Nigerian J. Anim. Sci. 2020 Vol 22 (3): 261-270 (ISSN:1119-4308)

Effect of replacing Nigerian brown beniseed cake for soybean cake in diets of broilers

***[1]Nwosu, C.I., [1]Ibrahim, M. U. and [2]Marire, B. N.**

**[1]Department of Animal/Fisheries Science and Management, Enugu State University of Science and Technology, PMB 01660, Enugu State, Nigeria*
[2]Department of Agricultural Education, College of Education, Akwanga, Nasarawa State.

***Corresponding Author:** irenkemnwosu@gmail.com; **Phone No.:** 0803322521*

***Target audience:** Academics, Researchers, Students, Poultry farmers.*

Abstract

This study was conducted to examine the effect of replacing Nigerian brown beniseed cake (BSC) for soybean cake (SBM) in diets of broilers. Replacement levels of BSC for SBM in diets were 0%, 25%, 75%, and 100%. 150-d old unsexed broilers were randomly assigned to five treatment groups of 20 birds each, with three replicates of 10 birds each in a completely randomized design. Body weights at 28 d, 56 d, average daily feed intake (ADFI), and carcass weight were significantly ($P < 0.05$) higher for birds on control and 25% BSC diet compared to the other treatment groups; among which, 50% BSC and 75% BSC had no significant ($P>0.05$) difference, while 100% BSC replacement for SBM had consistently least significant ($P<0.05$) value. The hematological parameters showed no significant ($P>0.05$) difference among all the groups. This study thus showed that the Nigerian brown beniseed cake had positive benefit on broiler performance at replacement level of 25% for soyabean meal without negative effects on the health status of the birds at any level.

***Keywords:** Broiler, Beniseed cake (BSC), Soyabean meal (SBM), Growth performance, Carcass characteristics, Hematological indices.*

Description of Problem

Generally, due to constant competition between humans, industries and livestock/poultry for plant sources of food, there is need to identify varieties of plant energy and protein sources that are readily available and inexpensive, to meet the demand of chicken producers. While Soybean meal (SBM) generally constitute a major plant protein ingredient in most dietary feedstuffs fed to broiler chickens, maize constitute the main energy source. These plant sources of poultry feed which contribute over 90% of total cost of feed [1] are highly in competition between man, industry and poultry thereby making their prices high [2], thus resulting to investigations into alternative sources which are cheap like beniseed (Sesamum indicum L.) cake. Earlier, [3] identified agro-industrial by products such as beniseed cake (BSC) as a potential alternative protein feed stuff for animal production.

Some researchers reported that it is a source of edible oil, protein and carbohydrate [4, 5, 6, 7, 8], while some reported that its seed is rich in leucine, arginine and methionine, but relatively low in lysine [9, 10]. The plant is widely grown in the northern and central parts of Nigeria [11], and eaten in soups or processed into biscuits [12], sprinkles on bread, hamburger and pastries [13]. [14] reported that BSC provides nearly complete protein supplement for most farm animals comparable to soyabean meal.

Beniseed or sesame seeds are available in three major varieties based on husk colors: white sesame, black sesame, and golden (brown) sesame. Their flavor, color and other characteristics are slightly different [15] and the black and brown are generally believed to contain more oil than the white variety for which results of some researchers [4, 5. 6. 7. 8]

showed that the qualities when viewed from a range perspective may be the same.

The depth of literature on the use of Beniseed cake as substitute or replacement for soyabean meal is scanty in Nigeria. In this regard, some authors had reported the effects of white beniseed cake on poultry especially as a source of methionine for finisher broilers and laying hens [16, 17, 18, 19, 20, 21, 22, 23, 8, 2, 3]. [8] reported lower performance of broilers placed on 100% white BSC whilst those fed diets containing 25%, 50% and 75% BSC performed well. This study was therefore aimed at evaluating the effects of Nigerian brown beniseed cake as a replacement for soybean meal in broiler diets in order to add to the contribution of the earlier researchers.

