Asian Journal of Research in Animal and Veterinary Sciences

1(3): 215-222, 2018; Article no.AJRAVS.43468

Effects of Dietary Levels of Doum Palm Pulp Meal (*Hyphaene thabaica)* Supplementation on the Performance of Broiler Chickens

Abdulsalam Ibrahim[1], Magaji Muktar Yahya[2] and Bah Sani Usman[3*]

[1]Department of Animal Science, College of Agriculture, Gujba, Yobe State, Nigeria.
[2]Department of Animal Science, Modibbo Adama University of Technology, Yola, Adamawa State, Nigeria.
[3]Desert Research Monitoring and Control Centre, Yobe State University, Damaturu, Yobe State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author AI designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors MMY and BSU performed the statistical analysis and managed the analyses of the study. Author BSU managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAVS/2018/43468
Editor(s):
(1) Dr. Fabio da Costa Henry, Associate Professor, Technology of Animal Products, State University of Northern of Rio de Janeiro, UENF, Brasil.
Reviewers:
(1) P. Chisoro, Aarhus University, Denmark and Wageningen University, Netherlands.
(2) Juan Carlos Troiano, University of Buenos Aires, Argentina.
(3) Ioniță Lucian, Romania.
Complete Peer review History: http://www.sciencedomain.org/review-history/26897

Original Research Article

Received 22 July 2018
Accepted 09 September 2018
Published 29 October 2018

ABSTRACT

The study was carried out to evaluate the effect of Doum palm pulp meal *(Hyphaene thabaica)* supplementation on growth performance in broiler chickens. A total of two hundred day old unsexed strain of Anak 2000 broiler chicks were subjected to 49-day study period. Chicks were randomly allotted to five dietary treatments with 10 birds per replicate and 40 birds per treatment in a completely randomized design (CRD). The levels of Doum palm inclusion were 0.0, 5.0, 7.5, 10.0 and 12.5% coded as (treatment 1 to 5) T1, T2, T3, T4 and T5 respectively. The birds in all groups were reared under deep litter system; feed and water were provided *ad-libitum.* Dietary Doum palm was not significant (*P*>.05) in terms of weight gain and feed intake in the same vein, the feed

**Corresponding author: E-mail: saniusmanbah@gmail.com;*

conversion ratio was not significantly altered at the starter phase of the study. At the finisher phase weight gain and feed conversion ratio were significant at (P<.01) and (P = .05) respectively, while daily feed intake was not affected. Birds on T4 had the highest daily weight gain (43.75g) while those on T1 had the lowest (33.97g). The same trend was elicited for feed conversion ratio with T4 haven the inferior value (1.22) while T1 was (1.44). The economic analysis showed significant variation in feed cost per kg in terms of broiler production across treatment groups. Feed cost kg/gain appeared to be higher in T1 (₦ 516.17) while lowest in T4 (₦ 267.92) this showed that increased level of Doum palm pulp meal will not increase the cost of production. Doum palm supplementation in broiler diets could improve growth performance especially in the level of 10.0% that was found to be better than the control and other treatment groups. It is therefore recommended that 10% level of inclusion of Doum palm pulp meal could be used in compounding broiler feeds.

Keywords: Doum palm pulp meal; broilers; growth performance and economic analysis.

1. INTRODUCTION

Broiler productions represent one of the most economic and easiest means of bridging the supply and demand gap of animal protein, due to their rapid growth rate and efficient feed conversion. In addition, compared to their rapid growth rate, broilers enjoy a relative advantage of easy management, quick return to capital investments and wide acceptance of its meat for human consumption. However, in spite of these enormous potentials, broiler production in many tropical and sub-tropical countries is affected by scarcity and the high cost of conventional feed ingredients [1]. However, the importance of poultry to the national economy cannot be overemphasized, as it has become popular industry for the small holders that have a great contribution to the economy of the country [2].

Most tropical countries have a shortage of conventional protein and energy concentrates like soya beans meal and maize. The competition between man and poultry for food ingredients is due basically to insufficient production of the feed items locally. Indeed the use of grains for feeding poultry when human needs have not been met raises questions of economic and moral justification.

