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Egg quality traits of some selected indigenous poultry species in Nigeria

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ABSTRACT: Egg quality traits are so important for both consumers and for developing new chicks, hence, this research investigated the egg quality traits of four indigenous poultry species (Guinea fowl, Turkey, Duck and Chicken). Forty-eight eggs (12 eggs from each species) were used for this experiment, each treatment was replicated three times, and each egg was assessed separately for its internal and external egg quality traits. T1 represents eggs from guinea fowl, T2 stands for eggs obtained from Turkey, T3 represents duck eggs, and T4 was collected from chicken. All data were subjected to one-way analysis of variance (ANOVA) using a completely randomized design (CRD) of the SPSS version 25 statistical package. The result of the external egg quality revealed that there were significant differences ($p<0.05$) in all the parameters investigated. It was observed that eggs obtained from Indigenous turkey (T2) had the highest egg weight and egg length values of 73.00 g and 6.33 cm respectively. The analysis also showed that eggs from indigenous guinea fowl (T1) had the highest ($p<0.05$) shell thickness value of 0.45 mm, while the lowest shell thickness value of 0.23 mm was observed in eggs obtained from indigenous chicken (T4). Analysis of the internal quality traits showed that eggs from indigenous ducks (T3) had the highest yolk weight value of 24.80 g which was significantly different ($p<0.05$) from the yolk weight values of other indigenous poultry species. Eggs obtained from guinea fowl (T1) and duck (T3) had the highest ($p<0.05$) yolk colour value of 11.30. The albumen height and weight were observed to be highest ($p<0.05$) in eggs obtained from Indigenous Turkey (T2) with values of 0.82 cm and 37.40 g respectively. It could be concluded that the indigenous Turkey eggs (T2) had high values for most of the egg quality parameters studied, which could have been responsible for its higher egg weight.

Keywords: Acceptability, consumer, external quality, internal quality, Indigenous species.

INTRODUCTION

The poultry business is a versatile business in Nigeria (Adebambo *et al.,* 1999) and it is one area of animal production with a significant contribution to human food production in egg and meat. Poultry products provide protein of high biological value (Eduvie, 2002). Nigeria is endowed with many poultry species which are indigenous to the country including the domestic fowl, pheasant, quail, guinea fowl, pigeon, Turkey, goose and Muscovy ducks (Oluyemi and Roberts, 2007).

Local poultry species play an important role in food security and income generation for poverty alleviation in Nigeria. Generally, poultry species are considered movable poor man's banks because of the ease of management of village poultry species and their short reproductive cycles (Markos *et al.,* 2014). Consumers usually prefer products of local chicken to exotic ones because of their flavour, taste and nutrition (Yemane *et al.,* 2013). In spite of their significant roles, their low performances masked their potential to uplift the living standards of their owners and contribute to rural developments in Nigeria. This has been attributed to their low genetic potential, limited feed resources and limited skill management practices (Yemane *et al.,* 2013).

Eggs from birds such as chickens, ducks, geese and quails are the most common and versatile food items since the prehistoric period (Song *et al.,* 2000). The egg is

inexpensive and well-balanced food source of high-quality nutrients among many nations of the world (Xu *et al*., 2018). Currently, considering the global level, it is one of the fastest-growing animal industries (The Poultry Site, 2015). Chicken egg is the almost expulsive egg industry in the world and information on eggs is mostly limited to chicken eggs (Song *et al.,* 2000). However, non-hen eggs such as duck, goose, turkey, guinea fowl and quail eggs are produced for human consumption in some parts of the world (Dudusola, 2010). Usually, eggs are marketed as shelled eggs. However, in recent decades the egg-processing industry has grown and, there is considerable demand for hen egg products (Linden and Lorient, 1999). Global egg production has increased during the past few years (Food and Agricultural Organization Statistics (FAOSTAT, 2015). However, more than 90% of global egg production comprises hen eggs and only the remaining percent is from non-hen eggs.

