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Comparison of the nutritional value, atherogenic index and glucose profile of eggs laid by various strains of intensively reared domestic chickens

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Abstract

This study compared the nutritional value, atherogenic index and glucose concentration of eggs laid by different strains of domestic chicken (Black Australorp, Isa Brown, White Leghorn and Local chicken) that were reared intensively in Umuahia, South Eastern Nigeria. Sixteen 18-week-old indigenous (local) and exotic (Isa Brown, Black Australorp and White Leghorn) laying chickens, comprising 4 layers per strain, were used for the study. A total of fifty six (56) eggs (14 eggs per strain) were collected for assay. The egg-yolk and egg-white were thoroughly mixed for proximate evaluation, determination of atherogenic index and glucose concentration assay. Results showed that the mean egg moisture and total ash contents of eggs laid by Black Australorp chickens were significantly ($p < 0.05$) higher when compared to that of eggs laid by other strains of chicken. Also, the eggs of Black Australorp chickens had significantly ($p < 0.05$) lower mean crude fat content than the eggs of other strains of chicken. The crude protein contents of the eggs of Isa Brown chickens was significantly ($p < 0.05$) higher when compared to that of other strains of chicken studied. The mean atherogenic index of eggs laid by local chicken was significantly ($p < 0.05$) lower when compared to that of other strains of chicken studied. Eggs of White Leghorn chicken had significantly ($P < 0.05$) higher mean egg dry matter, carbohydrate and glucose concentrations than the eggs of other strains of chicken. It was concluded from this study that variations exist among the eggs of different strains of chicken in their nutritional value, atherogenic index and glucose concentrations. Eggs laid by Isa brown layers had higher protein content; those laid by White Leghorn had the highest glucose concentrations, while eggs laid by local chickens had the lowest atherogenic index.

Keywords: Domestic chicken; Strains; Eggs; Nutritional value; Atherogenic index.

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Introduction

Poultry production has been recognized as one of the major sources of low cost animal protein in developing countries (Ajayi, 2010; Rahman *et al.,* 2013). In addition to the yield of meat and eggs, indigenous chickens play both economic (food security) and socio-cultural roles for rural dwellers (Yousif and Eltayeb, 2011). All these roles cannot be fulfilled by the conventional (exotic) chickens due to the strict management and high financial inputs needed for their production. It is therefore important to ensure the conservation of indigenous poultry resources since their erosion will bring about major disruptions of biological, food and socio-cultural systems capable of reducing the value of life especially among rural households (FAO, 2009; Groeneveld *et al.,* 2010).

The egg of domestic chicken is a complex biological structure and an entity intended for reproduction naturally. It protects and provides nourishment for the developing embryo, serving as the principal source of nutrient for the first few days of chick's life and a versatile nutrient food for man (Omede *et al.,* 2017). Eggs of domestic chicken have been consumed by humans since ancient times as it is a rich source of protein and contains other high quality nutrients. Eggs are used as ingredients in foods for their unique functional properties (Uysal *et al*., 2017), because a balanced diet is essential for normal growth, health and preservation of the human body. Eggs constituted an important part of human diets for centuries because of its high quality protein content (Forson *et al.,* 2011). They are known to supply the best proteins besides milk (Vaclavik and Christain, 2008). Eggs are also rich in amino-acids, carbohydrates, easily digestible fats and minerals, as well as valuable vitamins (Huopalahti *et al.,* 2007). Eggs are an important source of animal protein that are rich in high-quality protein and essential unsaturated fatty acids and are easy to obtain for humans (Réhault-Godbert *et al.,* 2019). Eggs are the only animal-derived foods that can be cooked in various ways for human consumption (Surai and Sparks, 2001). The yolk and white components of eggs are all of high biological value and are readily digested (Joel *et al.,* 2010). Generally, eggs represent an important source of energy, protein and other nutrients for humans, and their rational consumption stimulates the metabolic functions in the body and increases resistance to diseases (Sauveur, 1988). They are also an excellent source of vitamins and minerals, especially phosphorus and iron (Nys, 2011).

