*Nigerian J. Anim. Sci. 2018, 20 (2): 222-231*

# Evaluation of Commercial Layer Feeds and their Impact on Performance and Egg Quality

**Akinola, L.A F.*[1] and Ekine, O.A.[1]**

[1]*Department of Animal Science, Faculty of Agriculture, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Rivers State, Nigeria*

***Corresponding Author:** letorn.akinola@uniport.edu.ng / lafakinola@gmail*

**Target Audience:** Animal Scientists, Lecturers, Poultry Farmers, Animal Nutritionists

## Abstract

*One hundred and eight (108) ISA brown hens at 34 weeks of age were used for this study which lasted for 12 weeks. The hens were randomly assigned to three dietary treatments ($FT_{1,}$ $FT_2$ and $FT_3$) consisting of four replicates each with nine (9) hens per replicate in a completely randomized design. Three commonly available commercial layers feed were purchased from a sales outfit and were designated as $FT_{1,}$ $FT_2$ and $FT_{3.}$ Each of the three feeds were analysed for calcium, phosphorus and proximate composition. The hen day production (HDP), feed intake, number of eggs produced, feed conversion ratio, feed cost and mortality were recorded/calculated. The egg quality was obtained from samples of three eggs collected from each of the replicate at the end of the study. The results showed that there were significant ($P < 0.05$) differences in the analyzed moisture and ash content of the feed, and in the declared and analyzed values of the crude fibre, metabolizable energy, ME, calcium (Ca) and phosphorus (P) while the crude protein and fat did not differ. The crude fibre content indicated for all the feeds were significantly ($P < 0.05$) lower than the analyzed content while the declared ME, Ca and P were significantly higher than the analyzed values except for the ME in $FT_3$. The feeds ($FT_1$ and $FT_2$) with the determined high crude fibre content had significantly ($P<0.05$) better HDP, number of eggs laid per hen, feed conversion ratio and cost of feed per dozen egg. The feed intake of the hens fed the $FT_1$ and $FT_2$ were significantly ($P < 0.05$) higher than the $FT_3$ but did not have any negative effect on the cost of feed per dozen eggs. The egg quality parameters examined showed that the $FT_3$ feed produced significantly ($P<0.05$) higher weight of eggs, yolk and weight of the albumen while the other quality indices showed no differences. The study clearly showed the feed manufacturer's strategy of sustaining their businesses with high fibre content, which still ensures that feed users produce reasonable quantity of eggs. It was concluded that while all the three commercial feeds were useful in the absence of other quality layers' diets, the agencies concerned with feed regulation in Nigeria must ensure strict compliance with quality standards to enhance the farmers' confidence in commercial layer's feed and also boost egg production.*

***Keywords**: Commercial layers' feed, Egg production, Egg quality, Feed intake, Laying hens, Proximate analysis*

## Description of Problem

Poultry production is a major part of livestock production in the world. The meat and eggs obtained from poultry production provides a source of protein and other nutrients which are very essential for human development. Eggs had been described as a complete food for humans (1). Thus, the availability of good feed coupled with effective feeding programme is the basis for any successful livestock production (2). However, the feed required by the birds to produce this valuable food comes from different brands of commercial feed obtained from different feed producing companies. Report by (3) showed that farmers agreed that commercial feed is usually costly and do not have the desired quality as self-compounded feed. The farmers engaged in small and medium-sized poultry businesses normally feed the birds by simply using commercial diets that is expected to have a better balance of nutrients (4). This makes the farmers/poultry producers to select from the brands that are readily available in their area of operation. Each brand of feed tends to be composed of ingredients, which are slightly different from each other, purposely meant for different physiological stages and types of birds. Although each commercial feed contains protein, energy, minerals, and vitamins as indicated on the labels on the bags of the feed (4), the farmer would rather prefer the feed that would lead to maximum production and desirable profit. In achieving this, it is necessary to consider the cost, the brand name of the feed and the feed that would guarantee the desired balance needed in the supply of the requisite protein, energy and other nutrients for the particular class of bird to be fed. This is particularly important since the cost of feed represents up to 70% of the cost of production. Moreover, the nutritional value of the feed depends on the biochemical composition, digestibility and the presence or absence of anti-nutritional factors (5). The nutritive value of feed also depends on the age of the feed materials, the processing methods (6), seasonal variations and method of conservation (7). Thus, commercial feed must be analyzed from time to time to keep the farmers abreast of the composition of what they are feeding their birds, since some commercial feed manufacturers tend to be less cautious about meeting the required standard of the different feeds (8). Farmers may therefore choose the feed that would give them the least cost, while maintaining high production, so that the savings on feed can result in more profit. This study was therefore carried out to evaluate the composition of three commercial layers feed in Nigeria and their impact on the hen's performance and egg quality.

