Journal of Veterinary Research Advances
ISSN: 2582-774X **Research Article**
Open access

Evaluation of groundnut shell meal (GSM) on performance and haematological indices of finisher broilers

Ahaotu EO[1], Simeon-Ahaotu VC[2] and Herasymenko NV[3]
[1]Department of Animal Science, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria
[2]Department of Microbiology, Gregory University, Uturu, Abia State, Nigeria
[3]Vinnytsia National Technical University, Khmelnytskeshose, Vinnytsia, Ukraine

Corresponding author: emmanuel.ahaotu@uaes.edu.ng

Received on: 15/12/2024 Accepted on: 19/04/2025 Published on: 23/04/2025

ABSTRACT

Aim: Purpose of the study was to evaluate of groundnut shell meal (GSM) on performance and haematological indices of finisher broilers.

Method and materials: The study involved 150 mixed sexed broiler finisher birds divided into five groups of 50 each. The control treatment T_0 had no groundnut shell meal while the other four treatments included replacement of groundnut shell meal with palm kernel cake at 2.5, 5.0, 7.5 and 10 % (T_0, $T_{2.5}$, T_5, $T_{7.5}$ and T_{10} respectively). All treatments had the same calculated levels of crude protein and metabolisable energy contents.

Results: Results showed no evidence of effect of treatments on feed efficiency (p> 0.05). However, there was evidence that feed intake, live weight gain, average final live weight of birds receiving the control diet T_0 were lower than those with 10% substitution level of palm kernel cake (p<0.05). There was evidence that carcasses of chickens fed the T_5 diet were lower (p<0.05) than those fed T_{10} but similar to T_0 and $T_{7.5}$ (p> 0.05). T_{10} proved to be the most profitable diet.

Conclusion: It was concluded that the groundnut shell meal supplementation in broiler diets could be effectively utilized at 5% to obtain reasonably good growth rate and reduced disease infection risk in the finished broiler birds.

Keywords: Groundnut shell meal, performance and haematological indices of finisher broilers

Cite This Article as: Ahaotu EO, Simeon-Ahaotu VC and Herasymenko NV (2025). Evaluation of groundnut shell meal (GSM) on performance and haematological indices of finisher broilers. J. Vet. Res. Adv., 07(01): 21-27.

Introduction

Broiler production is one of the fastest means of bridging the animal protein gap in human nutrition (Ahaotu *et al.,* 2023a). Broilers are fast growing meat type birds (Ahaotu *et al.,* 2017). When compared to the beef industry, the poultry enjoys a relative advantage of easy management, higher turnover and quick return on investment (Okonkwo and Ahaotu, 2014; Anaeto *et al.,* 2009). Groundnut cake is a protein source that has been used over a long time in poultry feed. Increased cost of feeding like groundnut cake is the greatest problem of the poultry farmers. It contains 40-48 % crude protein (Kwari*et al.,* 2004). However, the incorporation of this raw material in monogastric feed has been faced with limitations as a result of the presence of anti-nutritional factors, its vulnerability to fungi (*Aspergillus flavus*), its limited content of some essential amino acids, but also to its availability and high cost in the market.

The most important sources of nutrients that can be utilized in broiler feeds are grains, oilseed meals, fish meal and Plumeria rubra (Ahaotu *et al.,* 2023b).

There is therefore a challenge of finding alternatives to groundnut cake which are accessible to all poultry farmers and could substitute groundnut cake in poultry feed. Ahaotu et al., (2016) stated that agro-industrial by-products have in recent years become important feed components in poultry diets in Nigeria due to the increased competition for the conventional ingredients by humans and the food industries. Ahaotu *et al.,* (2015) further stressed the need to utilize alternative feed ingredients far removed from human and industrial interest in order to reduce feed cost and the cost of poultry products. Groundnut production and processing has been a traditional business in many countries of the world for centuries back. The result is a generation of various products for human consumption, animal feeding and industries (FORA, 2012). The most popular of the products in animal feeding is groundnut cake (a conventional feedstuff) and recently groundnut seed offal (Aduku, 2004). Many of the products from groundnut processing are used as feeding stuffs for livestock, apart from the human use. Unconventional feedstuffs are a sure way of reducing the cost of animal feeding and consequently, animal products because of the ease of accessing them and their low cost.