Nigeria has the highest number of poultry farms in Africa. Nigeria presently produces about 300,000 tonnes of poultry meat per annum officially and 650,000 tonnes of eggs (USDA, 2014). In Nigeria, different poultry species contribute significantly to the annual animal protein supply to the populace (Ikeobi *et al.,* 1999). Poultry eggs are good sources of income and are of particular significance in scientific research, and in vaccine production (Adebambo, 2005). A parallel record from Poultry Association of Nigeria (PAN), indicates that Nigeria produces at present above 1.25 million tonnes of egg per year (Olusiyi *et al.,* 2020). Eggs of various poultry species are consumed as protein and amino acid supplements (Trziska, 2000). The question arises whether there are inter-species differences in nutritional value and quality of eggs from various poultry species and strains.

Egg production in Nigeria, as in other developing countries depends on commercial breeds of laying chickens, which are selected for their high egg production performance. However, the continuous use of exotic breeds may be the forerunner to a progressive reduction in genetic variability. Native breeds of chickens are characterized by their rusticity, resistance and adaptability to the environment (Ajayi, 2010). They also provide a pool of potential useful genetic resources for future commercial strains. Furthermore, there has been a shift in the demand for healthier and more sustainable products by consumers in the light of recent emerging diseases and climate change. Eggs produced by indigenous breeds of poultry are a compelling option for consumers (FAO, 2007).

Since each kind of bird has different genetic background, their egg qualities and nutritional components probably differ. Egg quality of Hyaline brown has been reported to be better than that of Jingbai hen, but nutrient content of eggs of Hyaline brown was lower than that of the Jingbai hen (Song *et al.,* 2012). There are also reports that the protein, phosphate and amino acid of hen eggs are lower than those of duck and quail eggs (Chen *et al.,* 2005). As a matter of fact, it has been posited that egg quality and nutrient components from eggs laid by the same species may vary significantly as a result of the differences in feed, feeding level and rearing environment (Mahdavi *et al.,* 2005). It has been further posited that when eggs are for human consumption, it is important that they are suitable for this purpose (Kabir *et al.,* 2014).

Egg white or albumen is approximately 2/3 of the total egg weight out of its shell, with nearly 90% of that weight being made up of water and the remaining weight coming from protein, minerals, vitamins and glucose. Egg white consists mainly of about 15% protein and some proportion of other nutrients (NRC, 1976) and unlike the yolk, contains negligible amount of fats. The nutrient content of egg white per 100 g was estimated to consist of 87.3 g water, 11.1 g protein, 0.2 g lipids, 0.4 g carbohydrate and 0.7 g minerals with a caloric value of about 203 kJ (48 kcal) [NRC, 1976]. Egg yolk is the part suspended in egg white which feeds the developing embryo. Yolk makes up about 33% of the liquid weight of the egg. It contains proteins, cholesterol, choline, carbohydrates, fatty acids, water, vitamins and minerals with caloric value of about 1,325 kJ (317 kcal) [NRC, 1976].

Although these natural constituents of egg are readily available in egg, their percentage compositions can be influenced by a lot of factors such as diet, age of bird, genetic make-up, environmental temperature, strain or breed of the chicken, photoperiod, stress, disease, etc. These suggest that variations in the atherogenic index, glucose and nutritional concentrations of egg may exist in eggs of different strains/breeds of chicken. The comparative study of eggs from different breeds of chicken in a given geographical location will be of immense benefits to the society in choosing egg with the best nutritional value for human consumption. There is paucity of information on the atherogenic index and quantitative nutritional constituents of eggs of indigenous chicken in comparison with eggs from exotic breeds. The present study evaluated the atherogenic index, nutritional value and glucose concentrations of eggs of local and exotic chickens reared intensively in Umuahia, South Eastern Nigeria.