Materials and Methods

Study Location

The study was carried out at the Teaching and Research Farm, Poultry Unit of the Department of Animal/Fisheries Science and Management. Faculty of Agriculture and Natural Resource Management. Enugu State University of Science and Technology.

Experimental Materials

One hundred and fifty (150) day old broiler chicks were used for the study. The chicks were purchased from a certified dealer in Enugu. They were raised in a deep litter system for eight (8) weeks. Food and water containing anti-stress agents (glucose) were provided ad libitum. Other management procedures such as vaccinations and daily cleaning of pens were strictly followed.

The beniseed was processed in a commercial company located in Makurdi, Benue State, Nigeria, where an oil expeller machine was used. Processing involved initial toasting of seeds for 10 min using a cylindrical pan to agitate the oil in the seeds, and thereafter the hot beniseed is transferred to the conical portion of the expeller; operated electrically to grind, press and release the oil through the right side of the perforated barrel while the beniseed cake (BSC) is expelled on the left side of the barrel.

Experimental Diets and Treatments

Five (5) experimental diets were formulated consisting of Treatment (T_1) with 0% inclusion of Beniseed cake as the control while T_2, T_3, T_4 and T_5 had 25%, 50%, 75% and 100% inclusion of Beniseed cake. Tables 1 and 2 shows the composition of the experimental diets.

Table 1: Composition of starter diets (0-4 weeks)

Ingredients	Treatments (%)				
	T_1	T_2	T_3	T_4	T_5
Maize	46	46	46	46	46
Beniseed meal	00	9	18	27	36
Soyobean meal	36	27	18	9	00
Fish meal	4	4	4	4	4
Wheat offal	9.1	9.1	9.1	9.1	9.1
Bone meal	2	2	2	2	2
Limestone	2	2	2	2	2
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Table 2: Composition of Finisher Diet (5-8 weeks)

Ingredients	Treatments (%)				
	T_1	T_2	T_3	T_4	T_5
Maize	52	52	52	52	52
Beniseed meal	00	6.5	13	19.5	26
Full Fat Soyobean?? (FFSB)	26	20.5	13.5	7	00
Fish meal	3	3	3	3	3
Wheat offal	13.5	13.5	13.5	13.5	13.5
Bone meal	2.1	2.1	2.1	2.1	2.1
Limestone	2.5	2.0	2.0	2.0	2.5
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.15	0.15	0.15	0.15	0.15
Methionine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100

Chemical analysis of test materials

Samples of BSC and SBM were analyzed for proximate composition in the Laboratory of the Department of Animal Science, University of Nigeria, Nsukka, Enugu State, using standard methods outlined by [24]. The moisture, crude protein, ether extract, crude fiber, ash and N free extract (NFE) contents were determined (Table 3).

Table 3: Proximate composition of beniseed cake and soyabean meal

Nutrients (%)	Beniseed meal (BSC)	Soyabean meal (SBM)
Dry Matter	91.13	88.95
Moisture	4.39	9.45
Crude protein	48.65	50.32
Ether Extract	12.21	7.33
Ash	6.12	5.22
Crude fibre	6.76	5.54
Nitrogen free extract	21.87	22.14

How many determinations. Provide SD values for each mean if it was done in duplicate or triplicates??

Management of experimental birds and design

One hundred and fifty (150) d-old broiler chicks procured from a reputable distributor in Enugu were used for the study. The chicks were brooded for the first week and fed experimental broiler starter diet during this period. Thereafter, the broiler chicks were randomly assigned to the four dietary treatments with 30 birds per treatment in a completely randomized design (CRD), and each treatment group replicated thrice, comprising of 10 birds. The experimental starter diets were fed from day 8 to day 28, while the experimental finisher diets were fed from day 29 to day 56, both provided with water ad libitum throughout the experiment. The birds were routinely vaccinated as

described by [25]. Electric bulbs and heaters were provided within the first 7 d of brooding, after which the nylon cover used to wrap around the brooder house in order to conserve heat during brooding was removed together with the heaters; and natural day light and ventilation allowed from then till the end of the feeding trial period.