Doum fruit (*Hyphaene thebaica*) is a good source of essential minerals such as potassium, sodium, calcium, magnesium and phosphorous. Furthermore, Doum fruit has shown to provide essential B-complex vitamins, carbohydrate and fibres essential for good nutrition. Doum fruit possess good functional properties which can be used for various important applications in food industry [3]. Doum palm (*Hyphaene thebaica*) is a desert palm native to Egypt, sub Saharan Africa and west India, it is known in Egypt as the Doum or Ginger bread palm which grows to a height of 6 or 9 m and usually has forked of stems with fan shaped leaves, 65 to 75 cm long. It is listed as one of the useful plant of world [4]. Therefore, in view of the potentially beneficial effects of Doum palm pulp meal supplementation, the present study was undertaken to find out the effects of Doum palm pulp meal supplementation on body weight gain, feed consumption, feed conversion ratio, mortality and cost of broiler production in unsexed strain of 'Anak 2000'broiler chickens.

2. MATERIALS AND METHODS

The study was carried out in the poultry production unit of the Teaching and Research Farm of the Department of Animal Science and Range Management, Modibbo Adama University of Technology (MAUTECH) Yola, Adamawa State, Nigeria. Two hundred unsexed strain of Anak 2000 broiler chicks were randomly allotted to five diets in which Doum palm pulp meal was incorporated at 0.0, 5.0, 7.5, 10.0 and 12.5% designated as diets 1, 2, 3, 4, and 5 respectively. Person's square method of feed formulation was used in formulating the feed taking into consideration the contribution of nutrients from all the ingredients, age of the animals and environmental factors. Diets were compounded using graded levels of Doum palm pulp meal and it was ensured that the diets meet the requirements of broiler production in the tropics as reported by Aduku [15]; Olomu [7]; and NRC [8].

The dried Doum palm fruits were purchased from the local market at Gashua, Yobe state, Nigeria, it was sorted and some were rejected. Using mortar and pestle the pulp was separated from the kernel and the sample was (Doum palm pulp)

then ground into fine particles called the Doum palm pulp meal. Finally, the pulp meal was boiled for 20 to 30 minutes at a relatively low temperature to reduce the level of anti-nutritional factors. It was later sundried for the period of 3 to 4 days before it was used for feed compounding.

Before the arrival of the chicks, the pen was thoroughly swept, washed and disinfected, so as to eliminate any disease causing organisms present that may be a source of infection to the chicks. After three days when the pen is dried, wood shaving was spread on the cemented floor to a depth of about two to three centimeters (2 – 3 cm) to serve as an insulator and also absorb moisture from droppings, it was covered with an old newspaper to avoid it been eaten by the chicks. All brooding equipment were cleaned, washed and disinfected. A medium size infrared was used as a source of heat. Flat feeding trays and plastic drinkers were used for feeds and water in the brooding pen. On arrival, chicks were given feed and water containing anti-stress to relieve them of transit stress. Subsequently, as the birds grow, they were switched over to bigger cone shaped plastic feeders and drinkers, similarly all brooding management was strictly taken into consideration. All vaccines were administered in clean drinking water and proper sanitation was maintained during the study period. The litter materials were changed periodically while feeders and drinkers routinely cleaned.

Based on the vaccination schedule for north eastern Nigeria chicks were vaccinated against infectious busal disease (IBD) and Newcastle disease. Feed and water were given *ad-libitum* and the study lasted for the period of seven weeks. The extension to seven week was due to the heat stress (tropic) experience by the birds toward the end of the study (39 – 40ºC), which consequently reduces feed intake and thereby general performance.

During the study, data were collected on growth performance which includes: feed intake that was measured on daily basis by subtracting leftover from feed served per group adequate measures were taken to minimised feed wastage.