Egg quality traits are egg's characteristics that affect its acceptability by the consumer. It has a great effect on poultry breeding due to their influence on production performance, breeding performance and growth of the chicks (Islam *et al*. 2001; Roberts, 2004; Duan *et al*.,2018; Sheng *et al*., 2018). The quality of an egg is influenced by many factors such as; the divergent process of evolution, breed, strain, variety, age, body weight, temperature, relative humidity, rearing practices and seasons (Roberts, 2004; Nwachukwu *et al*., 2006; Silversides *et al*., 2006; Wolanski *et al*., 2007). External egg quality is presented by its weight, shape, percentage of eggshell and thickness, while Internal egg quality is presented by albumen and yolk quality. In practice, egg weight is generally considered the indicator for uniformity of the shell's physical properties and the internal standard of the egg (Hrnčár *et al.,* 2016). Greater awareness of the factors affecting internal and external egg quality also allows egg producers to monitor eggs and optimize egg quality (Roberts, 2004).

However, the information on egg characteristics has been limited mostly to chicken In Nigeria, more emphasis is laid on the production and importance of domestic fowl to the neglect of other classes of poultry species like the pheasant, quail, guinea fowl, pigeon, turkey, goose and Muscovy ducks (Elango and Mahendrarasa, 2013). Hence, this experiment was conducted to investigate the internal and external egg quality traits of different indigenous poultry species including (guinea fowl, turkey, duck and chicken), with the view of identifying the species with outstanding egg quality traits.

MATERIALS AND METHODS

Source of experimental eggs

Freshly laid eggs from four indigenous poultry species (guinea fowl, duck, turkey and chicken) of the same age range (38 – 40 weeks old), raised under the semi-intensive system of management were obtained from Elshadai Farm, Ifewara, in Atakunosa West Local Government of Osun State. The farm is located in southwestern Nigeria, where the climate is influenced by the rain-bearing Southwest monsoon winds from the Atlantic Ocean and dry Northeast trade wind from the Sahara Desert. The rainy season lasts for about seven months with about 1524 mm of rainfall per annum. The atmospheric temperature ranges between 26 and 31°C, with a mean annual relative humidity of about 80% (Climatic Data, 2018).

Experimental laboratory

The egg quality traits determination was carried out at the Food Science and Technology Laboratory, Rufus Giwa Polytechnic Owo, Ondo State, Nigeria.

Experimental layout

A total of forty-eight (48) eggs (twelve eggs from each species) were used for this experiment. The experimental eggs were divided into four treatments, T1 was eggs obtained from guinea fowl, T2 stands for eggs from Turkey, T3 represents eggs from duck, and T4 was eggs from chicken. Each treatment was replicated three times, with four eggs per replicate. 12 Eggs from each treatment were labelled and stored under refrigerated conditions (10^{o}C) on plastic egg trays for three weeks and the quality parameters were measured within 3 weeks of storage. Each egg was assessed separately for its internal and external egg quality traits.

Data collection

Egg trait determination

Twelve (12) eggs were randomly selected from each species (each species represents a treatment) and replicated three times. The external egg qualities were assessed (egg weight, length, width, shape index, shell weight and thickness) after which the eggs were carefully broken and emptied into Petri dishes to evaluate the internal egg traits: yolk height, yolk diameter and weight, albumen height and weight.

The egg weight was measured using a sensitive electric weighing balance to the nearest 0.01 g. The egg length was determined by using the vernier calliper. The caliper was placed at the narrow and broad end of the egg and held firmly, but not too tight to prevent cracking of the egg. The Egg width was determined by the use of the vernier calliper, the instrument was placed at the equatorial plane of the egg and held firmly around the egg. The dimension

Table 1. External quality traits of eggs obtained from indigenous guinea fowl, turkey, duck and chicken.