Data collection and measurements

Data were collected on daily and weekly basis for feed and growth performance, while at the end of the 56 day period for the finishers, the birds were slaughtered and the carcass characteristics determined. The following parameters were measured: ***Weight gain*** was determined as the Final weight – Initial weight. ***Feed intake*** was calculated on a daily basis as Weight of feed offered – weight of the leftover feed. ***Feed conversion ratio*** was calculated as Feed intake / Weight gain

Carcass characteristics: At the end of 56 days, 3 birds were randomly selected from each replicate, starved of feed for 12 hours, slaughtered, eviscerated and the carcass weight determined. The dressing percentage was calculated as

Dressing % = carcass weight/live weight x 100

Hematological parameters: Two birds were selected from each replicate and blood samples collected through brachial vein puncture with a 5ml needle into a sterilized glass tubes containing EDTA (ethylenediamine tetra acetic acid) for determination of the hematological parameters as outlined by [26].

Statistical analysis

Data were analyzed using ANOVA for a complete randomized design according to [27]. Treatment means were separated using Duncan multiple range test 5% level of significance.

Results and Discussion

The proximate composition of beniseed cake shown in Table 3 revealed that the composition falls within the range cited for brown beniseed variety. Hence the nutrient (proximate) compositions of the diets are adequate and within the recommended range for broilers as cited in appendix 1.

Growth at Starter and Finisher Stages

The 100% replacement of BSC for SBM was significantly ($P<0.05$) lowest compared to other treatments for AFW28/56, ADWG28/56, ADFI28/56 and FCR28/56 (Tables 4 &5). Meanwhile, 0 and 25% replacement of BSC for SBM though not significantly ($P>0.05$) different, were significantly ($P<0.05$) highest compared to other treatments for AFW28/56, ADWG28/56, ADFI28/56 and FCR28/56 (Tables 4 & 5). 50% and 75% replacement of BSC to SBM were significantly ($P<0.05$) lower than 0% and 25% but significantly ($P<0.05$) higher than 100% replacement level (Tables 4 & 5).

Table 4: Growth performance of broiler starter chickens fed graded levels of beniseed as replacement for soyabeans (0-4 weeks)

Parameters	Treatments					
	T_1(0%)	T_2(25%)	T_3(50%)	T_4(75%)	T_5(100%)	SEM
Average final weight (g)	968.18^a	896.52^a	773.34^c	476.06^d	411.49^d	111.62
Initial average weight (g)	46.87	45.96	47.15	46.69	47.43	0.25
Average daily weight gain (g)	32.90^a	30.38^a	25.93^b	15.33^c	13.00^c	3.99
Average daily feed intake (g)	43.30^a	42.91^a	40.92^b	39.05^b	37.64^c	1.20
Feed conversion ratio	1.32^a	1.41^a	1.58^b	2.55^c	2.89^c	0.32

a, b, c, d Means on the same row with different superscripts are significantly ($P<0.05$) different.
SEM Standard error of mean

Table 5: Growth performance of broiler finisher chickens fed graded levels of beniseed as replacement for soyabeans (5-8 weeks)

Parameters	Treatments					
	T_1(0%)	T_2(25%)	T_3(50%)	T_4(75%)	T_5(100%)	SEM
Average final weight (g)	2674.13[a]	2542.64[a]	2283.71[b]	1910.43[c]	1518.01[d]	14.47
Initial average weight (g)	968.18[a]	896.52[a]	773.34[c]	476.06[d]	411.49[d]	11.62
Average daily weight gain (g)	60.93[a]	58.79[a]	53.94[b]	51.23[b]	39.52[c]	3.38
Average daily feed intake (g)	135.95[a]	134.41[a]	124.34[b]	114.78[b]	100.11[c]	6.65
Feed conversion ratio	2.23[a]	2.29[a]	2.31[a]	2.24[a]	2.53[b]	0.07

a, b, c, d Means on the same row with different superscripts are significantly (P<0.05) different.
SEM Standard error of mean

In all the growth parameters, the control and 25% BSC fed broilers performed significantly (P<0.05) better than the other treated groups. The least AFW28/56, ADW28/56, ADFI28/56 and FCR28/56 was when BSC was replaced 100% for SBM. This may be due to reduced feed intake at higher BSC replacement level occasioned by the un-palatable, fibrous and oily nature of the diet. This is similar to findings by [28, 29] that chickens fed 100% macadamia oil cake and sesame white seed cake [8] exhibited depressed feed intake and retarded growth, which was ascribed to high fiber content of the meal. Some reports [30, 20] also indicated a depressed performance in broilers when BSC totally replaced SBM.

