg components, thus according to [8] the longer the period after lay, the worse the internal quality of eggs such as lowered weight of the albumen, the height of the albumen and higher albumen ph. Thus, [9] recommended that eggs meant for the market should be properly labeled as “keep refrigerated’ apart from transporting in refrigerated vehicles and storing under refrigerated conditions or at ambient temperature of 7.2 ^{0}C (45 ^{0}F). However, most Nigerians even in this 20th century cannot meet up with this recommendation due to unsteady power supply in several parts of the country. Thus, eggs are mostly stored at ambient temperature which affects the albumen and yolk quality which are vital signs which show the level of freshness and the market value [10] and the contributors to the formation and maintenance of the aerated structure in bakery products [11]. It is against this backdrop and recognizing that most small poultry and commercial farmers depend solely on commercial layers’ feed that this study was conducted to evaluate the quality and proximate content of stored eggs that were collected from hens fed different commercial layers feed.

MATERIALS AND METHODS

The experiment was performed out at the Poultry Unit of University of Port Harcourt Teaching and Research Farm, Port Harcourt, Nigeria.

The study was conducted using the completely randomized design (CRD). A total of 108 ISA brown hens which were 34 weeks old were used for the 12 weeks’ study. The birds were obtained from the same farm and were randomly shared into three treatments which were marked as FT1, FT2 and FT3 with four replicates each. Thus, nine (9) hens were in each replicate. Three types of commercial layers feed commonly sold in the area were bought from a sales outlet (within the week when they were supplied) and served in each treatment. The labels on the feed bags contained Crude protein, CP 16.2%, Fat/Oil 5.0%, Crude Fibre, CF 6%, metabolizable energy, ME 2500kcal/kg ME, calcium 3.6% and phosphorus 0.45% for FT1, similar feed with CF 7% and Ca 3.5% for FT2 and CP 15%, CF 6.5%, ME 2400kcal/kg ME, calcium 1% and phosphorus 0.40% for FT3. Water was provided *ad libitum* while all routine activities were observed.

Twenty-one (21) eggs with similar weight were randomly collected per replicate within 72 hours (84 eggs per treatment) when the study terminated. Three (3) eggs were analyzed per replicate on the day that they were collected while the rest were analyzed weekly for the external, internal quality and the proximate content at week 1, 2, 3, 4, 5 and 6 (day 7, 14, 21, 28, 35 and 42).

The egg weight, albumen, yolk and shell weights were taken with a sensitive electronic weighing scale. The shell thickness was measured with a gauge (the micrometer screw) while the Vernier caliper was used to obtain the height of the albumen, the albumen diameter, egg length and width. The yolk pigmentation, albumen and yolk pH were obtained while the shape index of the egg (SI = shell weight ÷ egg weight x 100%), yolk index (yolk height ÷ yolk diameter x 100%), yolk: albumen ratio and Haugh unit, HU (100log H+7.5 – 1.7w$^{0.37}$) were calculated.

The weekly proximate assessment of eggs was carried according to the description by [12]. All the data were analyzed statistically using SAS software [13] while the differences between the means that were significant were determined accordingly.

RESULTS

The storage period significantly affected the egg weight, the shell weight and the shape index as contained in Table-1. The stored egg weight was significantly greater within the first three weeks for eggs collected from FT1 and FT2 and up to week 5 for FT3. Significantly higher weight of the shell and shape index were also obtained during the early storage period compared to the eggs stored for more than 21 days.

The influence of storage on the internal content of the eggs is given in Table-2. The duration significantly affected the height of the albumen, yolk weight, yolk height (in FT3) and the Haugh unit (HU). The albumen height, and HU had significantly greater values within the first fourteen days of storage and the values declined as age of the eggs increased whereas, the yolk weight showed a reversed trend. The eggs obtained from FT1 and FT2 deteriorated sharply after day 35 while the eggs obtained from FT3 were good even on day 42.