Parameters	T1	T2	T3	T4	SEM	p- value
Egg Weight (g)	42.70^{d}	73.00^{a}	64.10^{b}	53.30^{c}	3.49	0.00
Egg Length (cm)	4.80^{b}	6.33^{a}	5.98^{a}	5.83^{a}	0.19	0.00
Egg Width (cm)	3.91^{b}	4.56^{a}	4.39^{a}	4.12^{ab}	0.09	0.00
Egg Shape index (ESI)	82.00^{a}	72.00^{b}	73.00^{b}	71.00^{b}	0.02	0.00
Shell weight (g)	6.87^{b}	6.67^{b}	7.47^{a}	4.47^{c}	0.35	0.00
Shell Thickness(mm)	0.45^{a}	0.39^{a}	0.40^{a}	0.23^{b}	0.26	0.00

a, b, ab, c, d = Means on the same column for each factor and their interactions, but with different superscripts are statistically (P<0.05) significant; T1 = Eggs obtained from indigenous guinea fowl; T2 = Eggs collected from indigenous Turkey; T3 = Eggs collected from indigenous duck; T4 = Eggs obtained from indigenous chicken; SEM= Standard Error of Mean.

was read off in centimetres. The shape index was calculated by dividing the egg width with the egg length (Anderson, 2004).

$$\text{Shape index} = \frac{\text{egg width}}{\text{egg length}} \text{x } 100$$

After weighing and determining the egg length and width, the eggs were broken out on a flat non-absorbent surface and the thick albumen height was measured at its thickest part using an improvised broomstick. The Albumen weight (gram) was determined by separating the albumen from the yolk and was weighed on a scale and the weight was read in grams.

The internal egg membranes were pulled off the shells immediately after being broken. The shell thickness was determined by taking the thickness of the egg shell at three different places (the narrow end, the broad end and the side) by using a micrometre screw gauge calibrated in millimetres. The average of the three values was then recorded.

Yolk height (cm) was determined with the use of an improvised broomstick by inserting the broomstick gently into the yolk till it got to the end of the non-absorbent, and the height was read off in cm on a ruler. Yolk width (cm) was determined by placing a Vernier calliper at both edges of the yolk and the diameter read as yolk width.

The yolk index was calculated by dividing the yolk height by the yolk width (Funk, 1948; Eke *et al*., 2013).

Y. I = Height of yolk ÷ Width of yolk

Yolk colour was determined by visual observation of the yolk colour and its comparison was done using the Roche yolk colour fan.

Statistical analysis

All data were subjected to a one-way analysis of variance (ANOVA) (Steel and Torrie,1980) in a completely randomized design (CRD) of the SPSS version 25 statistical package. Differences between treatment means were compared using Duncan's multiple range Test (Duncan, 1955).

RESULTS

External quality traits of eggs obtained from Indigenous poultry species

Table 1 shows the external qualities of eggs obtained from indigenous guinea fowl, turkey, duck and chicken. The result revealed that there were significant differences ($p<0.05$) in all the external quality traits investigated. It was observed that eggs obtained from turkey (T2) had the highest egg weight and egg length values of 73.00 g and 6.33 cm, respectively. However, eggs from indigenous guinea fowl (TI) were observed to have significantly lowest egg weight and egg length values of 42.7 g and 4.80 cm, respectively. The remaining three other species (Turkey, duck and chicken) recorded higher ($p<0.05$) egg weight and length. The result also showed that eggs from Indigenous turkey (T2) and duck (T3) were statistically similar in their egg width values (4.56 cm and 4.39 cm, respectively) when compared with the egg width of guinea fowl. Eggs obtained from indigenous duck (T3) had significantly ($p<0.05$) the highest shell weight value of 7.47 g, while eggs from indigenous chicken (T4) had the lowest shell weight value of 4.47 g. Statistical variation ($p<0.05$) was also observed in the shell thickness across treatments, with eggs obtained from indigenous chicken (T4) having the lowest ($p<0.05$) value of 0.23 mm. The remaining three species (Guinea fowl, Turkey and Duck) had similar shell thickness values which are significantly ($p<0.05$) higher than that of chickens.

Internal quality traits of eggs obtained from Indigenous poultry species

Table 2 revealed the internal quality traits of eggs obtained from indigenous s guinea fowl, turkey, duck, and chicken.

Table 2. Internal quality traits of eggs obtained from indigenous Guinea fowl, Turkey, duck and chicken.