Materials and Methods

The study was carried out in the Poultry Unit of the Department of Animal Health and Production, College of Veterinary Medicine Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. Sixteen layer chickens made up of indigenous (local) chicken and exotic chickens (Isa Brown, Black Australorp and White Leghorn) (4 layers per strain) sourced at the point of lay (18 weeks of age) from poultry farms in southern Nigeria were used for this study. The birds (chickens) were acclimatized for three weeks before the commencement of this study. The birds were fed twice daily with commercial layers mash (Livestock Feeds®, Livestock Feed Mills Plc, Onitsha, Nigeria) throughout the period of the study. The declared nutrient content of the layers mash used for feeding the experimental birds was:

protein (16.5% minimum), fats (5.0% maximum), fibre (7.0% maximum), calcium (3.6% minimum), phosphorus (0.45% minimum), metabolizable energy (2600 Kcal/kg minimum), and essential amino acids such as lysine and methionine, brewers dried grains, rice bran, vitamins/mineral premix, groundnut cake, full fat soya, toxin binder, bone meal and other additives (enzymes). Clean drinking water was provided *ad libitum* throughout the period of the study. Ethical approval for this study was obtained from the Ethical Committee of College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Nigeria (MOUAU/CVM/REC/202216).

Appropriate routine prophylactic medications were given to the birds, as and at when due or when necessary to ensure optimal health during the experimental period.

Fifty six eggs (14 eggs from each of the 4 strains of chicken) produced by indigenous (local) chicken and exotic chickens (Isa Brown, Black Australorp and White Leghorn) were used for this study. The eggs were collected fresh from the chickens at 21 weeks of age. The fourteen (14) eggs from each group of the strains of chicken were randomly collected daily (in the morning and evening) and individually identified with tag letters as follows: $A_{1\text{-}14}$ for Isa Brown, $B_{1\text{-}14}$ for Black Australorp, $C_{1\text{-}14}$ for White Leghorn and $D_{1\text{-}14}$ for local chicken eggs. Each egg was gently and carefully broken, and the albumen and yolk of each egg was thoroughly mixed together, homogenized and analyzed immediately for their proximate compositions (AOAC, 2005), triacylglycerols (TAG) (Rifai *et al.,* 1999), high density lipoprotein cholesterol (HDL-C) (Rifai and Warnick, 1994) and glucose (Sacks, 1999). Atherogenic index (Aix) was calculated using the formula: Atherogenic index (Aix) = log (TAG/HDL-C) (Dobiasova and Frohlich, 2001; Tan *et al.,* 2004; Nwagha *et al.,* 2010; Kanthe *et al.,* 2012; Mudhaffar, 2013).

Data Analysis: Data obtained during the study were subjected to one way analysis of variance (ANOVA), using the Statistical Package for Social Sciences (SPSS), version 20.0 (SPSS, 2012). Variant means were separated using Duncan's New Multiple Range Test (Steel and Torrie, 2006; SAS, 2010). Probability values < 0.05 were considered significant (Bailey, 1995).

Results

The mean moisture and total ash contents of the eggs of the Black Australorp chickens were significantly ($p < 0.05$) higher when compared to the eggs of other strains (Table 1). Similarly, the mean crude fat content of the eggs of the Black Australorp chickens was significantly ($p < 0.05$) lower when compared to the eggs of other strains of chickens (Table 1). The mean egg crude protein content of Isa Brown was significantly ($p < 0.05$) higher when compared to other chicken egg counterparts (Table 1).

The mean dry matter, carbohydrate and glucose concentrations of eggs laid by White Leghorn chickens were significantly ($p < 0.05$) higher when compared to those of eggs of other chicken strains (Figure 1), but the mean atherogenic index of the eggs laid by the local chickens was significantly ($p < 0.05$) lower than the atherogenic index of eggs laid by other strains of chicken studied (Figure 2).