Table-1: Influence of storage period on the external quality parameters of the stored eggs

Treatments /Duration(Days)	External Qualities of egg					
	Egg weight (g)	Egg width (cm)	Egg length (cm)	Shell weight (g)	Shell thickness (mm)	Shape index (%)
FT1						
7	56.71[a]	4.09	5.42	5.82[a]	0.44	75.46[a]
14	57.11[a]	4.02	5.34	5.84[a]	0.46	75.28[a]
21	56.20[a]	4.00	5.27	5.61[a]	0.43	75.90[a]
28	51.78[b]	3.96	6.11	5.02[b]	0.43	64.81[b]
35	51.12[b]	3.82	6.08	5.00[b]	0.42	62.83[b]
SEM	1.21	0.02	0.04	0.30	0.01	1.41
FT2						
7	58.17[a]	4.11	5.50	5.87[a]	0.45	74.72[a]
14	58.21[a]	4.12	5.51	5.81[a]	0.45	74.77[a]
21	58.04[a]	4.07	5.88	5.72[a]	0.44	68.71[b]
28	57.00[b]	4.01	5.98	5.11[b]	0.43	67.06[b]
35	56.11[b]	4.00	6.00	5.01[b]	0.42	66.67[b]
SEM	0.24	0.15	0.76	0.35	0.02	1.41
FT3						
7	63.20[a]	4.80	5.94	6.02[a]	0.47	80.81[a]
14	65.41[a]	4.92	5.96	6.42[a]	0.47	82.55[a]
21	64.11[a]	4.78	6.06	6.07[a]	0.46	78.88[a]
28	62.50[a]	4.62	5.97	5.94[a]	0.45	77.39[a]
35	60.60[a]	4.47	5.92	5.02[b]	0.45	75.51[a]
42	55.78[b]	4.10	5.98	4.96[b]	0.44	68.56[b]
SEM	4.82	0.92	0.18	0.56	0.01	5.92

[a,b,c] - Means within the same column with different superscripts differ significantly ($p < 0.05$)

Table-2: Influence of storage period on the internal quality parameters of the stored eggs

Treatments /Duration (Days)	External Qualities of egg						
	Albumen weight (g)	Albumen height (cm)	Yolk weight (g)	Yolk height (mm)	Yolk diameter (cm)	Yolk: Albumen ratio	Haugh unit
FT1							
7	29.81	3.81[a]	15.76[b]	4.04	4.00	0.53	77.01[a]
14	30.02	3.86[a]	17.15[a]	4.01	4.14	0.57	77.01[a]
21	29.64	3.00[b]	17.02[a]	3.98	4.25	0.57	70.75[b]
28	28.78	2.56[b]	16.93[a]	3.61	4.29	0.59	68.30[b]
35	27.62	2.01[c]	17.00[a]	3.64	4.30	0.62	63.25[b]
SEM	0.21	0.51	0.14	0.03	0.06	0.01	1.21
FT2							
7	30.26	3.91[a]	15.97[b]	4.02	4.06	0.53	77.38[a]
14	30.27	3.91[a]	16.96[a]	4.00	4.08	0.56	77.38[a]
21	29.87	3.01[b]	17.11[a]	3.96	4.12	0.57	70.33[b]
28	28.42	2.36[b]	16.89[a]	3.84	4.21	0.59	64.64[c]
35	28.01	2.02[c]	17.02[a]	3.76	4.32	0.61	61.49[c]
SEM	0.82	0.40	0.56	0.51	0.33	0.07	1.47
FT3							
7	35.01	4.18[a]	16.92[b]	4.25[a]	4.20	0.48	76.86[a]
14	35.24	4.20[a]	16.89[b]	4.24[a]	4.24	0.48	77.67[a]
21	35.04	3.52[b]	17.02[b]	4.20[a]	4.41	0.49	72.84[b]
28	34.60	3.00[b]	17.21[b]	3.55[b]	4.63	0.50	68.84[b]
35	33.80	2.42[b]	18.86$_a$	3.51[b]	4.67	0.56	63.95c
42	31.62	2.01[c]	19.01[a]	3.41[b]	4.69	0.60	61.49[c]
SEM	1.21	0.40	0.81	0.51	0.50	0.60	0.98

[a,b,c] - Means within the same column with different superscripts differ significantly ($p < 0.05$)

Table-3: Influence of storage period on the proximate content of the stored eggs.