Parameters	T1	T2	T3	T4	SEM	P value
Yolk Weight(g)	14.00^{d}	23.50^{b}	24.80^{a}	19.10^{c}	1.27	0.00
Yolk Width(cm)	3.82^{c}	4.65^{a}	4.31^{b}	4.27^{b}	0.09	0.00
Yolk Height(cm)	1.64	1.67	1.57	1.50	0.03	0.07
Yolk Color	11.30^{a}	9.83^{b}	11.30^{a}	4.33^{c}	0.87	0.00
Yolk Index	0.43^{a}	0.35^{b}	0.37^{ab}	0.35^{b}	0.01	0.00
Albumen Width(cm)	4.69^{d}	6.09^{b}	6.46^{a}	5.11^{c}	0.22	0.00
Albumen Height(cm)	0.47^{c}	0.82^{a}	0.81^{a}	0.60^{b}	0.45	0.00
Albumen Weight(g)	20.30^{d}	37.40^{a}	33.40^{b}	26.70^{c}	1.97	0.00
SMW(g)	1.00^{b}	1.20^{a}	1.27^{a}	0.50^{c}	0.09	0.00

a, b, ab, c, d = Means on the same column for each factor and their interactions, but with different superscripts are statistically (P<0.05) significant; T1 = Eggs obtained from indigenous guinea fowl; T2 = Eggs collected from indigenous Turkey; T3 = Eggs collected from indigenous duck; T4 = Eggs obtained from indigenous chicken; SMW = Shell Membrane Weight.

The result showed that there were significant differences ($p<0.05$) in all the parameters investigated except for yolk height. It was observed that eggs from indigenous ducks (T3) had the highest yolk weight value of 24.8 g, which was different ($p<0.05$) from the yolk weight values of eggs from other indigenous poultry species. Eggs from indigenous guinea fowl (T1) had the lowest yolk weight value of 14.00 g. Eggs from guinea fowl (T1) and duck (T3) had significantly ($p<0.05$) highest yolk colour values of 11.30, while the lowest yolk colour value of 4.33 was observed in eggs from indigenous chicken (T4). The albumin height was highest ($p<0.05$) in eggs from Indigenous turkey (T2) and duck (T3) with the value of 0.82 mm and 0.81 mm respectively. Eggs from guinea fowl (T1) were observed to have the lowest albumen height and weight values. The analysis also showed that eggs obtained from Turkey (T2) and duck (T3) were not significantly different ($p>0.05$) from one another in shell membrane weight, with the highest values of 1.20 g and 1.27 g, respectively. Eggs from indigenous chicken (T4) had the lowest value of 0.50 g.

DISCUSSION

Egg quality is composed of those characteristics of an egg that affect its acceptability to consumers such as cleanliness, freshness egg weight, shell quality, yolk index etc (Song *et al.,* 2000). The result of the external egg quality traits revealed that there were significant differences in all the external quality trait parameters investigated, this is consistent with the findings of Nuhu *et al.* (2018), who observed significant differences in external egg quality parameters of six species of poultry under extensive management system in Nigerian Savanna. The result shows that eggs obtained from turkey (T2) had the highest egg weight and egg length values, while the lowest weight value was recorded in chicken (T4), this agrees with the finding of Orville *et al*. (2020) who reported significant high egg weight value in Turkey while comparing the egg quality traits in different poultry species and breeds. Hristakieva *et al.* (2017) also found that the weights of Turkey eggs obtained from 34 and 46 weeks were 82.04±0.76 g and 84.22±0.78g respectively, while the lowest weight was recorded in indigenous hens. The scholars have indicated that the low egg weight was due to the low body weights of the indigenous hens (Zita *et al.*, 2009; Elango and Mahendrarasa, 2013; Hristakieva *et al*., 2017).

This study also revealed that eggs from turkey, duck and guinea fowl had significantly high shell thickness values, while the lowest value was recorded in chicken. This result aligned with the work of Wijedasa *et al.* (2020) who reported significantly higher duck and turkey egg shell thickness values than that of indigenous chicken and quail. Okruszek *et al.* (2006) also reported shell thickness values of two different breeds of ducks as 0.67 mm and 0.65 mm. According to the nutritional composition analysis of Jalaludeen and Churchil (2006), it was revealed that turkey egg contains 99 mg of Ca and duck egg contains 64 mg of Ca in 100 g of eggshell respectively. Further, they stated that the egg shells of ducks are very hard and not easily broken while handling, and though the pore sizes of the duck eggs are large, they are covered with protective mucus covering which prevents entry of microorganisms.