Discussion

It is generally stated that foods with moisture content above 15% will favour microbial activities, which will possibly result in food spoilage (Hassan *et al.* 2008). Thus, since the moisture contents of all the eggs of the various species in this study exceeded 15%, this may imply that the eggs cannot be stored for a long period of time before use (2 weeks maximum). The findings in the present study differ from the results of the work of Isah *et al.* (2015) who reported higher moisture contents in eggs of ducks (*Anas platyhyncha*) and Shika Brown chickens, respectively. The moisture content recorded for eggs of Isa Brown, local chicken and Black Australorp in this study is nearly similar to the 73.20% reported for Jingbai hen by Yang *et al.* (2014), 74.60% for local chicken by Onyenweaku *et al.* (2018), but it is higher than 65.23% reported for Blue Peafowl by Yang *et al.* (2014) and 69.20% reported for exotic chicken by Onyenweaku *et al.* (2018).

The significantly higher crude protein composition of the egg of Isa brown layers compared to the eggs of other strains of chicken in this study could probably be as a result of a higher bio-availability of the nutrients in the chicken's body system for protein synthesis. However, our finding differ from the report of Isah *et al.* (2015) who reported lower egg crude protein compositions in ducks (*Anas platyhyncha*) and Shika Brown chickens. The crude protein contents of egg reported in this study was lower than the values of 15.55% reported for Blue Peafowl (Yang *et al.,* 2014), 15.20% reported for exotic chicken (Onyenweaku *et al.,* 2018) but higher than 12.60% reported for Jingbai hen (Yang *et al.,* 2014) and 12.70% reported for local chicken (Onyenweaku *et al.,* 2018). From this study, protein was the highest nutrient in the eggs. This is in accordance with most of the researches carried out on different eggs where the protein content is greater than the fat content (Ogunwole *et al.,* 2015). However, this contrasts with the report of Fakai *et al.* (2015) who reported that all the raw eggs of six species in their study had higher lipid contents than the protein. However, the observed variations may be attributed to the differences in the study design, analytical methods used, and species of the bird eggs analyzed and the diet compositions of the chickens. Findings in the present study and earlier reports confirm that eggs are a rich source of protein. Being a relatively inexpensive and accessible food, the benefits of consuming eggs of various bird species should be maximized especially by individuals of the lower economic class. This will help in reducing the incidence of protein malnutrition (which occurs as a result of insufficient protein intake) and facilitate proper development of neonates/children, as eggs have been found to contain all the essential amino acids required for growth and development.

Table 1. The mean moisture, total ash, crude fats and crude protein compositions of eggs laid by intensively reared local and exotic chickens (Black Australorp; White Leghorn and Isa Brown).

Parameters (%)	**Nutrient value of eggs from different strains of chicken ± SEM**			
	Black Australorp	**White Leghorn**	**Isa Brown**	**Local Chicken**
Moisture	75.45 ± 0.01 ^{d}	67.72 ± 0.00 ^{a}	73.43 ± 0.00 ^{c}	72.57 ± 0.00 ^{b}
Total ash	0.67 ± 0.01c^{d}	0.51 ± 0.00 ^{a}	0.63 ± 0.00 ^{b}	0.65 ± 0.01 ^{c}
Crude fats	0.49 ± 0.00 ^{a}	0.52 ± 0.00 ^{b}	0.53 ± 0.00 ^{c}	0.53 ± 0.01 ^{bc}
Crude Protein	14.47 ± 0.01 ^{c}	12.27 ± 0.00 ^{b}	14.90 ± 0.00 ^{d}	11.52 ± 0.00 ^{a}

$^{a\ b\ c\ d}$ Mean values in the same row with different superscripts are significantly different ($p < 0.05$).