Feed intake = Feed offered (g) – Feed leftover (g)

Body weight gain, the birds were weighted to determine their initial weight thereafter weekly to determined weekly weight gain the difference between preceding weight and the initial weight gave the weekly weight gain.

Body weight gain = Current body weight (g) – previous body weight (g)

Table 1. Ingredients composition (%) of broiler starter and finisher diets

Ingredients (%)	Starter diets					Finisher diets				
	1	2	3	4	5	1	2	3	4	5
Maize	52.50	46.50	43.00	40.00	37.00	52.50	46.50	43.00	40.00	37.00
Soya bean	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Wheat offal	5.70	5.70	5.70	5.70	5.70	10.00	10.00	10.00	10.00	10.00
Fish meal	7.0	7.0	7.0	7.0	7.0	2.0	2.0	2.0	2.0	2.0
Bone meal	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Lime stone	0.75	0.75	0.75	0.75	0.75	2.0	2.0	2.0	2.0	2.0
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.35	0.35	0.35	0.35	0.35	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Groundnut cake	18.0	19.0	20.0	20.5	20.5	18.0	19.0	20.0	20.5	20.5
Palm oil	3.0	3.0	3.0	3.0	3.0	3.50	3.50	3.50	3.50	4.0
Doum palm	0.0	5.0	7.5	10.0	12.5	0.0	5.0	7.5	10.0	12.5
Total	100	100	100	100	100	100	100	100	100	100

Vitamin /minerals premix each kg contains; vitamin A500 iμ, vitamin D3,888000 iμ, vitamin E,12,000mg, vitamin K3, 15,000 mg, vitamin B1, 1000 mg, B2, 2000 mg, vitamin B6, 1500 mg, Niacin, 12000 mg, Pantothenic acid, 2000 mg, Biotin, 1000 mg, vitamin B12, 3000 mg, Folic acid 1500 mg, Choline chloride< 60,000 mg, Manganese, 10,000 mg Iron, 1500 mg, Zinc, 800 mg, Copper 400 mg, Iodine, 80 mg, Cobalt 40 mg, Selenium, 8000mg.

Table 2. Calculated values of ingredients composition of broiler starter and finisher diets

Ingredients (%)	Starter diets					Finisher diets				
	1	2	3	4	5	1	2	3	4	5
Crude protein	23.00	23.00	23.00	23.00	23.00	20.00	20.00	20.00	20.00	20.00
ME (kcal/kg)	3120	3053	2948	2987	2940	3040	2973	2940	2907	2900
Crude fiber (%)	4.10	4.77	5.11	4.81	5.43	4.28	4.98	5.27	5.59	5.93
Calcium (%)	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29	1.29
Phosphorus (%)	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Lysine (%)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Methionine (%)	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86

Feed conversion ratio which is the index of feed utilisation and was obtained on a weekly basis. It is measured by dividing the mean feed intake by mean live weight gain for each treatment group using the following relation:

$$\text{Feed conversion ratio} = \frac{\text{Mean feed intake (g)}}{\text{Mean weight gain (g)}}$$

All data generated from the study were subjected to analysis of variance as described by Steel and Torrie [5]. Means were separated using Duncan's Multiple Range Test, where significant differences exist. The percentage ingredients compositions of starter and finisher diets are presented in (Tables 1 and 2).

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Doum Palm Pulp Meal

The result of the proximate composition of Doum palm pulp meal is presented in Table 3 and analyzed according to (AOAC, 2000) [6], the result showed that Doum palm pulp meal was low in protein (2.92) but an excellent source of energy. The ingredient was used as an energy source due to the fact that it contained a high amount of (metabolisable energy) of 2254.5kcal/kg as shown in (Table 2), the content of the Doum palm pulp meal may significantly induce an increase in body weight because of the nature and variety of nutrients it supply.