The shape index of a standard poultry egg is 74%. Furthermore, researchers have indicated that the shape index value of eggs from 9, 25 and 31 weeks age bird were 79.00, 79.00 and 79.10, respectively (Song *et al*., 2000; Dudusola, 2010). The shape index obtained in this study (71.00 - 82.00) fell within the normal range of poultry egg shape index, T1 (guinea fowl) was observed to have the highest egg shape index, while the lowest values were recorded in T4 (chicken). The observed high shape index value in T1 indicates better uniformity of the eggs, which is important for good hatchability and healthy chick production. Variations of shape index among different

species might be due to their genetic differences and differences in management systems.

The range of values obtained in this study for all the external egg parameters in all species investigated is within the range found in published literature (Bernacki *et al.,* 2012; Etuk *et al.,* 2012; Vekić *et al.,* 2019). The variation in the external egg quality parameters among species could be attributed to the differences in their genetic makeup (Isidahomen *et al.,* 2014), season (Benoit *et al.,* 2014), storage (Hristakieva *et al.,* 2011), and production system (Etuk *et al.,* 2012).

Internal egg quality owes it importance, both from nutritional aspects as well as hatchability. The result of the internal egg quality traits showed that there were significant differences in all the parameters investigated. The integrity of the egg yolk depends on the strength of its vitelline membrane (Zita *et al.,* 2009; Eke *et al*., 2013). Egg yolk quality depends on many factors such as the age of the bird, storage time, breed of the bird, variation of bird strain, and nutritional quality (Song *et al*., 2000; 2005; Zita *et al*., 2009). It was observed that eggs from indigenous duck (T3) had the highest yolk weight value, which was statistically different from the yolk weight values of eggs from other indigenous poultry strains investigated. Eggs from indigenous guinea fowl (T1) had the lowest yolk weight value. The high yolk weight recorded in duck is of relevance to health-conscious consumers and this could be attributed to the reason why duck eggs are traditionally preferred over chicken or quail eggs in the processing of salted eggs. Loetscher *et al*. (2013) reported that yolk colour is an important quality trait that affects consumer's perception of quality and their purchase decision. Eggs from guinea fowl (T1) and duck (T3) had significantly ($p<0.05$) the highest yolk colour, while the lowest yolk colour was observed in eggs from indigenous chicken (T4). Albumen contributes approximately 60% of egg weight and thus has a major influence on the internal quality of the egg. The albumen index is an indicator of the firmness and viscosity of albumen which is considered an important factor in the quality of eggs. The albumin height and weight were significantly highest in eggs from indigenous Turkey (T2). Eggs from guinea fowl (T1) were observed to have the lowest albumen height and weight values. The analysis also showed that eggs obtained from guinea fowl (T1), Turkey (T2) and duck (T3) were not significantly different from one another in shell membrane weight. Eggs from indigenous chicken (T4) had the lowest value.

Conclusion

This study revealed significant differences in all the external and internal egg quality parameters investigated, these differences could be attributed to the differences in the genetic makeup of various poultry strains. It was also observed that the eggs from the four poultry strains investigated have acceptable external and internal egg quality traits as the values obtained are within the normal range for each strain. However, indigenous turkey eggs (T2) had high values for most of the egg quality parameters studied, which could have been responsible for their higher egg weight.

CONFLICT OF INTEREST

The authors declare that they have no competing interest.

REFERENCES

Adebambo, O., Ikeobi, C. N., Adenowo, J. A., & Osinowo, O. A. (1999). Colour variations and performance characteristics of the indigenous chicken of South Western Nigeria. *Nigerian Journal of Animal Production*, *26*, 15-22.

Anderson, K. E., Tharrington, J. B., Curtis, P. A., & Jones, F. T. (2004). Shell characteristics of eggs from historic strains of single comb white leghorn chickens and the relationship of egg shape to shell strength. *International journal of poultry science*, *3*(1), 17-19.