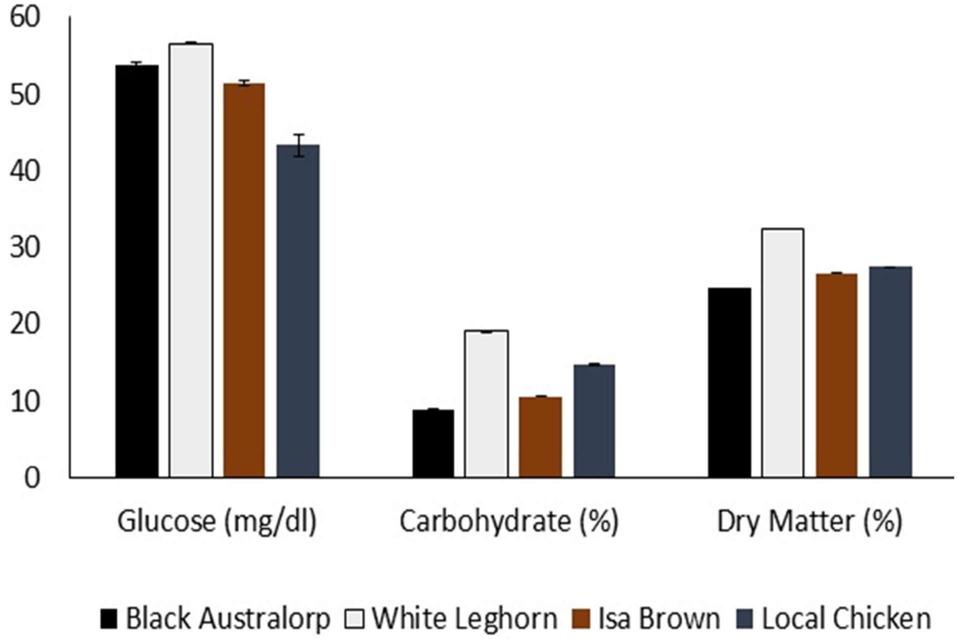

Figure 1: The glucose, carbohydrate and dry matter concentrations of eggs laid by intensively reared local and exotic chickens (Black Australorp, White Leghorn and Isa Brown). Values are expressed as means ± SEM.

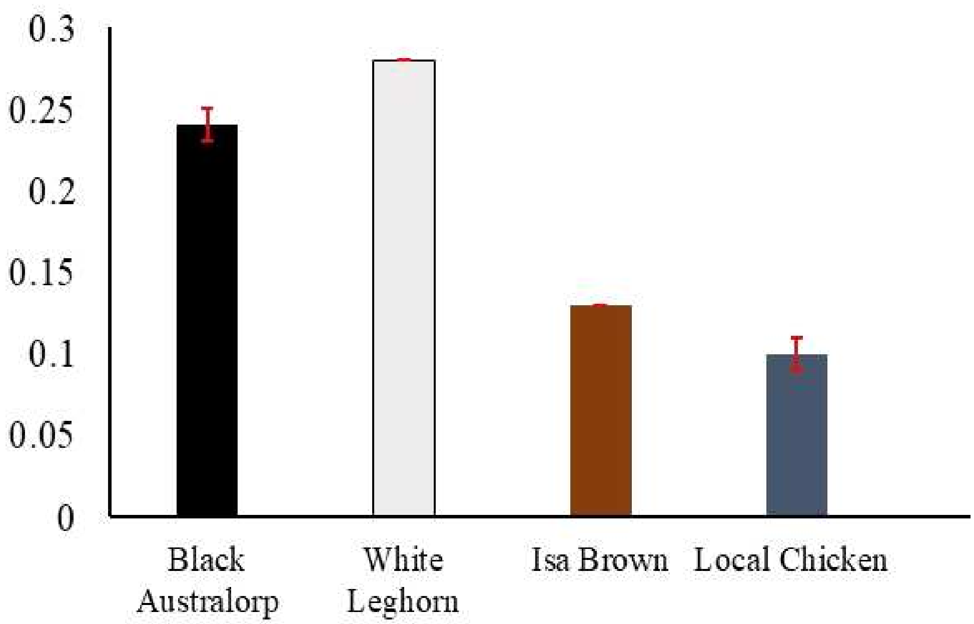

Figure 2: The atherogenic index of eggs laid by intensively reared local and exotic chickens (Black Australorp, White Leghorn and Isa Brown). Values are expressed as means ± SEM.