3.2 Proximate Composition of Experimental Broiler Starter and Finisher Diets

The result of chemical composition of the starter and finisher diets as analyzed according to (AOAC, 2000) [6] showed the crude protein of the starter diets ranges from 23.66 to 23.30% and that of finisher diets was 19.20 to 20.40% while, the metaboliserble energy was found to be 2962.58 to 3142.52 and 2915.65 to 3174.10 kcal/kg in starter and finisher diets respectively. The chemical composition revealed that the crude protein (23% starter diets, 20% finisher diets) and metaboliserble energy value of about 2900 kcal/kg as well as other parameters met the requirement for broiler production under the tropical environment (Olomu, 1995 [7]; NRC [8].

3.3 Performance of Broiler Chicks Fed Diets Containing Different Levels of Doum Palm Pulp Meal

3.3.1 Feed intake

The average daily feed intake of broiler chicken fed graded levels of dietary Doum palm pulp meal in the study showed non-significant difference (P>.05) across the treatments. The decrease in feed intake across the dietary treatments may probably be because of increase in fibre level and decrease in the energy level as the Doum palm pulp meal increased in the dietary treatments which may have affected the palatability which agrees with the report of Kwari and Igwebuike [9] they reported a decrease in feed intake with an increase in the dietary levels of Parkia pulp. On the other hand feed intake in finisher diets fed graded levels of Doum palm pulp meal also show non-significant (P=.05) difference across the treatment groups. This agrees with the report of Olajide [10] who reported that the non-significant (P =.05) difference in feed intake could point to better ability of these older birds (finishers) to tolerate contents of anti-nutritional factors in soaked wild Cocoyam corms.

3.3.2 Weight gain

The result of the study on daily weight gain for broiler starter fed graded levels of dietary Doum palm pulp meal were not significant (*P*>.05) across the treatment groups. The result of the study is in agreement with the report of Kwadwo et al. [11] who reported no significant (*P*>.05) difference with regards to an average daily weight gain of broiler starter when cockerels were fed graded levels of tiger nut meal. The daily weight gain in broiler finisher and overall performance fed graded levels of Doum palm pulp meal showed significant (*P* = .05) difference across the dietary treatment with the highest weight gain obtained in T4 (43.75 and 34.63) respectively. The result of the study agrees with that of Kwari and Igwebuike [9] who reported an increase in daily weight gain as level of Parkia pulp increased across the dietary treatments. This may be due to palatability; nature and variety of nutrients supply by Doum palm pulp meal and essentially Doum palm contained a high amount of energy, provide essential B-vitamins and save as antioxidant. Therefore, Doum palm pulp meal (DPPM) may be a good dietary energy source for optimal growth of broiler chickens.

3.3.3 Feed conversion ratio

In the study, non-significant difference (*P*>.05) was observed in the starter phase for the feed conversion ratio (FCR) among the treatments groups and this was probably due to the uniformity of nutrients in the feed. The result in the current study was also in agreement with the study of Jacob et al. [12] who reported non-significant difference (*P*>.05) in feed conversion ratio for Hubbard Classic broiler chicks and the result of Okeye et al., [13] who also reported no significant difference (*P*>.05) in feed conversion ratio when Maize replaced Sorghum up to 20% level of inclusion. Feed conversion ratio at the finisher stage showed significant (*P* = .05) difference with a highest value 3.64 observed in T1the higher value observed may be attributed to the effect of heat stress experienced by the birds towards the end of the study this was in line with the study conducted by Lucas et al., [14] who reported that broiler subjected to heat stress had significantly (*P* = .05) reduced feed intake and higher feed conversion ratio (2.56%) at 42 days of age. This was in agreement with the climatic condition found in Yola Adamawa State Nigeria. Adamawa State has a maximum temperature between 38 to 40^{o}C, with an altitude 299 meters above the sea level (www.adamawastate.gov.ng, [16].

3.3.4 Mortality

The cumulative mortality rate was lower in the birds of treatment 3, 4, and 5 than the control group. There was no mortality in starter phase whereas, in the finisher phase thirteen birds were recorded, four out of the thirteen birds were from the control group. This may be attributed to the effect of heat stress experienced by the birds towards the end of the study.