## Materials and Methods

**Experimental Location**: This study was carried out at the Poultry Unit of the University of Port Harcourt Teaching and Demonstration Farm, Port Harcourt. The Farm is located between longitude $6^0$55N to $7^0$10E and latitude $4^0$35N and $4^0$54N of the Greenwich meridian. The average low temperature during the study period (November to February) was 21 – $22^0$C while the highest was $26.5^0$ – $30^0$C with an annual rainfall of 2500mm.

**Experimental Birds, Diets and Management**: One hundred and eight (108), 34 weeks old ISA brown laying hens were used for the 12 weeks' study. The birds were collected from the Poultry Unit of the University Farm and randomly assigned to three treatments designated as $FT_1$, $FT_2$ and $FT_3$ with four replicates of nine (9) hens each. Three types of commercial layer feed commonly sold in the area were purchased (within the week when they were supplied) from a sales outlet and served in each of the treatment. The birds were arranged in a completely randomized design.

**Proximate analysis of the experimental diets**

Feed samples were collected and subjected to proximate analysis using the method of (9). The moisture content, ash, crude protein (CP), fat, crude fibre (CF) and energy were analyzed and compared to the values stated on the bag labels. Bomb calorimeter was used in the determination of the energy content of the feed. The calcium (Ca) and phosphorus (P) content of the feeds were also analyzed using the atomic absorption spectrophotometer, model ZA-3300 according to the method described by (10,11). Each hen was fed with 150g of feed per day (fed in the morning and evening), water was given *ad libitum* while all other routine management procedures were observed.

**Data collection**: Records of the feed purchased, feed intake and egg production were kept to calculate hen day production, feed intake, feed conversion ratio (feed consumed per hen for the 12 weeks in kg ÷ dozens of egg produced per hen) and feed cost per dozen eggs. At the end of the experiment, three eggs were randomly collected from each replicate (12 eggs per treatment) to study the external and the internal quality traits of the eggs. The egg weight, albumen, yolk and shell weights were measured with a sensitive weighing scale (model 200, capacity of 200g × 0.1g). The shell thickness was measured with a micrometer screw gauge while the vernier caliper was used to measure the albumen height, albumen diameter, egg length and width. The yolk pigmentation (using the Roche yolk fan), albumen and yolk pH were obtained while the egg shape index (SI = shell weight ÷ egg weight x 100%), yolk index (yolk height ÷ yolk diameter x 100%), yolk: albumen ratio and Haugh unit, HU were calculated. The HU was calculated using the formula: $HU = (100\log H+7.5 - 1.7w^{0.37})$, where H = albumen height and w = egg weight in grammes.

**Data Analysis**: Data collected were subjected to one-way analysis of variance using the SAS software (12), while significant differences between the means were determined according to Duncan's procedure.

**Results**

The results obtained from the proximate analysis of the commercial layer feeds compared to the values of the nutrients indicated/declared on the bag labels are shown in Table 1. The manufacturers did not indicate the moisture and ash content of the feeds. However, the analyzed moisture content of $FT_2$ was significantly ($P < 0.05$) higher than $FT_1$ and $FT_3$ while the ash content of $FT_3$ was significantly ($P < 0.05$) higher than $FT_1$ and $FT_2$. The analyzed crude protein (CP) and fat content and that indicated on the bag labels were not significantly ($P > 0.05$) different. The analyzed crude fibre (CF) content of the feed was significantly ($P < 0.05$) higher in $FT_1$ and $FT_2$, although it was not different from $FT_3$ while the content indicated by the manufacturers were lower. The declared energy, calcium and phosphorus content of the feed were significantly lower than the analyzed values except the energy in $FT_3$.