The significantly lower crude fat content of the eggs laid by the Black Australorp chickens in this study could probably be as a result of the lower fat content of the ingredients fed to BA pullets as the chickens were sourced from different farms and locations and fed with different feed ingredients before the commencement of this study (from day old - 18weeks). The crude fat contents of egg recorded in this study was far lower than the values of 12.30% reported for exotic chicken by Onyenweaku *et al.* (2018), 10.40% reported for local chicken by Onyenweaku *et al.* (2018), 10.50% reported for Jingbai hen by Yang *et al.* (2014), 0.92% reported for Blue Peafowl by Yang *et al.* (2014) and 10.73% reported for Shika brown chickens by Isah *et al.* (2015).

The crude ash contents of eggs recorded in this study was lower than the values of 1.60% and 1.10% reported respectively for exotic and local chickens by Onyenweaku *et al.* (2018). The difference between the crude ash content of the eggs in this study when compared to the work done by earlier researchers could probably be as a result differences in the breed/strain of birds chosen for the study, variations in the analytical procedures, climatic factors, management dichotomy, among others.

The carbohydrate concentrations recorded for the eggs in this study was lower than the values of 16.98% reported for Blue Peafowl by Yang *et al.* (2014), but was higher than 1.50% reported for Jingbai hen by Yang *et al.* (2014).

The atherogenic index of eggs recorded in this study was lower than the values of 0.78 reported for laying hens by Obasoyo and Omoikhoje (2021). The variations in the atherogenic index and nutritional profiles of eggs seen in this study when compared to the work of previous authors may be attributed to differences in feed ingredients and feeding frequencies, feed intake, genetic make-up, photo-period, strain of chickens and climatic factors, among other factors.

Conclusion: The results of this study showed that variations exist among the eggs of different strains of chicken in the nutritional value, atherogenic index and glucose concentrations. Eggs laid by Isa Brown layers had higher protein content while eggs laid by local chickens had the lowest atherogenic index.

Conflicts of Interest

The authors declare no conflict of interest.

References

Adebambo OA (2005). Indigenous poultry breeds genetic improvement for meat and egg. *Proceedings of 1st Nigerian International Poultry Summit*, pp. 1 – 8.

Ajayi FO (2010). Nigerian indigenous chicken: A valuable genetic resources for meat and egg production. *Asian Journal of Poultry Science*, 4: 164 – 172.

AOAC (Association of Official Analytical Chemists) (2005). Official Methods of Analysis, 5th edition, AOAC, VA, USA.

Bailey NT (1995). Statistical methods in biology. Cambridge University Press.

Chen Y, Chen-guang E and Liu M (2005). Comparison of the egg, dark egg, quail egg. *Feed Industry*, 26(7): 10 – 12.

Dobiasova M and Frohlich J (2001). The plasma parameter log (TAG/HDL-C) as an atherogenic index: correlation with lipoprotein particle size and esterification rate in apo B- lipoprotein –depleted plasma (FERHDL). *Clinical Biochemistry*, 34: 583 – 588.

Fakai IM, Sani I and Olalekan OS (2015). Proximate Composition and Cholesterol Content of Eggs Obtained from Various Bird Species. *Journal of Harmonized Research in Medical and Health Sciences*, 2: 18 – 25.

FAO (Food and Agriculture Organization) (2007). The Global plan of action for animal genetic resources and the Interlaken Declaration Commission on Genetic Resources for Food and Agriculture, Switzerland.

FAO (Food and Agriculture Organization) (2009). Status and trends report on animal genetic resources-2008. In: Information Document CGRFA/WG-ANGR-5/09/inf.7. Rome. Available at htt://www.fao.

Forson A, Ayivor JE, Banini GK, Nuviadenu C and Debrah SK (2011). Evaluation of some elemental variation in raw egg yolk and egg white of domestic chicken, guinea fowl and duck eggs. *Annals of Biological Research*, 2(6): 676 – 680.