Treatments /Duration (Days)	Proximate content of the eggs (%)					
	Moisture	Fat	Protein	Ash	Carbohydrate	Total solid
0	71.17	10.71	13.00^a	0.46	26.46	28.87
7	73.17	10.82	13.01^a	0.25	24.40	26.80
14	69.33	10.93	13.12^a	0.35	28.78	27.43
21	67.14	10.94	12.83^a	0.48	30.24	30.61
28	71.70	10.66	11.22^b	0.61	25.91	28.23
35	71.42	10.64	11.55^b	0.46	26.06	28.34
SEM	6.06	0.50	0.38	0.41	5.87	3.92
FT2						
0	71.02	10.75	12.94^a	0.47	27.72	28.41
7	71.41	10.79	12.82^a	0.46	26.57	28.07
14	70.21	10.84	12.86^a	0.39	27.91	27.65
21	70.18	10.80	12.96^a	0.40	28.02	27.92
28	70.12	10.77	11.87^b	0.48	27.11	27.16
35	69.56	10.92	11.84^b	0.45	26.84	26.95
SEM	1.84	0.21	0.31	0.10	1.57	1.61
FT3						
0	72.15	10.84	13.12^a	0.49	26.74	28.77
7	72.01	10.91	12.97^a	0.47	26.12	28.44
14	71.62	10.87	12.85^a	0.38	27.54	27.92
21	71.41	10.81	13.01^a	0.39	28.01	28.04
28	70.47	10.90	12.91^a	0.46	27.06	27.05
35	70.25	10.88	12.24^b	0.46	27.14	27.17
42	71.16	10.92	11.87^b	0.43	27.44	27.66
SEM	2.71	0.14	0.30	0.13	1.90	1.80

^{a,b} - Means within the same column with different superscripts differ significantly ($p < 0.05$)

The result obtained (Table-3) showed that storage affected only the protein content of the eggs. The proximate composition of the stored eggs revealed that the protein content declined from day 28 in T1 and T2 and from day 35 in T3.

DISCUSSION

The weight of the stored eggs which were significantly greater ($P < 0.05$) during the first 21 days of storage at room temperature in FT1 and FT2 and declined from day 28 to 35 confirmed the report by [14] who found similar higher egg weight within the first three weeks of storage at 25 – 30^{0}C. Earlier report of decline in egg weight with increasing storage time had been stated by [15]. The decline in weight from day 28 to 35 in FT1 and FT2 could be related to the onset of deteriorative changes since the eggs could no longer be analyzed on day 42 in these treatments. However, the FT3 eggs which had significantly greater ($P < 0.05$) weight till week 5 and declined in week 6 (day 42) could be traced to the better nutritional content of the feed fed to the hens in that treatment. Recent report by [16] stated that the analyzed value of crude fibre, CF (11.6 and 12.2%) in feed FT1 and FT2 had significantly greater levels compared to FT3 (8.01%) even though the feeds were declared to contain 6, 7 and 6.5% CF respectively. The extended good content of eggs in FT3 till week 6 (day 42) could be connected to the fairly better nutrient content of the feed. Thus, loss in the egg weight may be related to the content of the feed that is fed to the hens apart from the duration of storage and the environmental temperature. The result obtained in this study covering November to February in Port Harcourt, Nigeria (beginning of dry season) when the lowest temperature was 21 – 22^{0}C and highest temperature was 26.5 – 33^{0}C, was better than that reported by [7] who recorded fast deterioration of eggs after 2 weeks when temperature was about 37^{0}C and [1] who reported that eggs stored for 14 days in Northern Nigeria (Bauchi State) had more weight reduction when compared to eggs stored for a day and 7 days. This confirmed earlier report that that loss in egg weight was positively related to the storage duration and to the environmental temperature [7, 6, 17]. It had been observed that the loss of CO_2 and moisture and the O_2 that moves into the egg usually create air bubble inside the egg in place of the lost moisture (which is closely followed by weight loss) causing the egg to float when it is dropped in water [18]. The shell weight and egg shape index which also reduced as the duration of storage increased was in contrast to the finding of [1] who stated that egg index was not altered by the duration of storage. The egg width, length and shell thickness which did not change significantly (P > 0.05) could be due to the eggs which were collected from the same strain of bird since [19] reported that differences in these parameters could only be found when various strains of hens were used.