Table 3. Proximate Composition of Doum palm pulp Meal

Nutrients	Percentage composition (%)
Protein	2.92
Fat	0.49
Calcium	0.15
Moisture	10.42
Ash	7.37
Crude fibre	15.14
ME (Kcal/kg)	2254.5

ME: Metabolizable Energy

Fig. 1 showed the daily weight gain in broiler starter which was not significant across treatment groups whereas, the weight gain in broiler finisher was significantly (*P* = .05) different when compared to the control diet. The daily weight gain and feed conversion ratio in the overall performance in Fig. 2 indicate that daily weight gain increased across the treatment with the highest gain in treatment four in the same vein feed conversion ratio was observed to be lower (2.43) and this indicate the lower the feed conversion ratio the better the feed utilization.

3.4 Economic Analysis

Feed cost/kg (FC) and Total feed cost (TFC) were higher in T1 (₦179.13 and ₦ 784.58) respectively. Feed cost (kg/gain) was also higher in T1 (₦516.17) the result showed that feed cost per kg gain decreases as the level of Doum palm pulp meal was increased. Lower cost/kg gain revealed a reduction in the cost of production, better performance and lower FCR obtained in T5 (₦267.92/gain) where inclusion level of maize was reduced significantly.

Table 4. Performance of broiler chickens fed diets containing graded levels of Doum palm pulp meal

Parameters	Diets					P - Values	SEM
	1	2	3	4	5		
Initial weight (g)	150.75	147.75	145.00	148.00	152.25	0.164	2.05^{NS}
Week 4 weight (g)	805.75	780.00	766.50	778.25	798.00	0.658	21.10^{NS}
Final weight (g)	956.50	927.75	911.50	926.25	950.25	0.741	23.64^{NS}
Starter phase							
DFI (g)	64.06	63.83	64.05	63.98	64.68	0.692	0.43^{NS}
DWG (g)	28.52	27.85	27.37	27.79	28.50	0.996	2.44^{NS}
FCR	2.22	2.29	2.30	2.30	2.26	0.827	0.06^{NS}
Mortality (No)	0	0	0	0	0	-	-
Finisher phase							
DFI (g)	123.56	115.25	120.24	111.31	117.10	0.599	5.57^{NS}
DWG (g)	33.97^{d}	39.57^{bc}	36.12^{cd}	43.75^{a}	40.35^{ab}	0.351	1.17^{*}
FCR	3.64^{a}	2.91^{ab}	3.32^{ab}	2.54^{b}	2.90^{ab}	0.110	0.24*
Mortality	4	3	2	2	2	-	-
Overall performance							
DFI (g)	44.78	42.93	44.06	42.14	43.57	0.917	1.13^{NS}
DWG (g)	31.00^{b}	32.87^{ab}	31.12^{b}	34.63^{a}	33.57^{a}	0.035	0.67**
FCR	1.44^{a}	1.30^{abc}	1.41^{ab}	1.22^{c}	1.29^{bc}	0.314	0.04*
Mortality (No)	4	3	2	2	2	-	-

a,b,c = means within the same raw bearing different superscripts differ significantly (P= .05), (P<.01)**,(P<.001)***.ns = not significant, DWG = daily weight gain, DFI = daily feed intake, FCR = feed conversion ratio, SEM = standard error of mean.*