Bernacki, Z., Kokoszynski, D., & Bawej, M. (2013). Laying performance, egg quality and hatching results in two guinea fowl genotypes. *Archiv fur Geflugelkunde*, *77*(2), 109-115.

Duan, X., Li, M., Shao, J., Chen, H., Xu, X., Jin, Z., & Liu, X. (2018). Effect of oxidative modification on structural and foaming properties of egg white protein. *Food Hydrocolloids*, *75*, 223-228.

Dudusola, I. O. (2010). Comparative evaluation of internal and external qualities of eggs from quail and guinea fowl. *International Research Journal of Plant Science, 1*(5), 112-115.

Duncan, D. B. (1955). Multiple range and multiple F tests. biometrics, 11(1), 1-42.

Eduvie, L. O. (2002, September). Poultry production as an important component of Nigeria's Livestock Subsector. In *A training manual on National Training Workshop on Poultry Production in Nigeria in Napri, ABU, Shika, Zaria, Nigeria*.

Eke, M. O., Olaitan, N. I., & Ochefu, J. H. (2013). Effect of storage conditions on the quality attributes of shell (Table) Eggs. *Nigerian Food Journal, 31*(2), 18-24.

Elango, S., & Mahendrarasa, R. (2013). Comparative analysis of the egg quality traits in different chicken genotypes in the dry zone of Sri Lanka (pp. 86-91). In *Proceedings of the 3rd International Symposium, South Eastern University of Sri Lanka, Oluvil, Sri Lanka*. Pp. 86-91.

Etuk, I. F., Ojewola, G. S., Abasiekong, S. F., Amaefule, K. U., & Etuk, E. B. (2012). Egg quality of Muscovy ducks reared under different management systems in the humid tropics. *Revista Científica UDO Agrícola*, *12*(1), 226-229.

FAOSTAT (2015). *Food and Agriculture Organization of United Nations Production Data*. Retrieved from http://faostat.fao.org/site/291/default.aspx

Funk, E. M. (1948). The relation of the yolk index determined in natural position to the yolk index as determined after separating the yolk from the albumen. *Poultry Science*, *27*(3), 367.

Hristakieva, P., Oblakova, M., Mincheva, N., Lalev, M., &

Kaliasheva, K. (2017). Phenotypic correlations between the egg weight, shape of egg, shell thickness, weight loss and hatchling weight of turkeys. *Slovak Journal of Animal Science, 50*(2), 90-94.

Hrnčár, C., Biesiada-Drzazga., B., Nikolova, N., Hanusová, E., Hanus A., & Bujko, J. (2016). Comparative analysis of the external and internal egg quality in different pure chicken breeds. *Acta Fytotechn Zootechny*, *9* 123-127.

Isidahomen, C. E., Njidda, A. A., & Adeniji, A. A. (2014). The effects of genotype on internal and external egg quality traits, egg proximate composition and lipid profile characteristics of three Strains of layer turkeys. *International Journal of Agriculture and Bioscience, 3*(2), 65-69.

Islam, M. A., Bulbul, S. M., Seeland, G., & Islam, A. B. M. M. (2001). Egg quality of different chicken genotypes in summer and winter. *Pakistan Journal of Biological Sciences*, *4*(11), 1411-1414.

Jalaludeen, A., & Churchil, R. R. (2006). Duck eggs and their nutritive value. *Poultryline, 10*, 35-39.

Linden, G., & Lorient, D. (1999). *New ingredients in food processing: Biochemistry and agriculture*. Woodhead Publishing Ltd., Abington, Cambridge, UK.

Loetscher, Y., Kreuzer, M., & Messikommer, R. E. (2013). Utility of nettle (*Urtica dioica*) in layer diets as a natural yellow colorant for egg yolk. *Animal Feed Science and Technology*, *186*(3-4), 158-168.

Markos, S., Belay, B., & Dessie, T. (2014). Village Chicken Production Constraints and Opportunities in Western Zone of Tigray, Northern Ethiopia. *Journal of Biolology, Agriculture and Healthcare*, *4*(27), 232-245.