The albumen height and HU which followed a downward trend with increasing duration of storage tallied with the report by [20]. The HU values obtained indicated that they were good quality eggs since [21] stated that HU range of 57.95 - 61.86 indicated good quality eggs while HU below 40 were bad quality eggs. Thus, the HU were good up to week 5 (day 35) in FT1 and FT2 and week 6 (day 42) in FT3, confirming the report by [22] who found that eggs had maximum quality when freshly laid by hens but reduced as the time of storage was prolonged. Despite the decreasing HU as the duration of storage prolonged, all the eggs attained the 'AA' and 'A' grades which are regarded as 'high quality' by [23] who classified eggs as 'AA' for those with HU of 72 and above (high quality), 'A' for those with HU of 60 – 70 (also high quality), 'B' for those with HU of 31 – 59 (low quality) and 'C' for those with HU of 30 and less (low quality). The yolk weight which increased significantly (P < 0.05) as the duration of storage increased tallied with the report of [14, 24] who found significantly increasing yolk weight as the duration of storage increased. This implied that there was movement of water from the albumen to the yolk due to the variation in osmotic pressure. This made the yolk to gradually acquire a flabby shape (flattened shape) instead of the spherical shape of freshly laid egg, thus, the albumen gets thinner progressively as the storage period increased [25]. The albumen and yolk weight, yolk height, yolk diameter and yolk: albumen ratio which showed no significant differences (P > 0.05) could suggest that there was less effect of time, humidity, air movement and temperature on these parameters. Movement of CO_2 and moisture through the egg shell during the period of storage usually cause a decrease in the moisture percentage of the albumen, egg weight and albumen weight [26].

The influence of the duration of storage on the eggs which indicated that the moisture, ash, fat, carbohydrate and total solid percentages were not altered significantly could be ascribed to the season of this study (November to February, when the daily temperature was 26.5^0 – 30^0C while the low temperature was 21 – 22^0C). This did not tally with the finding by [27, 28] who stated that eggs sharply loss physical and nutritional qualities when stored at high ambient temperature compared to those stored in refrigerators. The non-significant difference found in the moisture level of the stored egg across the treatment groups may be connected to the environmental temperature whose influence could not result to differences despite the decreasing weight of eggs that was observed as the storage duration increased. According to [29], moisture is generally lost through evaporation from egg when stored at a rate that is determined by the temperature of the environment. The non-significant difference found in the fat levels of the stored eggs from this study supported the report of [30] who found that the total lipids, phospholipids, phosphorus and iron were usually very constant in eggs. The values for fat obtained in this study across the treatments (10.64 – 10.94 %) was similar to that reported by [31] who gave values of 10.887 % for local chicken eggs and 11.08 % for exotic chicken when the proximate content of eggs from various poultry species was compared. It was also similar to the report by [32] who gave the values of 9.93 – 11.71 % on wet basis for the proximate percentage of crude fat of the eggs from different shell colour and types.

The protein levels of the stored eggs across all the treatments which reduced as the time of storage increased may be related to some factors such as humidity, time and temperature [33]. A similar finding was reported by [20] who found that the concentration of protein in the three groups of eggs (control, eggs oiled with vegetable oil and eggs oiled with shea butter) stored at room temperature declined significantly with increase in the storage time. But [34] reported increase in crude protein and ash content which were significant, with decreased moisture content for stored eggs from two rearing systems. The ash content of the stored eggs which did not reveal any difference could be likened to the report of [32] who stated that the compositional differences in eggs were only noticed for various egg types that were studied and were not due to the eggs age (12 – 26 days). However, [35] found that the ash and moisture content of the egg white and yolk decreased as the period of storage increased. The level of ash obtained across the treatment groups (0.35 – 0.61 %) was similar to that reported by [36] who stated the value of ash in egg as 0.67 % for *Gallus domesticus* but was lower than 0.91 % reported by [37]. The ash content obtained in this study was also less than 0.85 – 0.91 % for eggs collected from different production systems and 0.86 – 0.89 % for eggs of different shell colour (brown and white) according to [32]. The level of the carbohydrate of the stored eggs which did not differ indicated that there was uniformity in the energy breakdown during the storage of period. The similar total solids during the 35days period for T1 and T2 and 42 days for T3 was similar to the report by [38] as 23 – 25 % for whole egg and [39] who stated that whole egg solids showed no difference throughout the 10 weeks when eggs were kept in cold storage.

CONCLUSION

The HU which was above 60 across the treatment groups on completion of the duration of storage proved that the eggs were of high quality (AA and A grades) and will attract better prices in the market till day 35 for eggs collected from FT1 and FT2 and day 42 for those obtained from FT3. The better protein values recorded from the eggs till day 21 for T1 and T2 and day 28 for eggs from T3 provides more confidence for both the farmer and the consumer of the worth of the eggs produced/purchased when the three commercial layers feed were fed to hens.