The result of the impact of the feeds on the hens' performance is shown in Table 2. The three diets significantly ($P < 0.05$) affected all the parameters studied with the exception of the mortality of the birds. The hen day production (HDP), feed intake per hen, number of eggs laid per hen and the dozens of eggs obtained per hen were significantly ($P < 0.05$) higher in birds fed the $FT_1$ and $FT_2$ feed while the same parameters were lower for $FT_3$. The feed conversion ratio and feed cost per dozen eggs were significantly ($P < 0.05$) lower in $FT_1$ and $FT_2$ and higher in $FT_3$.

The impact of the commercial layer diets on egg quality is given in Table 3. The egg weight, length, width, yolk weight and albumen weight were significantly ($P < 0.05$) affected by the feeds such that they were higher in $FT_3$ and lower in $FT_1$ and $FT_2$. The yolk colour was significantly ($P < 0.05$) higher in $FT_3$ followed by $FT_2$ while $FT_1$ was the least. The other parameters (shell weight, thickness, shape index, yolk height, diameter, index, yolk and albumen pH, albumen height, yolk: albumen ratio and HU) were not affected ($P > 0.05$) by the feeds.

**Discussion**

Although the moisture content was not declared by any of the three feed manufacturers, the determined proximate analysis revealed that the moisture content ranged from 5.9 – 8.7%. Previous report by (8) had shown 10 – 13.5% moisture content in commercial layer feeds when they were analyzed while commercial broiler starter and finisher feeds had values of 10.09 – 11.89%. The values obtained in this study were lower than the optimum value of 14 – 15% recommended for better storage of feedstuffs in the humid tropics (13,14). The result obtained implied that the growth of fungi in the stored feeds would be greatly reduced since (15) found that higher moisture content in feed favoured the growth of fungi organisms.

The crude ash content gives an idea of the insoluble ash, minerals and trace element content of the feed (2). It, therefore, implied that birds fed $FT_3$ had the highest ash content which would give them better access to trace minerals that could boost enzymatic reactions in the bird's body. According to (8), the ash and moisture contents of layer, broiler starter and finisher feeds were not declared by feed manufacturers, however in their study, values of (5.94 – 8.98 %) were recorded.

The CP content indicated on the bag labels which was not different from the analyzed values showed that the manufacturers tended to be more truthful with the declaration of the CP content, knowing that farmers were usually more interested in the CP and energy content of the feed. The result obtained in this study showed an improvement compared to (16) who obtained 13.2% as the analyzed CP value for layers' mash instead of the 18% indicated by the manufacturer while (8) reported values of 14.83, 15.33, 15.35 and 15.36% instead of 16.5% each declared for four types of commercial layer feeds.

The similarity in the level of the fat/oil in the feed, even though values were on the high side (maximum) for layer feeds exposes the manufacturer's strategy to possibly boost the energy content of the feed with oil which is a cheaper source of energy while also providing fatty acids and some vitamins. Higher values of 9.45, 5.96, 5.96 and 6.02% were reported by (8) for fat instead of the values that were declared on the bag labels as 3, 3.5, 5, and 4%.

The significantly high values of the CF obtained in this study compared to the content that was indicated on the labels of the bags clearly revealed the level of manipulation which had continued to exist in the feed industry in Nigeria. Feed manufacturers may have continued to use less costly ingredients containing high fibre level instead of the expensive conventional feed ingredients. This might have led to the high fibre content of the feed, yet they declared the expected maximum fibre level. Higher CF levels of 5.75 – 13.21, 11.3, and 5.0 – 9.0% were also reported by (8, 16 and 17) respectively when commercial layer feeds were analyzed, instead of the declared values of 5.0 – 7.0, 7.0, and 4.5 – 5.0%. According to (18), it is important to use high quality feeds which would contain less fibre, higher amount of essential amino acids and more readily available forms of other nutrients to achieve maximum production of meat and eggs. However, high fibre could be used in poultry feeds if the type, handling, processing and enzyme supplementation of the fibre is planned to meet the need of the particular age and class of bird to be fed as reported by (19).