Groeneveld LF, Lenstra JA, Edng H, Toro MA, Scherf B, Pilling D, Negrini R, Finlay EK, Jianlin H, Groeneveld E, Weigend S and Globaldiv C (2010). Genetic diversity in farm animals - A review. *Animal Genetics*, 41 (suppl. 1): 6 – 31.

Hassan L, Dangogo SM, Umar KJ, Saidu I and Folorunsho FA (2008). Proximate, mineral & antinutritional factors of Daniellia oliveri seed kernel. *ChemClass Journal*, 5: 31 – 36.

Huopalahti R, López FR, Anton M and Schade R (2007). Bioactive egg compounds. *Springerverlag Heidelberg*; 298.

Ikeobi COM, Hyginus CM, Adenowo JA and Adebambo OA (1999). Egg quality characteristics of four poultry species in Nigeria. *Tropical Journal of Animal Science*, 1(1): 37 – 42.

Isah MF, Ibrahim S and Oginni SO (2015). Proximate composition and cholesterol content of egg obtained from various bird species. *Journal of Harmonized Research in Medical and Health Sciences*, 2(2): 18 – 25.

Joel N, Udobi1 CE and Nuria A (2010). Effect of oven drying on the functional and nutritional properties of whole egg and its components. *African Journal of Food Science*, 4(5): 254 – 257.

Kabir M, Sulaiman RO, Idris RK, Abdu SB, Daudu OM, Yashim SM, Hassan MR, Adamu HY, Eche NM, Olugbemi TS and Adedibu II (2014). Effects of strain, age and the interrelationships between external and internal qualities of eggs in two strains of layer chickens in northern Guinea savannah zone of Nigeria. *Iranian Journal of Applied Animal Science*, 4(1): 179 – 184.

Kanthe PS, Patil BS, Bagali SH, Deshpande A, Shaikh G and Aithala M (2012). Atherogenic index as a Predictor of Cardiovascular Risk among women with Different Grades of Obesity. *IJCRIMPH*, 4(10): 1767 – 1774.

Mahdavi AH, Rahmani HR and Pourreza J (2005). Effect of probiotic supplements on egg quality and laying hen's performance. *International Journal of Poultry Science*, 4(7): 488 – 492.

Mudhaffar SK (2013). Atherogenic Index of Plasma (AIP) As a Parameter in Predicting Cardiovascular Risk in Males Compared To the Conventional Dyslipidemic Indices (Cholesterol Ratios). *Karbala Journal of Medicine*, 6(1): 1506 – 1513.

NRC (National Research Council) (1976). Fat content and composition of animal products. Printing and Publishing Office, National Academy of Science, Washington, DC.

Nwagha UI, Ikekpeazu EJ, Ejezie FE, Neboh EE and Maduka IC (2010). Atherogenic index of plasma as useful predictor of cardiovascular risk among postmenopausal women in Enugu, Nigeria. *African Health Sciences*, 10(3): 248 – 252.

Nys Y (2011). Improving the safety and quality of eggs and egg products. Woodhead Publishing Limited, UK.

Obasoyo DO and Omoikhoje SO (2021). Haematology, serum biochemistry and egg lipid profile of laying hens fed diets supplemented with *Moringa oleifera* and *Senna occidentalis* leaf meal composite mixture. *International Journal of Research and Scientific Innovation (IJRSI)*, 8(2): 9 – 16.

Ogunwole OA, Ojelade AY, Oyewo MO and Essien EA (2015). 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*, 5: 59 – 67.

Olusiyi JA, Igila TT, Yusuf HB, Jatutu SS and Ebule k (2020). Comparative analysis of egg quality parameters of Guinea fowl and local chickens in Benue and Taraba States. *Nigerian Society for Animal Production (NSAP) 45^th^ Annual Conference – Bauchi 2020 Book of Proceedings, page* 293 – 297.

Omede AA, Bhuiyan MM, Islam AF and Iji PA (2017). Physico-chemical properties of late-incubation egg amniotic fluid and a potential in ovo feed supplement. *Asian-Australas Journal of Animal Sciences,* 30: 1124 – 1134.