Groundnut availability worldwide is uncontestable since world production is put at 34.9 million metric tons (FAO, 2007) and Nigeria produces 2 million metric tons (FORA, 2012). However, there is scarcity of groundnut cake and soyabean cake in many parts of Nigeria as a result of collapse of most oil milling industries (Musa, 2010), which should form a larger percentage of protein feedstuff for broiler nutrition (Nnadi *et al*., 2022). Even where these cakes are found, the cost is higher than their full fat seeds and unprofitable as a feedstuff to the small scale animal farmer.

According to (Boateng *et al.,* 2008) palm kernel cake (PKC) is an agro-industrial by-product that is produced locally and within the West African sub-region in sizeable quantities. This feed should be fully utilized to reduce feed cost and also curb the problem of environmental pollution that accompanies its disposal. PKC is a by-product of the extraction of palm kernel oil (Ahaotu *et al*., 2013a). PKC has been found to contain between 16.0 and 21.3% crude protein with low content of lysine, methionine, histidine and threonine (Ezieshi and Olomu, 2008).

It has not however been greatly used in monogastric feed because crude fibre content ranges from 6.7% (Ahaotu *et al*, 2012) to 17.5% (Ayo-Enwerem, *et al.,* 2017) PKC crude fibre is high and it's difficult to digest (Siregar *et al.,* 2003 and Adua *et al*., 2012). The crude protein and cellulose contents are also high (Sukaryana, 2001). PKC is highly available and relatively less expensive compared to groundnut cake. It is not yet known to contain anti-nutritional factors that significantly affect poultry and has less palatability problems. However, existing data on its use in monogastric feeding focused on determining its optimal inclusion rate in feed rations and their influence on carcass characteristics of broilers (Sundu et *al*., 2006 and Ononiwu *et al.,* 2017). Soltan (2009) stated that 30% palm kernel cake-diet with high level of residual fat led to a higher average daily gain and better feed conversion efficiency compared to a low-fat palm kernel cake-based diet; but increased carcass fat with a consequent reduction in leanness in pigs. A 20% palm kernel cake-diet also yielded positive responses in broilers and layers but beyond that, reduced egg numbers and quality were recorded (Oko *et al.,* 2021 and Costa *et al.,* 2001).

Materials and Methods

The study was conducted at Poultry Unit of University of Agriculture and Environmental Sciences Umuagwo, Imo State, Nigeria which is located at The site is situated between longitudes 7^{o} 0^{1} 06^{11}E and 7^{o} 03^{1} 00^{11} and latitudes 5^{o}28^{1} 00^{11}N and 5^{o} 30^{1} 00^{11}N in the humid tropical West Africa (IMLS, 2009).The climate is marked by two seasons.

Collection and processing of Ground Shell as ingredients: Five kilogram weight of groundnut shells used for this research was obtained from rural women in Atta – Ikeduru, Imo - State, Nigeria where shells were indiscriminately dumped after removing the groundnut seed. Other ingredients were purchased from feed ingredients vendor at Owerri, Imo – State, Nigeria. The groundnut shells were pre-treated using hot air oven at 100^{0}C until a constant weight was obtained for any dry matter. This was to obtain constant dryness and to prevent groundnut shells from being infected with fungi such as aflatoxin before milling.

Animal Material, Experimental Diets and Experimental Design: A group of 150 Arbor Acres strain mixed chickens aged 29 days, with an average weight of 515± 83g were distributed into 5 treatments of 30 birds each. The birds were fed in five pens and replicated thrice in wire cages, giving 15 replicates from 5 experimental treatments. The experiment lasted for five weeks and food and water were served *ad libitum*. The birds were randomly assigned to five dietary groups in which groundnut shell meal (GSM) was replaced at varying levels with palm kernel cake (PKC) as follows:

A = 0% GSM and 100% PKC
B = 25% GSM and 75% PKC
C = 50% GSM and 50% PKC
D = 75% GSM and 25% PKC
E = 100% GSM and 0% PKC

Two dietary types, one for starter phase (23% crude protein (CP) and 2900kcal/kg metabolizable energy (ME) and other for finisher phase (20% CP and 2300 kcal/kg ME) of production, were formulated (Tables 3). The test diets in each phase were formulated to be iso-caloric and iso-nitrogenous. Each treatment group consisted of thirty birds, divided into three replicates of ten birds each. Prior to arrival of birds, brooding and growing houses were disinfected and demarcated into five experimented units corresponding to five dietary test groups. The birds were weighed on arrival to obtain their initial body weights and at weekly intervals thereafter. The experiment was terminated at the end of nine weeks.