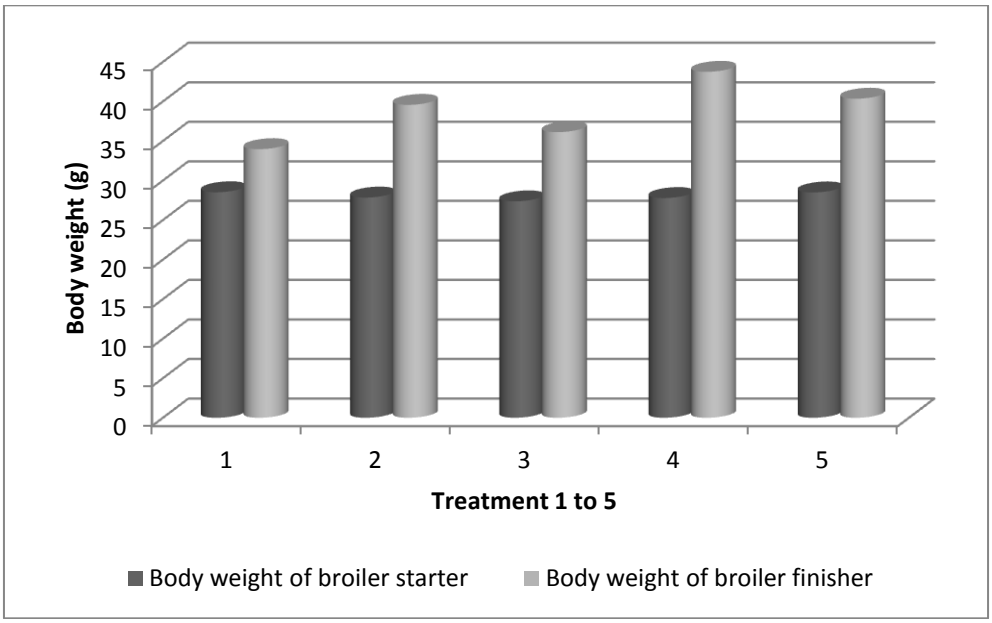

Fig. 1. The body weight gain of broiler starter and finisher in treatment 1 to 5

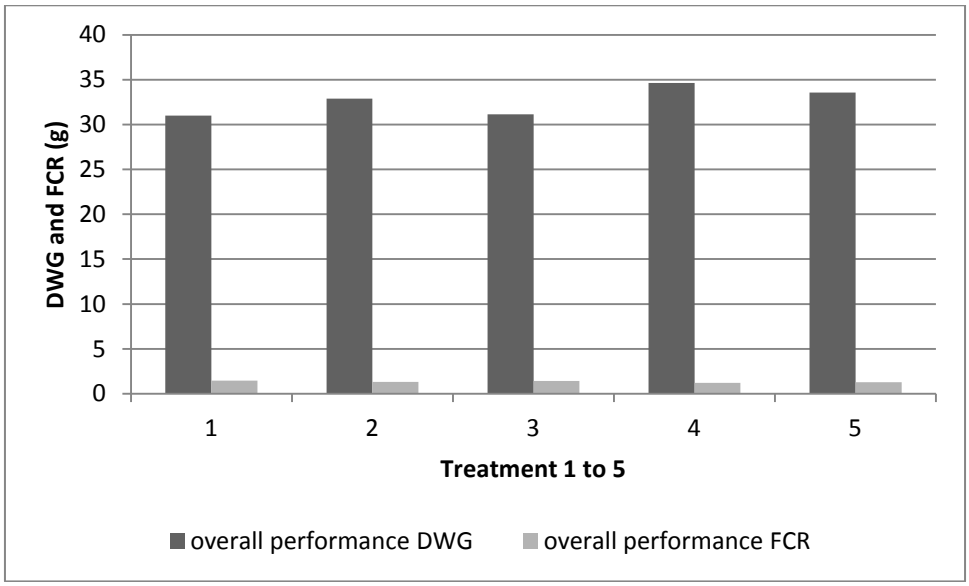

Fig. 2. The overall performance in DWG and FCR of broiler chickens in treatment 1 to 5

Table 5. Economic of broiler chicken fed dietary levels of doum palm supplement

Parameters	Levels of doum palm pulp meal in the diets				
	1(0%)	**2 (5%)**	**3 (7.5%)**	**4 (10%)**	**5 (12.5%)**
TFI(kg)	4.38	4.20	4.31	4.12	4.27
FC (₦/kg)	179.13	111.68	108.24	110.55	122.55
TFC (₦)	784.58	469.05	466.51	455.47	523.30
TWG (kg)	1.52	1.61	1.53	1.70	1.60
FC (₦/kg/gain)	516.17	291.33	304.90	267.92	327.06
Cost saving	-	224.84	211.27	248.25	189.11