Onyenweaku EO, Ene-Obong HN, Williams IO and Nwaehujor CO (2018). Comparison of nutritional composition of bird egg varieties found in Southern Nigeria: A preliminary study. *Food and Nutrition Sciences*, 9: 868 – 879. https://doi.org/10.4236/fns.2018.97065.

Rahman MM, Faruque S, Islam MS, Islam MN and Rashid MA (2013). Comparison of growth performance and meat yield of Hilly Chicken under two Feeding Regimens. *The Agriculturists*, 11(2): 38 – 43.

Réhault-Godbert S, Guyot N and Nys Y (2019). The golden egg: nutritional value, bioactivities and emerging benefits for human health. *Nutrients*, 11: 684.

Rifai N and Warnick GR (1994). Laboratory Measurement of Lipids, Lipoproteins and Apolipoproteins, AACC Press. Washington, DC, USA.

Rifai N, Bachorik PS and Albers JJ (1999). Lipids, lipoproteins and apolipoproteins. In: Burtis CA, Ashwood ER, editors. *Tietz Textbook of Clinical Chemistry*. 3rd ed. Philadelphia: W.B Saunders Company, pp. 809 – 861.

Sacks DB (1999). Carbohydrates. In: Burtis CA, Ashwood ER, editors. *Tietz Textbook of Clinical Chemistry. 3rd ed. Philadelphia: W.B Saunders Company*; pp. 750 – 808.

Sauveur B (1988). Structure, composition et valeur nutritionnele de l´oeuf, 347-374; Qualité de l´oeuf, 377 – 433. In: Reproduction des volailles et production d´oeuf, INRA (eds), Paris.

Song, Ai-yi., Pang, Huan-ming, Li, Jin-yu, Zhu, Zheng-lan, Gulinazi, Wang and Zi-rong (2012). Study on the quality and nutrition of eggs of Hyline brown and Jingbai. *Xinjiang Agricultural Sciences*, 49(2): 330 – 335.

SAS (Statistical Analysis System) (2010). SAS User's Guide. SAS Institute, Cary, NY.

SPSS (Statistical Package for Social Sciences) (2012). International Business Machines Statistical Package for Social Sciences Statistics for Windows, Version 21.0. IBM Corp., Armonk, NY.

Steel RDG and Torrie JH (2006). Principles and Procedures of Statistics. 3rd. Edn. McGraw-Hill Book Co. Inc., New York.

Surai PF and Sparks NHC (2001). Designer egg: from improvement of egg composition to functional food. *Trends in Food Science and Technology*, 12: 7 – 16.

Tan MH, Johns D and Glazer NB (2004). Pioglitazone reduces atherogenic index of plasma in patients with type 2 diabetes. *Clinical Chemistry*, 50: 1184 – 1188.

Trziska T (2000). Processing of eggs. In: Egg Science, University of Agriculture in Wroclaw (Poland), pp. 291 – 401.

USDA (2014). The National Agricultural Statistics Service's Chicken and Eggs' Report, USDA.

Uysal RS, Boyacı İH, Soykut EA and Ertaş N (2017). Effects of heat treatment parameters on liquid whole egg proteins. *Food Chemistry*, 216: 201 – 208.

Vaclavik AV and Christain WE (2008). Essentials of Food Science, Springer Science Business Media, LLC New York, pp. 205 – 230.

Yang, Fu-min, Xu, Xiao-xia, Yang, Min, Qiang, Kai-xia and Wang, Xue-yan (2014). Comparison of Quality and Nutritional Components of Eggs from Blue Peafowl and Hen. *Journal of Food and Nutrition Research*, 2(4): 141 – 147.

Yousif IA and Eltayeb NM (2011). Performance of Sudanese native Dwarf and Bare Neck chicken raised under improved traditional production system. *Agricultural and Biological Journal of North America*, 2(5): 860 – 866.