There was an observed lower body weight with increasing BSC from 0-100%. This agrees with [31], who reported the trend of a lower body weight and feed conversion efficiency when increasing levels of BSC were introduced in broiler starter, grower and finisher diets. However, previous BSC studies revealed that layer hens tolerated higher levels of BSC [19, 20], without adversely deviating from their control groups' counterparts. This corroborates the findings of [32] that a combination of 23.5% soybean meal extraction and 28.2% sesame meal as a protein supplement in broiler ration was economical and gave maximum performance in broilers; while [33] concluded that macadamia oil cake meal at 25% inclusion level can improve performance of broiler chickens.

This result of decreasing body weight with increasing BSC level when compared to [8] who found increasing body weight from 25% - 75% BSC inclusion level may imply that the difference in variety (brown vs white beniseed) may have contributed to the difference in results. Another possible explanation might be due to the known negative effect of anti-nutritional factor on digestibility of nutrients. It is known that broilers consuming more phytate based diets tend to have reduced growth as a result of reduced protein digestibility [34].

Carcass Characteristics

For the carcass weights and dressing percentages, 0% and 25% replacement of BSC for SBM was significantly (P<0.05) highest than other treatments, and lowest for 100%. 50% and 75% replacement levels were significantly (P<0.05) lower than 0% and 25% but higher than 100% (Table 6). For the prime cuts, 0% and 25% replacement of BSC for SBM were significantly (P>0.05) comparable in most of the weights and higher when compared to the other treatments; 100% was significantly (P<0.05) lowest, while there was no trend for 50% and 75% replacement levels.

Furthermore, in Table 7 for the organ weights, 100% replacement of BSC for SBM was significantly (P<0.05) lowest compared to other treatments which amongst themselves, did not show any trend.

Table 6: Carcass characteristics of broiler chicks fed graded levels of beniseed as replacement for soyabeans

Parameters	Treatments					
	T_1(0%)	T_2(25%)	T_3(50%)	T_4(75%)	T_5(100%)	SEM
Live weight (kg)	2674.13^a	2542.64^a	2283.71^b	1910.43^c	1518.01^d	214.47
Carcass weight (kg)	2292.18^a	2186.67^a	1925.76^b	1609.44^c	1134.09^d	197.5
Dressing percentage (%)	85.71^a	85.99^a	84.33^b	84.25^b	74.71^c	1.05
Prime cuts						
Head weight (g)	47.49	44.89	46.48	39.86	30.88	3.09
Neck weight (g)	74.37	77.20	81.48	56.57	42.72	7.30
Breast muscle (g)	409.11^a	326.86^b	360.18^b	242.29^c	202.56^d	37.90
Drumstick weight (g)	117.02^a	106.41^a	100.83^b	92.95^b	61.37^c	9.40
Thigh weight (g)	114.50^a	106.12^b	94.95^c	91.13^c	55.84^d	10.05
Leg weight (g)	36.31^a	34.88^a	33.49^a	31.53^a	19.67^b	2.98
Back weight (g)	360.00^a	280.00^b	248.06^c	263.00^b	154.52^d	31.44
Wing weight (g)	83.60^a	71.33^b	69.35^b	57.69^c	35.30^c	8.15

a, b, c, d Means on the same row with different superscripts are significantly (P<0.05) different.
SEM Standard error of mean

Table 7: Organ weights of broiler chicks fed graded levels of beniseed as replacement for soyabeans