The declared energy content of the feeds were within the recommended level of 2500kcal/kg ME stated by (20) for laying hens was only similar to the analyzed value for $FT_3$ where the label stated it as minimum value instead of stating the exact value used. The analyzed energy content of $FT_1$ and $FT_2$ that was less than the declared content confirmed the high content of the fibre in the two diets. The scarcity and high cost of feed ingredients might have led to the use of feedstuffs that resulted in lower energy and high fibre in the feeds. On the contrary, a higher energy content of 13.0MJ/kg compared to a declared content value of 11.0MJ/kg was reported by (16). The energy content of feed had been found to significantly influence feed intake (21, 22), on-set of lay and follicular genesis of birds (23), egg quality, hen day production and serum hormones (24). It is therefore necessary that feed manufacturers should compound feed that will have adequate energy and indicate same on the labels since energy is a major factor which indicates the nutrient potential of the feed.

The values of calcium indicated by the feed manufacturers for $FT_1$ and $FT_2$ were within the acceptable levels of 2.5% stated by (20) for laying hens in the tropics, and 3.25% for leghorn type and 3.6% for brown laying hens (25). However, the 1% declared for $FT_3$ was below the minimum of 2.5% recommended for laying hens in the tropics. The analyzed values of calcium obtained here pointed to the insincerity of feed manufacturers. Similar poor value of calcium was reported by (16) who analyzed commercial layer feed and found very poor calcium value of 0.5% instead of 3.5% declared by the manufacturer. It is evident that the manufacturers never included any external/additional calcium ingredient, even when ingredients, which serve as sources of calcium in poultry feed are very cheap. Calcium and phosphorus (P) are useful for various structural, physiological, metabolic and regulatory activities in poultry and they maintain the body mineral reserve (26). They play crucial role in the formation of good quality eggshell. According to (27) egg shell quality is improved when the level of Ca is increased in old laying hens. A high rate of bone resorption had also been observed during lay due to bone weakness which occurs at the end of each reproduction cycle (28), thus, there is need to include adequate quantity of Ca in layers feed for optimum production.

The values of phosphorus declared by the manufacturers were within the recommended levels, however, the analyzed values obtained in this study which were significantly lower confirmed that there was no inclusion of any major ingredient that would supply P apart from the main feed ingredients. Similar false declaration by the manufacturer of a commercial layer feed was reported by (16) who found P level of 0.51% instead of the declared value of 0.8%. According to (29), Ca and P are the major cations in a diet and also the most abundant mineral elements in the animal body. However, the need for Ca and P vary sharply throughout the lifespan of an animal (25, 30, 31) and should be supplied in adequate quantity at every stage of development. In order to obtain adequate P inclusion in feed for non-ruminants, it is necessary to include feed ingredients that are rich in P, such as di-calcium phosphate, meat meal, and bone meal (29). The results obtained, therefore indicated that the manufacturers did not include any external supply of the minerals and this supported the finding of (32) who stated that adding external source of P may cause the feed to be expensive, apart from excessive P excretion in urine and demand for non-renewable rock phosphate. Apparently, the non-inclusion of adequate Ca and P, yet declaring adequate inclusion on the bag labels could be part of the manufacturers strategy to make much more profit by spending less money on the purchase of ingredients.

The high HDP, number of eggs laid and dozens of eggs produced per hen in $FT_1$ and $FT_2$ may be attributed to the high fibre inclusion in the feed since significantly ($P < 0.05$) higher HDP had been reported when quails were fed with high fibre diet, containing 10% fibre, 24% CP, 5% fat and 2600 Kcal/kg ME (24) when the processing method and enzyme supplementation was planned to suit the age and type of bird to be fed.

The feed conversion (feed per dozen egg produced) and the cost of feed per dozen egg were better for $FT_1$ and $FT_2$ while they were higher for $FT_3$ since the number of eggs (the dozen of eggs) produced was significantly higher. Farmers would ordinarily prefer the feed that could lead to the production of more eggs at the least cost, as this subsequently leads to more profit. Normally, the profit realized from livestock production most times depended on the feed utilized by the animals, which account for 60 – 80% of the total cost of production (33).