Table 1: The Chemical Composition and Essential Amino Acids of Groundnut.

Content	Percentage
Protein	45.2
Oil	48.2
Starch	11.5
Soluble sugar	4.5
Crude fiber	2.1
Moisture	6.0
	g (100 g of protein)-
Lysine	4.00
Threonine	3.12
Valine	4.59
Methionine+ Cysteine	2.56
Isoleucine	3.69
Leucine	6.95
Phenylalanine+ Tyrosine	10.12

Table 2: Proximate Composition of Ground Nut Shell

Parameters	%
Moisture	4.85
Crude protein	31.08
Crude fibre	7.50
Ether extract	19.30
Ash	5.00
NFE	32.27
Calcium	0.25
Phosphorus	0.20
ME* (kcal/kg)	3774.29

Blood samples collected from the wing veins of three birds in each treatment group at the end of mime weeks of feeding were sent to a commercial Laboratory in Owerri, Imo State, Nigeria for the determination of the blood parameters and serum proteins. Parameters determined included packed cell volume (PCV), red blood cell counts (RBC), haemoglobin concentration (Hb), white blood cell counts (WBC), erythrocyte sedimentation rate (ESR), blood coagulation time (CT) and serum proteins. From these parameters, mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were calculated using the method of Schalm *et al.* (1975). All data collected were analyzed using the modified S.A.S. (2000) computer software.

Data collection: Feed consumption was assessed daily, while growth was evaluated weekly. At the end of the trial, five birds per treatment were slaughtered for carcass evaluation (gizzard, intestine, bowel density, carcass yield) and average weight gain. The length of the intestine was measured from the beginning of the duodenum to the end of the cloacae with a tape.

Statistical analysis: For clarity of interpretation, the simple consumption index was shown. Feed consumption is proportional to metabolic weight. Feed consumption, average weight gain, feed efficiency, carcass yield and proportions of the internal organs were subjected to analysis of variance according to a Completely Randomized Design and Means will be separated by the Duncan's test (SAS, 2000; Gordon and Gordon, 2004).

Table 3: Formulation and production cost of experimental diets

Ingredients (g/kg)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish Meal	9.00	9.00	9.00	9.00	9.00
Maize	40.00	40.00	40.00	40.00	40.00
Palm Kernel Cake	10.00	7.50	5.00	2.50	0.00
Groundnut shell Meal	0.00	2.50	5.00	7.50	10.00
Wheat Offal	14.00	14.00	14.00	14.00	14.00
Soya bean meal	18.00	18.00	18.00	18.00	18.00
Bone Meal	5.00	5.00	5.00	5.00	5.00
Vitamin and Mineral Premixes	2.00	2.00	2.00	2.00	2.00
Methionine	1.00	1.00	1.00	1.00	1.00
Lysine	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00
Calculated Crude Protein (%)	40.02	40.02	40.02	40.02	40.02
Cost of production (N/kg)	266.20	242.20	242.20	242.20	242.20
Calculated gross energy (kcal/100g)	12.07	12.07	12.07	12.07	12.07
Protein/Energy ratio	3.32	3.32	3.32	3.32	3.32

Results and Discussion

The haematological and the serological indices of the Finisher broilers: The nutrient analysis of groundnut shell meal (GSM). Its protein content was 34.10%, thus confirming its status as a high - protein feedstuff (Table 3). The haematological and the serological indices of the broiler chicken fed the various test diets are presented in Table 4. With the exception of MCV, MCH and coagulation time, all other haematological and serological indices tended to decrease as greater proportions of PKC were incorporated into the diets. PCV for diet A (33.55%) was significantly (p<0.05) higher than those for the other levels of GSM inclusion (diet B = 29.05%; C = 30.45% and E = 32.35%). In the same vein, the PKC in diet A (2.7 x 106/mm3) was significantly (p<0.05) higher than in all other levels of PKC substitution.