REFERENCES

1. Tor NET, Egahi JO, Gwaza DS. Comparative studies on the internal and external qualities of brown and white local and exotic eggs in Bauchi. Proceeding of 38th Annual Conference of Nigerian Society for Animal Production. 17-20th March 2013, Rivers State University of Science and Technology. Port Harcourt; 2013.
2. Mine Y. Egg proteins and peptides in human health-chemistry, bioactivity and production. Current Pharmaceutical Design. 2007 Mar 1;13(9):875-84.
3. Elkin RG. Reducing shell egg cholesterol content. I. Overview, genetic approaches, and nutritional strategies. World's Poultry Science Journal. 2006 Dec;62(4):665-87.
4. Ryu KN, No HK, Prinyawiwatkul W. Internal quality and shelf life of eggs coated with oils from different sources. Journal of food science. 2011 Jun 1;76(5).
5. Zhang W, Zheng JX, Xu GY. Toward Better Control of Salmonella Contamination by Taking Advantage of the Egg's Self-Defense System: A Review. Journal of food science. 2011 Apr 1;76(3).
6. Khan MJ, Khan SH, Bukhsh A, Abbass MI, Javed M. Effect of different storage period on egg weight, internal egg quality and hatchability characteristics of Fayumi eggs. Italian Journal of Animal Science. 2013 Jan 1;12(2): 323- 328.
7. Tabidi MH. Impact of storage period and quality on composition of table egg. Advances in Environmental Biology. 2011 Apr 1;5(5):856-61.
8. Scott TA, Silversides FG. The effect of storage and strain of hen on egg quality. Poultry science. 2000 Dec 1;79(12):1725-9.
9. USDA. United State Department of Agriculture, Safety Information, Shell Eggs from Farm to Table Food. USDA Food Safety and Inspection Services. http:/www.fsis.usda.gov/wps/wcm/connect/5235aa20-feel-4e5b-8d6e09f351b6/shell-Egg-from-Farm-to-Table. Pdf? MoD = AJPERES. 2011, Accessed 6th August, 2017.
10. Samli HE, Agma A, Senkoylu N. Effects of storage time and temperature on egg quality in old laying hens. Journal of applied poultry research. 2005 Oct 1;14(3):548-53.
11. Kiosseoglou V, Paraskevopoulou A. Eggs: In Bakery Products, Science and Technology, Hui, Y.H and H. Corker (Eds). Blackwell Publishing Ltd., Oxford. 2006, pp 161
12. AOAC. Association of Official Analytical Chemists. Official Methods of Analysis. 15th edition, Washington DC. 2000.
13. Statistical Analysis System Institute. SAS/STAT User's Guide, Version 8. SAS Institute; 1999.
14. Akinola LA, Ibe GC. Effect of colour, source and storage on quality of table eggs in Port Harcourt Metropolis, Rivers State, J. Res Agric Anim Sci. 2014;2:1-6.
15. Demirel S, Kırıkçı K. Effect of different egg storage times on some egg quality characteristics and hatchability of pheasants (Phasianus colchicus). Poultry science. 2009 Feb 1;88(2):440-4.
16. Akinola LAF, Ekine OA. Evaluation of commercial layers feeds and their impact on performance and egg quality traits. Nigerian Journal of Animal Science. 2018, 20: In Press
17. Gomez-de-Travecedo P, Caravaca FP, González-Redondo P. Effects of storage temperature and length of the storage period on hatchability and performance of red-legged partridge (Alectoris rufa) eggs. Poultry science. 2014 Feb 25;93(3):747-54.
18. Akyurek H, Okur AA. Effect of storage time, temperature and hen age on egg quality in free-range layer hens. Journal of Animal and Veterinary Advances. 2009 Aug;8(10):1953-8.
19. Ojedapo LO, Adedeji TA, Ameen SA, Olayeni TB, Amao SR, Ige AO, Rafiu TA, Ojediran TK, Akinniran TN. Effect of strain and age on egg quality characteristics of two different strains of layer chickens kept in cages in derived savannah zone of Nigeria. InProc. 14th Ann. conf. of Animal Sc. Ass. of Nig. 2009 Sep (pp. 14-17).
20. Pius O, Olumide A. Preservation of Quality of Table Eggs Using Vegetable Oil and Shea Butter. International Letters of Natural Sciences. 2017 Jan 1;63:27-33.
21. Garba S, Jibir M, Omojola AB. Egg quality of commercial laying hens fed diets with increasing substitution levels of metabolizable energy of pearl millet for corn. Energy. 2010 Mar;1:T2.
22. Panigrahi S, Plumb VE, Machin DH. Effects of dietary cottonseed meal, with and without iron treatment, on laying hens. British Poultry Science. 1989 Sep 1;30(3):641-51.
23. USDA. United States Department of Agricultural Marketing Services, USDA Egg Grading Manual. Agricultural Handbook No. 75 Washington. www.amusdagov/poultry/pdfs/EggGrading%20manual.pdf. 2000, Retrieved on 24th September, 2017.
24. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. Macmillan; 1985.
25. Hill AT, Hall JW. Effects of various combinations of oil spraying, washing, sanitizing, storage time, strain, and age of layer upon albumen quality changes in storage and minimum sample sizes