The non-significant ($P > 0.05$) level of the mortality recorded in this study may imply that the feed was not the cause of the mortality. The diets may have been nutritionally adequate to sustain the hens' health despite the high levels of fibre included. According to (34), poor quality feed and poor environmental conditions cause high mortality, low productivity, feed condemnation and poor rate of return on investment.

The egg weight, yolk and albumen, which were significantly ($P < 0.05$) lower in $FT_1$ and $FT_2$, although within acceptable range could be attributed to higher levels of fibre analyzed as 11.86 and 12.22% respectively. This result supported the finding of (24) who found significantly reduced weight of quail eggs obtained from the treatment fed high fibre diet compared to those fed the normal, low energy, low protein and high fat diets. The higher weight of the egg, yolk and albumen in $FT_3$ could be as a result of the analyzed fibre, which was not different from the declared value coupled with the higher ash content found in the feed in this treatment. This implied that the nutrients were more balanced and better utilized in $FT_3$ than the other treatments, and will result to better egg grading which would attract better price since egg weight, width, albumen and yolk weights are essential parameters that influence egg quality and grading (35).

The egg length and width (indicators of the egg shape index) which were higher in eggs obtained from $FT_3$ implied that the stiffness of the egg shells was better than those from $FT_1$ and $FT_2$, however, the shell thickness and egg shape index were not significantly different ($P > 0.05$).

The highest yolk colour obtained from $FT_3$, followed by $FT_2$ and least in $FT_1$ may directly reflect presence of carotene content in the feed. According to (36), about 20 – 60% of the nutrient in the feed capable of causing the pigment is transported to the yolk for coloration. Yolk colouring nutrients in feed could be red pepper, pine and corn meal (37). Since the acceptable preference of yolk colour for eggs is 7 – 8 according to (38), it will imply that only diets $FT_2$ and $FT_3$ would be better diets in terms of giving the desired yolk colour. Yolk colour level of 7.4 was reported by (39) when some parameters of whole eggs and egg yolk of some birds were studied while a range of 7.3 – 8.0 was reported by (23) when red pepper (RP) was incorporated in diet for laying hens at levels of 0.0 – 1.5g RP/kg feed.

The non-significant ($P > 0.05$) differences in the yolk and albumen pH were similar to the values of 6 for yolk pH and 7.6 – 8.5 for albumen pH reported by (40) for good quality eggs. The result obtained therefore showed that there had been no loss of water and $CO_2$

through the shell pores, and no deterioration of the gelatinous structure of the albumen since decrease and or alteration in yolk and albumen pH has been credited to loss of water and $CO_2$ from the egg (40).

The similarity in the values of the other egg quality determinants (yolk index, yolk: albumen ratio and Haugh unit, HU) across the treatments implied that the diets supported good quality eggs despite the wrong indications/declarations (the crude fibre, ME in $FT_1$ and $FT_2$, calcium and phosphorus) of the content of the feed. This fact may have been known to the manufacturers, thus their strategy of increasing the fibre and maximizing the fat content in order to reduce their cost of production, since the internal quality of the fresh eggs were not affected.

**Conclusion and Applications**

1. The wrong indication of some of the nutrient content and the non-declaration of some content of the different feeds call for stringent policies and adequate control of the feed milling industry in Nigeria.
2. The Nigerian Institute of Animal Science (NIAS) and other agencies of government, such as Standard Organization of Nigeria, must act fast to save the egg industry from sharp practices by the feed manufacturers.
3. The performance evaluation portrayed $FT_1$ and $FT_2$ as feed which gave good output, however, further studies of the egg quality proved that $FT_3$ which had better egg weight, yolk and albumen weights has its own merits.
4. All three feeds could be used for feeding layers since the shape index, yolk index, yolk: albumen ratio and HU of the eggs were similar when the fresh eggs were analyzed.
5. Nevertheless, further studies would be necessary to confirm the quality of the eggs during storage.