Serum proteins and WBC levels in the blood were significantly depressed as more GSM was included in the diets beyond 0% and 25% respectively. This implies that feeding over 25% GSM in broiler diets without further processing for prolonged periods may be detrimental to broilers since these two factors are involved in the formation of immunoglobin responsible for the development of antibodies. Prolonged feeding of GSM in this form therefore posed health hazards to such birds when challenged with infections.

MCV generally tended to increase (p< 0.05) as the proportion of GSM in the diets increased (Table 4). Highest MCV was obtained in diet E (141.27 fl) with 100% PKC. MCV is an important trait which determines the cell size of erythrocytes and is therefore an important factor in determining the ability of birds to withstand prolonged oxygen starvation (Adeyemi *et al.*, 2000).

Average Daily Weight Gain (g): It was presented that the highest daily weight gain (g) was observed in birds fed diet 2 (2.5% GSM), while the lowest was observed in birds fed diet 5 (10% GSM). It was observed that the body weight gain of birds decreases with increase in dietary levels of the GSM (Table 5). The result agreed with the observation made by Ahaotu *et al.*, (2013b) where graded dietary inclusion of groundnut shell meal induced cause related depression in growth of chicken even when palm kernel cake was used to compensate for low metabolizable energy value of the groundnut shell meal. Similar observation of decreasing performance of broilers at high levels of GSM inclusion have been observed by Ahaotu *et al.*, (2010) who reported that the body weight gain of broilers drastically reduced at high levels of GSM incorporation. Akpodiete *et al.* (2006) followed the same suit with the incorporation of high levels of GSM. The effect observed above could have resulted from imbalance nutrient value and improper metabolism associated with the GSM as reported by Anaeto *et al.* (2009). Other workers (Boateng *et al.*, 2008) have also reported the effect of nutrient imbalance on monogastric animals fed high levels of unconventional feed ingredients. This could also be probably due to the effects of incomplete elimination of toxic factors as reported by Ahaotu *et al.* (2013b).

Table 4: The Haematological and Serological Indices of the Experimental Chickens

	Dietary Groups				
Indices	A	B	C	D	E
RBC (mm3 x 106)	2.70±0.04^{a}	2.62±0.04^{a}	2.52±0.04^{c}	2.38±0.03^{c}	2.29±0.02^{c}
PCV (%)	33.55±0.64^{a}	29.05±0.65^{c}	30.50±0.52^{b}	32.45±0.42^{a}	32.35±0.02^{a}
Hb (g1100)	11.09±0.21^{a}	9.80±0.23^{b}	9.43±0.08^{c}	8.23±0.20^{d}	8.80±0.17^{cd}
Coagulation Time (s)	177.80±1.55^{d}	184.50±1.97^{c}	189.60±1.78^{b}	190.60±1.31^{b}	193.10±1.03^{a}
ESR (mm/3hr)	5.50±0.05^{a}	4.41±0.12^{b}	4.19±0.13^{c}	4.21±0.17^{c}	4.03±0.11^{d}
MCV (fl)	124.26±1.35^{c}	110.88±1.23^{e}	121.03±1.09^{d}	136.34±1.95^{b}	141.27±1.98^{a}
MCH (pg)	41.07±1.05^{a}	37.40±1.53^{b}	37.42±1.21^{b}	34.48±1.08^{c}	34.06±1.21^{c}
MCHC (%)	33.10±1.09^{a}	33.73±1.52^{a}	30.91±0.95^{b}	25.36±0.89^{c}	24.11±0.58^{d}
WBC (mm3/103)	19.47±0.45^{a}	19.08±0.45^{a}	18.50±0.22^{b}	18.39±0.30^{b}	17.92±0.19^{c}
Serum Protein (g/d)	4.95±0.15^{a}	4.05±0.13^{b}	3.73±0.13c^{d}	3.53±0.11^{d}	3.26±0.27^{d}

a,b,c Means with different superscripts in the same row are significantly different (P<0.05). A = 0% GSM, 100% PKC; B = 25% GSM, 75% PKC; C = 50% GSM, 50% PKC; D = 75% GSM, 25% PKC; E = 100 GSM, 0% PKC.