Parameters	Treatments					
	T_1(0%)	T_2(25%)	T_3(50%)	T_4(75%)	T_5(100%)	SEM
Organ Weights						
Liver weight (g)	32.23^a	23.73^c	27.53^b	25.44^b	22.25^c	1.75
Gizzard weight	45.95^a	37.51^b	46.66^a	34.31^b	28.24^c	3.51
Heart weight (g)	8.77^b	6.29^b	11.56^a	6.78^b	5.58^c	1.10
Kidney weight (g)	2.62^b	1.32^c	3.87^a	1.38^c	0.97^d	0.54
Bile weight (g)	3.77^a	2.26^c	5.07^a	2.14^c	2.12^c	0.59
Abdominal fat (g)	20.61	22.04	18.76	12.03	14.91	1.20

a, b, c, d Means on the same row with different superscripts are significantly (P<0.05) different.
SEM Standard error of mean

The effect of replacing BSC on carcass weights and dressing percentage shows significantly (P<0.05) superior performance in favour of control and 25% BSC, followed by 50% and 75% which amongst themselves did not differ (P>0.05), while 100% replacement level was consistently lowest. Earlier [23] reported that there was no difference between control and treated groups studied, but the current result partially agrees with the work of [8] who found lowest carcass weight and dressing percentage for chickens fed on 100% BSC based diet. However, it disagrees with their views that the differences did not follow any trend as the current result showed the control and 25% BSC being significantly (P<0.05) heavier, while 50 -75% did not differ (P>0.05) from each other.

On the other hand, results of prime cuts and organ weights showed inconsistencies. Interestingly, 100% BSC replacement of SBM still was consistently and significantly (P<0.05) lowest than other treatments. This was contrary to the work of [8] who found non-significant (P>0.05) differences among the treatments except in abdominal fat.

Hematological Parameters

In Table 8 for the hematological indices, the differences observed were not significantly (P>0.05) different in all the parameters. The result did not follow any trend and was contrary to the works of [8] who found significant (P<0.05) effect on WBC with increased levels of BSC substitution (25%-100% substitution).

Table 8: The hematological indices of the broiler chickens fed varying levels of BSC in replacement of SBM

Parameters	Treatments					
	T_1(0%)	T_2(25%)	T_3(50%)	T_4(75%)	T_5(100%)	SEM
PCV (%)	27.08	27.38	26.25	25.28	27.15	0.39
WBC (10^3/µ)	133.20	135.30	134.20	126.15	136.58	1.82
RBC (10^3/µ)	0.55	0.59	0.45	0.47	0.75	0.05
MCHC (%)	38.80	41.35	43.08	43.70	46.15	7.44
Hb (g/dl)	19.1	8.30	7.95	7.75	8.55	0.33

SEM Standard error of mean

The non-significant (P>0.05) differences in all treatments on the hematological profile of the birds was contrary to the works of [8] but similar to the values reported by [35] and [16]. Meanwhile, while the values of all hematological parameters fall within the normal range as reported by [36, 37], WBC value was high above the normal ranges reported by them. This high WBC value was similar to the reported value by [8] and might suggest the peculiar reaction of the chickens to the environment of the South eastern Nigeria. On the other hand, [38] explained that a highly significant value of WBC with increased levels of BSC substitution (25%-100% substitution) may be due to increased secretion of cells in the blood due to increased levels of anti-nutritional factors (phytate) found in the BSC based diets.

Conclusion and Applications

1. This study has shown that the Nigerian brown beniseed cake had positive benefit on broiler performance at replacement level of 25% for soyabean meal which is within the reported range of some literatures using other varieties of beniseed.
2. It showed that the beneficial effect at 25% BSC declined from 50% - 100% replacement of SBM resulting to poor performance of the birds with increasing BSC level.
3. It did not however have any deleterious effect on the health status of the broilers.
4. These results suggest that BSC can be reasonably included in broiler diets up to 25% BSC inclusion level without adversely affecting the blood profile of the broiler birds.
5. Further study is recommended on the use of brown BSC in broiler diet supplemented with exogenous enzymes to investigate its effect at higher level of replacement.