**References**


1. Costa, F.B., Batista, A.S.M. Beltrao-Filho, E.M., Dal-Monte, H.L.B., Jordao-Filho, J. and
Pereira, V.O. (2006). *Enriquecimento de Ovos. Higiene Alimentar*, 21(146),16
2. Food and Agricultural Organization. (2011). Quality Assurance for Animal Feed Analysis Laboratories. *FAO Animal Production and Health Manual* No.14
3. Apantaku, S.O., Oluwalana, E.O.A. and Adepegba, O.A. (2006). Poultry farmers' preference and the use of commercial and self-compounded feeds in Oyo Area of Oyo State, Nigeria. *Agriculture and Human Values*. 23(2):245 – 252
4. Jacob J.P. (2015). Feeding chickens for egg production, small and backyard flocks.
Article.extension.org>pages>feeding-c…Retrieved 19th August 2017
5. Afolabi, O.O., Nworgu, F.C. and Oluoku, J.A. (1998). Evaluation of chemical composition and nutritional values of some forage for rabbit production. *Proceedings of Silver Anniversary Conference of Nigerian Society for Animal Production/West African Society for Animal Production, Inaugural Conference, Abeokuta, Nigeria.*
6. Esonu, B.O., Udedibie. A.B.I. and Agbabiaka, L.A. (2001). Comparative performance of broilers fed diets containing differently processed jack beans meal. *Proceeding of the 26th Annual Conference of Nigerian Society for Animal Production, Zaria, Nigeria*. pp. 202-203
7. Ekweong, F.W., Okon, B.I. and Umoh, B.J. (1996). Evaluation of the nutrient contents of selected preserved forages in

the derived savanna zone. *Nigerian Journal of Animal Production.* 23:164 – 168

8. Oyedeji, J.O., Olupitan, T.C., Ajayi, H.I., Imouokhome, J.I., Sonuyi, O.O and Iyede, O. (2013). Physical, chemical and performance evaluation of different commercial brands of layers, broiler starter and finisher feeds. *Albanian Journal of Agricultural Science.* 12(2):267 – 273
9. AOAC (1999). Association of Official Analytical Chemists, Official Methods of Analysis, 17th ed Washington DC. USA.
10. Gosling, P. (1986). Analytical reviews in clinical biochemistry: Calcium measurement. *Analytical Clinical Biochemistry*. 23:146 – 156
11. ISO (1998). Animal feeding stuff – Determination of phosphorus content – Spectrophotometric method. Geneva, Switzerland
12. SAS Institute (1990). SAS/STAT User's Guild. SAS Institute Inc., Cary, NC, USA.
13. Mabbett, T. (1998). Mycotoxin hazards, more accurate quantification in the field. *Feed International*. 18:23 – 29
14. Esonu, B.O. (2000). Animal Nutrition and Feeding: A Functional Approach. *Rukzeal and Ruksors Associates Memory Press, Owerri, Nigeria*.
15. Vieira, S.L. (2003). Nutritional implications of mould development on feedstuffs and alternatives to reduce the mycotoxin problem in poultry feeds. *World Poultry Science Journal*. 59: 111 – 122
16. Carew, S.N., Oluremi, O.I.A. and Wambutda, E.P. (2005). The quality of commercial poultry feeds in Nigeria: A case study of feeds in Makurdi, Benue State, Nigeria. *Nigerian Veterinary Journal*. 26(1): 47 – 50
17. Ucheghu, M.C. Okoli, I.C. Omede, A.A., Opara, M.N. and Ezeokeke, C.T. (2008). Biochemical, physical and performance evaluation of commercial growers and layers ration manufactured in Nigeria. *Asian Journal of Poultry Science.* 2(1):1 - 9
18. Obioha, F.C. (1992). *A Guide to Poultry Production in the Tropics*. Arenna Publishing, Nigeria
19. Akinola, L.A.F. and Onunkwo, D.N. (2009). A review of the role of fibre in poultry nutrition. *Environment and Ecology*. 27(4A):1689 – 1691
20. Aduku, A.O. (1993). *Tropical Feedstuff Analysis Table*. Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University Zaria, Nigeria
21. Oluyemi, J.A. and Roberts, F.A. (2007). *Poultry Production in the Warm Wet Climates.* Revised edition. Spectrum Books Limited, Ibadan, Nigeria. pp 244
22. Akinola, L.A.F. and Sese, B.T. (2012). Performance and body composition of Japanese quail (*Coturnix coturnix japonica*) fed different nutrients in Nigerian humid tropical environment. *Journal of Animal Science Advance*. 2(11):907 –913
23. Akinola, L.A.F., Nwokolo, E. and Ekejiuba, H.C. (2017). Egg quality, serum proteins and enzymes of laying hens fed different levels of red pepper (*Capsicum annum* L) in diet. *African Journal of Agriculture, Technology and Environment*. In Press
24. Akinola, L.A.F.and Igwe, B.N. (2017). Influence of Different Dietary Nutrients on Egg Production, Quality Traits and Serum Hormone Levels of Japanese Quails (*Coturnix coturnix japonica*). *International Journal of Livestock Research*, 8: In Press