Table 5: Effects of varying levels of Groundnut Shell Meal on the Performance of Finisher Broilers 0

	Dietary Treatment					
Parameters	**T_1(0%)**	**T_2(2.5%)**	**T_3(5.0%)**	**T_4(7.5%)**	**T_5(10%)**	**SEM**
Initial Body Weight (g).	320	320	310	320	310	0.01
Avg. Final Body Weight (g).	2320^b	2520^a	2280^c	2270^c	1890^d	0.40
Avg. Daily Wt. Gain (g).	40.82^b	44.80^a	40.20^b	39.80^b	32.36^c	0.77
Avg. Daily Feed Intake (g).	129.39^a	131.71^a	128.24^a	126.56^b	110.60^c	0.85
Feed Conversion Ratio (g).	3.17^b	2.94^c	3.19^b	3.18^b	3.43^a	0.05

Average Daily Feed Intake: The analysis of variance conducted on the daily feed intake showed that there was significant ($p<0.05$) differences among the treatment means. The feed consumption of birds fed diet 1, 2 and 3 were similar ($p>0.05$) but significantly ($p<0.05$) higher than those of birds fed diets 4 and 5. However the feed intake of birds fed diet 5 was significantly ($p<0.05$) lower than that of birds fed diet 4. The observed general trend was that of decreasing average feed intake as level of supplementation increased. This might be attributed to the high crude fibre which reduced the palatability of the feed. This is in consonance with the observations of Abo-Donia *et al*. (2014) who fed finisher broilers with raw groundnut shell and reported reduced feed consumption among the sheep on the test diets. Ahaotu *et al*. (2013b) has also established the presence of fungi *Aspergillus flavus* and *Aspergillus parasiticus* mouldy groundnut shells. However, debitterization through water washing, alkali soaking and urea ammonization to improve palatability has been recommended (Coasta *et al*., 2001). Also the decrease in feed intake observed could be as a result of anti-nutritional factors present in the test ingredient. This agreed with the findings of Akpodiete *et al.* (2006) who incorporated different levels of GSM noted for their anti-nutritional factors in the diets of poultry and observed decreases in feed intake.

Feed Conversion Ratio: The analysis of variance showed that there were significant ($p<0.05$) differences among the treatment means. As shown in table 5, the amounts of feed consumed by birds fed diet 1(0% GSM), diet 3 (5.0 % GSM) and diet 4 (7.5 % GSM) to gain the same unit (kg) of bodyweight, were similar ($p>0.05$). However, birds fed diet 2 (2.5%, GSM) were significantly ($p<0.05$) higher than those birds fed diet 5 (2%) to gain the same unit of body weight. The efficiency of feed conversion of birds fed diets containing more than 2.5% GSM were significantly ($p<0.05$) lower when compared to those of birds fed diet 2 (2.5%, GSM). The poor utilization of diets containing higher levels of GSM might be related to the inability of the birds' enzyme to break down the active bitter substance in the GSM and also the imbalance nutrient value and improper metabolism associated with the groundnut shell meal as reported by Cowart *et al*. (2006).

The results of this study showed that there were significant ($p<0.05$) difference among the performance of birds across the various treatments in terms of average body weight gain, feed intake, and feed conversion ratio. Further supplementation of GSM beyond 5% showed decrease in average body weight gain and average final weight of the birds. This study also showed that the supplementation of GSM had little or no effect on the hematological values of the birds, as the parameters evaluated for across the treatment groups fell within the accepted normal ranges for poultry birds.

Conclusion

It was concluded that the groundnut shell meal supplementation in broiler diets could be effectively utilized at 5% to obtain reasonably good growth rate and reduced disease infection risk in the finished broiler birds. Since the GSM has shown great promise as a possible substitute for PKC, processing methods should be improved in such a way that all traces of anti-nutritional and haemolytic factors which are capable of distorting the haematological parameters are eliminated.

Reference

Abo-Donia FM, Abdel-Azim SN, Elghandour MMY, Salem AZM, Buendía G and Soliman NAM (2014). Feed intake, nutrient digestibility and ruminal fermentation activities in sheep-fed peanut hulls treated with *Trichoderma viride* or urea. Trop. Anim. Health Prod., 46(1): 221-228

Adeyemi OA, Fasina OE and Balogun MO (2000). Utilization of full fat *Jatropha* seed on broiler diet: Effort on haematological parameters and blood chemistry. Proc. 25th Annu. Conf. NSAP, Umudike,pp: 108-109.