References

1. Mengesha, M. (2012). Feed resources and chicken production in Ethiopia. *Worlds Poultry Science Journal 68:491-501.*

2. Mahmoud, K.Z., Obeidat, B.S., and Ishmais, M.A. (2015). Roasted sesame hulls improve broiler performance without affecting carcass characteristics. *Italian Journal of Animal Science 14:495-501.*

3. Rao, S.R., Raju, M., and Panda, A. (2008). Utilisation of sesame (Sesamum indicum) seed meal in broiler chicken diets. *British Poultry Science 49:81-85.*

4. Aglave, H. R. (2018). Physiochemical characteristics of sesame seeds. *Journal of medicinal plants studies. 6(1): 64-66.*

5. Christian, E. E., Stanley, C. and Emmanuel, C. (2019). Proximate and Mineral Composition of Sesamum Indicum L. Seed. *Medicinal & Analytical Chemistry International Journal. 3(4): 000152.*

6. Mbabie, B., Omosun, G.Uti, A. and Oyedemi, S. (2010). Chemical composition of Sesamum indicum L. (Sesame) grown in southeastern Nigeria and the physicochemical properties of the seed oil. *Seed science and biotechnology. 4(1): 69-72.*

7. Njoku, O. U., Boniface, J. A. E., Obitte, N. C., Odimegwu, D. C. and Ogbu, H. I. (2010). Some nutriceutical potential of beniseed oil. *International journal of applied research in natural products. 2(4): 11-19.*

8. Okoro, V., Akwukwuegbu, S., Mabajiorgu, C. and Anyanwu, G. (2017). Substitution and optimization of Nigerian white beniseed Sesamum indicum L.) cake for soybean meal in Cobb broiler diets. *Journal of Agricultural Research. 77(4): 365-372.*

9. McDonald, P., Edwards, R. A. and Greenhalgh, J. F. D. (1998). Animal Nutrition. Fifth Edition. Pearson Education Ltd., Malaysia. pp. 230-525.

10. Robbelen, G., Downey, R. K. and Asnri, A. (1989). Oil crop of the world. McGraw-Hill Publishing Company. pp: 377-386.

11. Nalim, M. (2007). Thermal-Boundary-Layer Response to Convected Far-Field Fluid Temperature Changes. *Journal of Heat Transfer. 130, 101001.*

12. Kanu, P. J. (2011). Biochemical analysis of black and white sesame seeds from China. *American Journal of Biochemistry and Molecular Biology. 1: 145 – 157.*

13. Salunkhe, D. K., Chavan, J. K., Alsuia, N. and Kadam, S. S. (1991). Sesame. In: World Oilseeds: History, Technology and Utilization. Van Nostrand Reinhild, New York, pp: 371-402.

14. Dipasa, B. M. (2003). Sesame honey bits. www. Dipasa.nl/seshobit htm. 3-9.

15. Langham, D. (2007) . Phenology of sesame. Reprinted from issues in new crops and new uses. 2007. 120-132 p. Janick, J., and Whipkey, A. (eds.) ASHS Press, Alexandria, Virginia, USA.

16. Yakubu, B., and Alfred, B. (2014). Nutritional evaluation of toasted white sesame seed meal Sesamum indicum as a source of methionine on growth performance, carcass characteristics. IOSR. *Journal of Agriculture and Veterinary Science 7:46-52.*

17. Agbulu, O., Gyau, A., and Abakura, J. (2010). Effect of the replacement of sesame seed for methionine in broiler production in middle belt region-Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies 1:16-21.*

18. Diarra, S., and Usman, B. (2008). Performance of laying hens fed graded levels of soaked sesame (Sesamum indicum) seed meal as a source of methionine. *International Journal of*

Poultry Science 7:323-327

19. Tangtaweewipat, S., and Cheva-Isarakul, B. (1993). Sesame meal as soybean meal substitute in poultry diets. *Asian-Australasian Journal of Animal Science 6:253-258.*

20. Mamputu, M., and Buhr, R. (1995). Effect of substituting sesame meal for soybean meal on layer and broiler performance. *Poultry Science 74:627-684.*