25. NRC (1994). *Nutrient Requirement for Poultry*. 9th edition. National Academy Press, Washington DC, USA.
26. Underwood, E.J. and Suttle, N.F. (2001). *The Mineral Nutrition of Livestock*, 3rd ed. CAB International, Wallingford, UK.
27. Nascimento, G.R., Murakami, A.E., Guerra, A.F.Q.M., Ospinas-Rojas, J.C., Ferreira, M.F.Z. and Fanhani, J.C. (2014). Effect of different vitamin D sources and calcium levels in the diet of layers in the second laying cycle. *Brazillian Journal of Poultry Science*. 16(2):37- 42
28. Whitehead, C.C. (2004). Overview of bone biology in the egg-laying hen. *Poultry Science*. 83(1):193 – 199
29. Vitti, D.M.S.S. and Kebreab, E. (2010). *Phosphorus and Calcium Utilization and Requirement in Farm Animals*. CAB International. Pp. 1 – 77
30. NRC (1998). National Research Council. *Nutrient Requirement of Swine*. 10th ed. National Academy Press, Washington, DC, USA.
31. NRC (2001). National Research Council. *Nutrient Requirement of Dairy Cattle*. 7th ed. National Academy Press, Washington, DC, USA.
32. Selle, P.H. and Ravindran, V. (2007). Phytate-degrading enzymes in pig nutrition. *Livestock Science*. 113:99 - 122
33. Adebowale E.A., Bamgbose, A.M., Nworgu, F.C. (1998). Performance of broilers fed with different protein sources. *Proceedings of Silver Anniversary Conference of Nigerian Society for Animal Production/ West African Society for Animal Production, Inaugural Conference, Abeokuta, Nigeria*.
34. Fagbenro, O.A. and Adebayo, O.T. (2000). A review of the animal and aquatic industries in Nigeria. *FAO Corporate Document Repository*.
35. Farooq, M., Mian, M.A., Ali, M., Durranim, F.R., Asquar, A. and Muqarrab, A.K. (2001). Egg traits of Fayoumi bird under subtropical conditions. *Journal of Agriculture*. 17:141 – 145
36. Bartov, I. and Bornstein, S. (1980). Studies on egg yolk pigmentation: Effect of ethoxyquin on xanthophylls within and among genetic sources. *Poultry Science*. 50, pp 1460 – 1461
37. Blount, J.D. Houston, D.C. and Moller, A.P. (2000). Why egg York is yellow. *Trends. Ecology of Evolution*. 15, pp 47-49
38. Lesson, S. and Summers, J.D. (1997). *Commercial Poultry Nutrition*. 2nd ed. University Books, University of Guelph, Guelph, ON, Canada: Feeding Programs for Broilers. pp. 207 – 254
39. Popoola, M.A., Alemede, C.I., Aremu, A. and Ola, S.I. (2015). Morphometric parameters of whole egg and egg yolk of five Nigerian domestic avian species. *IOSR Journal of Agriculture and Veterinary Science*. 8(3):41 - 45
40. Coutts, J.A. and Wilson, G.C. (2009). Optimum Egg Quality, A Practical Approach. 5mBooks.com