Adua MM, Alu SE, Thani RJ, Abubakar HT and Matthew UD (2012). Effect of different alkali-treated groundnut (Arachis hypogea) shell meal on blood parameters and meat yield of broiler finisher chickens. Scholarly J. Agri. Sci., 2(9): 224-230.

Aduku AO (2004). Animal nutrition in the tropics; feeds and feeding, pasture management, monogastric and ruminant nutrition. Devcon computer and Business Bureau, No. 11 Calvary Baptist Church Road, Samaru, Zaria, Kaduna state, Nigeria.14-19.

Ahaotu EO, Okoro CN, Ukwuaba SI, Nwokeforo CU, Onuruka AC, Ikpe JN and Oko EC (2023a). Comparative Analysis and Efficiency of Poultry Enterprise in Ezinihitte Mbaise Local Government Council of Imo State, Nigeria.Merit Research Journal of Agricultural Science and Soil Sciences. 11(4): 042-047.

Ahaotu EO, Ezeafulukwe CF, Oko EC, Marvellous SO, Okeke AW, Ahaotu VC, Patricio R and Mbachu MU (2023b). Production responses of Isa Brown laying birds to supplementary dietary levels of Plumeria rubra pod meal. J. Vet. Res. Adv., 05(01): 01-14.

Ahaotu EO, Ekenyem BU and Aggrey E (2017). Sustainability of sweet orange (*Citrus sinensis*) peel meal on the performance of finisher Broilers. J. Agric. Sci. Pract. 2: 27-32.

Ahaotu EO, Anietie EM, Iwunze FC and Ihenacho RA (2016). Marketing of Poultry and Poultry Products in Itu Local Government Area of Akwa Ibom State, Nigeria. International Journal of Environmental and Agriculture Research. 2(8): 93-95.

Ahaotu EO, Adeyeye SA and Nnorom N (2015). Effects of *Amaranthus spinosus* (green leaf) on the performance of broiler chicks. Scientific Journal of Veterinary Advances, 4(3): 21-24.

Ahaotu EO, Ezeafulukwe CF, Ayo-Enwerem CM and Ekenyem BU (2013a). Effects of Enzyme Fortified Raw Moringa Seed (*Moringa oleifera*) Waste Diets on Nutrient Utilization and Haematological Parameters of Broilers. Inter J Appl. Sci. Engr, 1(1): 25-30.

Ahaotu EO, Ihezuo JP, Ahumibe K, Anumihe EC, Ayo –Enwerem CM, Iwuanyanwu UP and Ehirim VI (2013b). Partial replacement value of sun dried Layers droppings for groundnut (*Arachis hypogea*) cake on the performance of Chinchilla Rabbits. Proc.38th Conf., Nig. Soc. Anim.Prod. 17-20 March, 2013. Pp 282 - 285.

Ahaotu EO, Ayo–Enwerem CM, Ogbuokiri UDE, Edih MC, Onyerekwere MU, Komolong MK, Wanapat M and Tullet S (2012). Performance and some carcass measurements in Starter broiler birds fed sweet potato meal (*Ipomea batatas*). Animal Production Research Advances.7(4): 277-281.

Ahaotu EO, Ekenyem BU, Agiang EA, Balakrishnan V and Madubuike FN (2010). Effects of dietary substitution of rubber seed cake for groundnut cake on the body conformations of finisher broilers. Animal Production Research Advances 6(1): 44 – 47.

Akpodiete OJ, Eruvbetine D and Gagiyovwe EE (2006). Effect of enzyme supplementation on palm kernel cake based diets on broiler chicken performance. Nigerian Poultry Science Journal, *4:39-46.*

Anaeto M, Chioma GO and Omosebi DJ (2009). Palm Kernel Cake as Substitute for Maize in Broiler Finisher Diet. International Journal of Poultry Science. 8(12): 1206-1208.

Ayo-Enwerem MC, Ahaotu EO, Nwogu CM and Opara J (2017). Growth performance of starter broilers fed diets containing red sandalwood *(Pterocarpus santolinoides)* leaf meal. Direct Research Journal of Veterinary Medicine and Animal Science. 2(4): 106-109.