Nuhu, B. T., Adelanwa, M. A., Hassan, M. R., & Duru, S. (2018). Egg quality parameters and blood biochemical profile of six strains of poultry under extensive management system in Nigerian savanna. *Nigerian Journal of Animal Science*, *20*(1), 72-80.

Nwachukwu, E. N., Ibe, S. N., & Ejekwu, K. (2006). Short term egg production and egg quality characteristics of main and reciprocal crossbred normal local, naked neck and frizzle chicken× exotic broiler breeder stock in a humid tropical environment. *Journal of Animal and Veterinary Advances*, *5*(7), 547-551

Okruszek, A., Książkiewicz, J., Wołoszyn, J., Kisiel, T., Orkusz, A., & Biernat. J. (2006). Effect of laying period and duck origin on egg characteristics. *Archives Animal Breeding, 49*(4), 400-410.

Oluyemi, J. A., & Roberts, F. A. (2007). Poultry production in warm wet climates. Revised edition printed by Golden Wallet Press, Ibadan.

Orville, L., Bondoc P., Aldrin, O., & Ebron, B. S. (2020). Comparison of egg quality traits in different poultry species and breeds. *Philippine Journal of Veterinary Medicine*, *57*(2), 220-235.

Roberts, J. R. (2004). Factors affecting egg internal quality and egg shell quality in laying hens. *The Journal of Poultry Science*, *41*(3), 161-177.

Sheng, L., Huang, M., Wang, J., Xu, Q., Hammad, H. H. M., & Ma, M. (2018). A study of storage impact on ovalbumin structure of chicken egg. *Journal of Food Engineering*, *219*, 1-7.

Silversides, F. G., Korver, D. R., & Budgell, K. L. (2006). Effect of strain of layer and age at photostimulation on egg production, egg quality, and bone strength. *Poultry Science*, *85*(7), 1136-1144.

Song, K. T., Choi, S. H., & Oh, H. R. (2000). A comparison of egg quality of pheasant, chukar, quail and guinea fowl. *Asian-Australasian Journal of Animal Sciences*, *13*(7), 986-990.

Steel, R. G. D., & Torrie, J. H. (1980). *Principles and procedures of statistics: A biometrical approach*. 2nd Edition, McGraw Hill Book Co., New York, USA., p. 633.

The Poultry Site (2015). *Global poultry trends—Strong Growth in Egg Output Recorded in Africa and Oceania*. Retrieved from http://www.thepoultrysite.com/articles/3488/global-poultry-trends-strong-growth-in-egg-out put-recorded-in-africa-and-oceania.

Vekić, M., Savić, Đ., & Cvijanović, D. (2019). Changes of selected egg quality traits depending on the laying period of semi-intensively raised Guinea fowl hens. *Agro-knowledge Journal*, *20*(3), 141-149.

Wijedasa, W. M. R. M., Wickramasinghe, Y. H. S. T., Vidanarachchi J. K., & Himal, S. M. C. (2020). Comparison of egg quality characteristics of different poultry species. *Journal of Agricultural Science*, *12*(11), 331-342.

Wolanski, N. J., Renema, R. A., Robinson, F. E., Carney, V. L., & Fancher, B. I. (2007). Relationships among egg characteristics, chick measurements, and early growth traits in ten broiler breeder strains. *Poultry Science*, *86*(8), 1784-1792.

Xu, L., Jia, F., Luo, C., Yu, Q., Dai, R., & Li, X. (2018). Unravelling proteome changes of chicken egg whites under carbon dioxide modified atmosphere packaging. *Food Chemistry*, *239*, 657-663.

Yemane, N., Tamir, B., & Belihu, K. (2013). Characterization of village chicken production performance under scavenging system in Halaba district of southern Ethiopia. *Ethiopian Veterinary Journal*, *17*(1), 68-80.

Zita, L., Tůmová, E., & Štolc, L. (2009). Effects of genotype, age and their interaction on egg quality in brown-egg laying hens. *Acta Veterinaria Brno*, *78*(1), 85-91.