**Table 1: Analyzed and declared nutrient contents of the three commercial layer feeds**

| Nutrient | $FT_1$ | | $FT_2$ | | $FT_3$ | | SEM |
|---|---|---|---|---|---|---|---|
| (%) | Declared | Analyzed | Declared | Analyzed | Declared | Analyzed | |
| Moisture | NA | $6.40^b$ | NA | $8.70^a$ | NA | $5.90^b$ | 1.40 |
| Ash | NA | $13.6^a$ | NA | $11.7^b$ | NA | $14.7^a$ | 1.62 |
| Crude protein | 16.5 | 16.2 | 16.5 | 16.2 | 15.0 | 15.6 | 0.02 |
| Fat/Oil | 5.00 | 6.50 | 5.00 | 4.60 | 5.00 | 4.50 | 0.05 |
| Crude fibre | $6.00^b$ | $11.9^a$ | $7.00^b$ | $12.2^a$ | $6.50^b$ | $8.01^{ab}$ | 4.06 |
| ME (Kcal/kg) | $2500^a$ | $1820^b$ | $2500^a$ | $1864^b$ | $2400^a$ | $2044^a$ | 467.0 |
| Calcium | $3.60^a$ | $0.12^c$ | $3.50^a$ | $0.11^c$ | $1.00^b$ | $0.11^c$ | 2.44 |
| Phosphorus | $0.45^a$ | $0.0005^b$ | $0.45^a$ | $0.0009^b$ | $0.40^a$ | $0.0009^b$ | 0.32 |

$^{a,b,c}$ - Means within the same row with different superscripts are different ($P < 0.05$)
NA – Not Available

**Table 2: Performance of laying hens fed three commercial layer feeds**

| Parameter | $FT_1$ | $FT_2$ | $FT_3$ | SEM |
|---|---|---|---|---|
| Hen day production (%) | $79.9^a$ | $79.8^a$ | $72.6^b$ | 2.11 |
| Feed intake (g/hen/day) | $129^a$ | $128^a$ | $121^b$ | 0.27 |
| No. of eggs laid /hen | $67.0^a$ | $67.0^a$ | $61.0^b$ | 0.53 |
| Dozen egg/hen | $5.58^a$ | $5.58^a$ | $5.08^b$ | 0.38 |
| Feed/dozen egg | $1.94^b$ | $1.93^b$ | $2.00^a$ | 0.08 |
| Feed cost/dozen egg (N) | $332.8^b$ | $331.1^b$ | $343.1^a$ | 2.86 |
| Mortality (%) | 1.08 | 1.08 | 0.72 | 0.45 |

$^{a,b}$ - Means within the same row with different superscripts are different ($P < 0.05$)

**Table 3: Impact of the commercial layer feeds on egg quality**

| Parameter | $FT_1$ | $FT_2$ | $FT_3$ | SEM |
|---|---|---|---|---|
| **External qualities** | | | | |
| Egg weight (g) | $57.4^b$ | $58.7^b$ | $63.5^a$ | 1.78 |
| Egg length (cm) | $5.48^b$ | $5.54^b$ | $5.98^a$ | 0.12 |
| Egg width (cm) | $4.19^b$ | $4.23^b$ | $4.71^a$ | 0.40 |
| Shell weight (g) | 5.88 | 5.92 | 6.04 | 0.18 |
| Shell thickness (mm) | 0.44 | 0.46 | 0.47 | 0.05 |
| Egg shape index (%) | 76.5 | 76.4 | 78.8 | 2.55 |
| **Internal qualities** | | | | |
| Yolk weight (g) | $15.8^b$ | $15.9^b$ | $16.9^a$ | 1.26 |
| Yolk height (mm) | 4.05 | 4.06 | 4.27 | 0.41 |
| Yolk diameter (cm) | 4.01 | 4.10 | 4.24 | 0.26 |
| Yolk index (%) | 10.1 | 9.90 | 10.1 | 0.29 |
| Yolk pH | 7.31 | 7.26 | 7.45 | 0.53 |
| Yolk colour | $6.22^c$ | $7.09^b$ | $8.56^a$ | 0.77 |
| Albumen weight (g) | $31.0^b$ | $30.6^b$ | $35.1^a$ | 0.98 |
| Albumen height (cm) | 3.89 | 3.92 | 4.20 | 0.42 |
| Albumen pH | 8.05 | 8.12 | 8.24 | 0.63 |
| Haugh unit (HU) | 77.4 | 77.3 | 78.12 | 0.94 |
| Yolk: Albumen ratio | 0.51 | 0.52 | 0.48 | 0.06 |

$^{a,b,c}$ - Means within the same row with different superscripts are different ($P < 0.05$)