21. Farran, M., Uwayjan, M., Miski, A., Akhdar, N., and Ashkarian, V. (2000). Performance of broilers and layers fed graded levels of sesame hull. *Journal of Applied Poultry Research 9:453-459.*

22. Yamauchi, K., Samanya, M., Seki, K., Ijiri, N., and Thongwittaya, N. 2006. Influence of dietary sesame meal level on histological alterations of the intestinal mucosa and growth performance of chickens. *Journal of Applied Poultry Research 15:266-273.*

23. Nikolakakis, I., Bonos, E., Kasapidou, E., Kargopoulos, A. and Mitlianga, P. (2014). Effect of dietary sesame seed hulls on broiler performance, carcass traits and lipid oxidation of the meat. *European Poultry Science 78: 1612 - 9199*

24. AOAC. (1995). Official methods of chemical analysis. Association of Official Analytical Chemists, Arlington, Virginia, USA.

25. Oluyemi, J., and Roberts, F. (2000). Poultry production in warm wet climates. 2nd ed. Macmillan Press, London, UK.

26. Braggs C. and Bain B. J. (2012). Basic Haematological Techniques. In: Bain B. J., Bates I., Laffan M. A: Dacie and Lewis – Practical Haematology. 11th ed., pp 18-49.

27. Steel, R. G. D. and Torrie, J. H. (1980). Principles and procedures of statistics. 2nd ed: London. McGraw-Hill.

28. Phosa, M. (2009). The nutritive value of macadamia oil cake meal and wood ash as alternative feed ingredients for chickens in rural areas. University of Pretoria, Pretoria, South Africa.

29. van Ryssen, J., Phosa, M., and van Rensburg, C. (2014). Different levels of macadamia oil cake meal, and wood ash vs. feed lime as dietary sources of calcium on bone characteristics of slow growing chickens. *South African Journal of Animal Science 44:71-79.*

30. Kaneko, K., Yamasaki, K., Tagawa, Y., Tokunaga, M., Tobisa, M., and Furuse, M. (2002). Effects of dietary sesame meal on growth, meat quality and lipid accumulation in broilers. *Journal of Poultry Science 39:56-62.*

31. Rahimian, Y., Tabatabaie, S., Valiollahi, S., Toghiani, M., Kheiri, F., Zamani, F., et al. (2013). Effect of cumulative levels of sesame (Sesamum indicum) meal with phytase enzyme on performance of broiler chicks. *Scientific Journal of Veterinary Advances 2:178-188.*

32. Baghel, R., and Netke, S. (1987). Economic broiler ration based on vegetable proteins. Indian Journal of Animal Nutrition 4:24-27.

33. Acheampong-Boateng, O., Bakare, A., and Mbatha, K. (2016). The potential of replacing soybean oil cake with macadamia oil cake in broiler diets. *Tropical Animal Health and Production 48:1283-1286.*

34. Hossain, M., and Jauncey, K. (1989). Nutritional evaluation of some Bangladeshi oilseed meals as partial substitutes for fish meal in the diet of common carp, Cyprinus carpio L. *Aquaculture Research 20:255-268.*

35. Banerjee, G. (1998). Feeds and principles of animal nutrition. Revised edition. Oxford & IBH Publishing, New Delhi, India.

36. Talebi, A., Asri-Rezaei, S., Rozeh-Chai,

R. and Sahraei, R. (2005). Comparative Studies on Haematological Values of Broiler Strains (Ross, Cobb, Arbor-acres and Arian). *International Journal of Poultry Science 4 (8): 573-579.*

37. Bounous D, Stedman N. (2000). Normal avian hematology: chicken and turkey. In: Feldman BF, Zinkl JG, Jain NC, editors. Schalm's veterinary hematology. New York: Wiley; p.1147-1154.

38. Adejumo, D. (2004). Performance, organ development and hematological indices of rats fed sole diets of graded levels of cassava flour and soybean flour (soygari) as substitutes for energy and protein concentrates. *Tropical Journal of Animal Science 7:57-63.*