required for their measurement. Poultry Science. 1980 Oct 1;59(10):2237-42.
26. Eke MO, Olaitan NI, Ochefu JH. Effect of storage conditions on the quality attributes of shell (table) eggs. Nigerian Food Journal. 2013 Jan 1;31(2):18-24.
27. Okiki PA, Moro DD, Fajana OO. Effects of storage conditions on physical, nutritional and bacteriological quality of eggs. Asset B. 2006, 5:29 – 38.
28. Kenawi MA, Aly AS, Abd E. Quality of table eggs and their product as affected by storage temperature. Lucrări Științifice-Universitatea de Științe Agricole și Medicină Veterinară, Seria Zootehnie. 2016;66:64-9.
29. Al-Hajo NN, Zangana BS, AL-Janabi LA, MH F. Effect of coating materials (gelatin) and storage time on internal quality of chicken and quail eggs under refrigerated storage. Egypt. Poult. Sci. J. 2012;32:107-15.
30. Nys Y, Gautron J, Garcia-Ruiz JM, Hincke MT. Avian eggshell mineralization: biochemical and functional characterization of matrix proteins. Comptes Rendus Palevol. 2004 Oct 1;3(6-7):549-62.
31. Kabir M, Nkeonye UK, Adamu HY, Umar UA, Badmus KA. Comparison of proximate composition of internal and external qualities of eggs from four species of poultry marketed in Samaru, Zaria, Nigeria. Proceeding of 40th Annual Conference of Nigerian Society for Animal Production. 15th – 19th March 2015, NAPRI/ABU Zaria. 2015, pp 32 – 35.
32. Jones DR, Musgrove MT, Anderson KE, Thesmar HS. Physical quality and composition of retail shell eggs. Poultry science. 2010 Mar 1;89(3):582-7.
33. Gavril R, Usturoi MG. Effect of storage time and temperature on hen egg quality. Lucrări Științifice-Universitatea de Științe Agricole și Medicină Veterinară, Seria Zootehnie. 2012;57:221-9.
34. Ogunwole OA, Ojelade AY, Oyewo MO, Essien EA. Proximate Composition and Physical Characteristics of Eggs from Laying Chickens Fed Different Proprietary Vitamin-Mineral Premixes Under Two Rearing Systems During Storage. International Journal of Food Science and Nutrition Engineering. 2015;5(1):59-67.
35. Guo W, Trabelsi S, Nelson SO, Jones DR. Storage effects on dielectric properties of eggs from 10 to 1800 MHz. Journal of Food Science. 2007 Jun 1;72(5).
36. Fakai IM, Sani I, Olalekan OS. Proximate composition and cholesterol content of eggs obtained from various bird species. Journal of Harmonized Research (JOHR), 2015, 2(2):18 – 25.
37. Matt D, Veromann E, Luik A. Effect of housing systems on biochemical composition of chicken eggs. Agronomy Research. 2009;7(2):662-7.
38. Stadellman WS. Quality Identification of Shell Egg in Egg Science and Techonology. WJ Stadellman and OJ Cotterill ed. Avi. Publishing Co. Inc. Wesport, Connecticut. 1995.
39. Jones DR. Egg functionality and quality during long-term storage. International Journal of Poultry Science. 2007 May 30;6(3):157-62.