Boateng M, Okai DB, Baah J and Donkoh A (2008). Palm kernel cake extraction and utilization in pig and poultry diets in Ghana IRRD. 20:(7).

Costa EF, Miller BR, Pesti GM, Bakalli RI and Ewing HP (2001). Studies on feeding peanut meal as protein source for broiler chickens.Poultry Science. 80(3): 306-316.

Cowart D, Powell S, Locke, M, Starling R and Takash J (2016). Raw peanut processing. In: Stalker, H. T., Wilson R. F. (Eds), 2016, Peanuts Genetics, Processing, and Utilization. AOCS Press: 381-403

Ezieshi EV and Olomu JM (2008). Nutritional evaluation of palm kernel meal types: 2.

Effects on live performance and nutrient retention in broiler chicken diets. African Journal Biotechnology. 2008, 7(8): 1171-1175.

FAO (2007). Agricultural crop production statistics.www.fao.org/faostat. FAO 2006.Production Year Book, Vol. 60, Rome, Italy.

FORA (2012). Feasibility report on groundnut in Nigeria. Foraminifera market research. http://www.forafrea.com.

Gordon SP and Gordon FS (2004). Contemporary statistics: A computer approach. McGraw – Hill Publishers, U.S.A. 495 pp.

Imo State Ministry of Lands and Survey (IMLS) (2009). Longitudes and Latitudes locations of Umuagwo, Ohaji / Egbema Local Government Area of Imo State, Nigeria.

Kwari ID, Igwebuike JU, Bello .N, Rabo SJ and Birma M (2004). Replacement of groundnut cake with sorrel *(Hibiscus sabdariffa*) seed meal in broiler finisher diets, Proceeding. 9th Annal Conference. Animal Science Nigeria., 5-7.

Musa H (2010). Nigeria: How to revive groundnut business in the North. Daily trust, 29 September, 2010. p9

Nnadi GL, Simeon–Ahaotu VC, De los Ríos-Escalante P and Ahaotu EO (2021). Replacement level of rubber seed cake for soybean meal on the growth of Japanese quail. Brazilian Journal of Biology, 2022, vol. 82, e243242

Oko EC, Ahaotu EO and Lawal M (2021). Evaluation of Market Demand for Alternative Poultry Feeds in Nigeria.*Acta Scientific Nutritional Health* 5 (8): 36-43.

Okonkwo VN and Ahaotu EO (2014). Effects of Cassava pulp Sievate meal on hematological indices of finisher broiler birds. World Journal of Agri. Sciences. 2 (6):142 – 145.

Ononiwu CC, Ahaotu EO,.Okonkwo VN, Ayo-Enwerem CM and Botchway H (2017). Effects of Bambara Nut Sievate Fortified Exogenous Enzyme on Performance and Carcass Characteristics of Finisher Broiler Birds. Proceedings of the 20th Biennial Conference, Ghana Society of Animal Production (GSAP), 1-5 August, 2017. Sasakawa Centre, University of Cape Coast, Ghana Pp 73-80.

S.A.S. Institute, (2000). S.A.S User's Guide Cary, NC. USA, pp: 949.

Siregar Z, Supriadi DAN and Mirwandhono E (2003). Quality Improvement Palm Kernel Oil-cake through fermentation by Rhizopus oligosporus and Nopcozime Supplementation to Broiler. Faculty of Agriculture, University of North Sumatra. Medan. Pp 56-87.

Soltan MA (2009). Growth performance, immune response and carcass traits of broiler chicks fed on graded levels of palm kernel cake without or with enzyme supplementation. Livestock Research for Rural Development. 21(3): 37.

Sukaryana Y (2001). Effect of Fermentation of Palm Oil-cake with Tricho-dermaviride on Change of Chemical Composition, bio-conversion efficiency, and the Food and metabolizable energy in broiler chickens.Thesis.Padjadjaran University Graduate Program. Bandung. 231 pp.

Sundu B, Kumar A and Dingle J (2006). Palm kernel meal in broiler diets: effect on chicken performance and health. World Poultry Science Journal. 62(2): 316-325.

******