TFI: total feed intake, FC: feed cost, TFC: total feed cost, TWG: total weight gain, KG: kilogram, ₦: naira

4. CONCLUSION

It is evident that Doum palm pulp meal (DPPM) possessed good dietary energy quality for optimal growth of broiler chickens. Thus, Doum palm pulp meal could be a potential energy source for broiler chickens production, therefore up to 12.5% of DPPM can be included in the diets of broiler chickens. However, dietary level of 10% Doum palm pulp meal with a cost saving of ₦ 248.25 per kilogram was the most economical and proved to increase the general performance of broiler chicken.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care "(NIH publication NO. 85-23 revised 1985) were followed as well as specific national laws where applicable. All experiments have been examined and approved by Animal utilization and study committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Esonu BO, Emenelom OO, Udedibbie A. Anyanwu AB, Herbert U, Ekpor CF, et al. Performance and blood chemistry of weaner pigs fed raw mucuna (Velvet bean) meal. Tropical Animal Production Investigation. 2001;4:49-54.
2. Adebayo A, Tukur A. Adamawa State in Maps. Paraclete Publishers, Yola, Nigeria 2005;112.
3. Waleed A, Zangh L, Mohammed D, Mohammed, Abubakar M, Elshareif O, Malik T. Physiochemical, Nutrition and

functional properties of the Epicarp, Flesh and Pited sample of Doum palm fruit (*Hyphaene thebaica*). Journal of Food and Nutrition Research. 2014;24:180-186.

4. Fletcher R. Listing of useful plants of the world. Australian New crops; 1997. Available:http://www.newcrops.uq.edu.au/listining/hyphaene thebaica Retrieved 2016
5. Steel RGD, Torrie JA. Principles and procedures of statistics a biometrical approach, 2nd ed. Mc. Graw Hill, Books Co. New York USA; 1980.
6. AOAC. Association of Official Analytical Chemists. Official methods of analysis of the association of official analytical Chemists International 17th edn. Association of Official Analytical Chemists International, Arlington, VA, USA; 2000.
7. Olomu JM. Monogastric animal nutrition: Principles and practice, A. Jackson publishers. Benin City. Nigeria. 1995;320.
8. National Research Council. Nutrients requirements of poultry.9th Rev. Ed. National Academic Press, Washington D.C. USA; 1984.
9. Kwari ID, Igwebuike JU. Performance of broiler chickens fed graded levels of African Locust bean (*Parkia biglobosa*) Pulp. Proceedings of the Nigerian Society of Animal Production (NSAP) Sept. 19th, University of Maiduguri, Nigeria; 2002.
10. Olajide R. Growth performance, carcass, haematology and serum of broilers as affected by contents of anti-nutritional factors in soaked wild cocoyam (*Coloxasia esculanta* (L) Schott) Corn- based Diets. Asian Journal of Animal Sciences. 2012;6:23-32.
11. Kwadwo O, Atuahene CC, Attonkotoku Y, Adjei MB. The Growth performace, carcass and haematological characterestics of broiler chickens fed alkaline-treated tiger nut (*Cyperus esculentus*) residue meal. Journal of animal Science Advances. 2014;14(10):1068-1081.
12. Jacob JP, Mitaru N, Mbugu PN, Blair R. The effect of substituting Kenyan serena sorghum for maize in broiler chickens starter diets with different dietery protein and methionine levels. Animal Feed Science Technology. 1996;61:41-56.
13. Okeye FC, Ugwuena MC, Ubaeduonu LC. Effects of the replacement of maize with graded levels of sorghum malt (Sorghum bicolor) on the performance of broiler chicks. Agricultural Journal. 2006;1:77-80.
14. Lucas J, Lara MR. Impact of heat stress on poultry production; 2013. Available:www.mdoi//journal/animal (Accessed in July 2016)
15. Aduku AO. Practical livestock feeds production in the tropics. S. Asekome and Co. Publishers Samaru, Zaria Nigeria; 1992.
16. Adamawa State Website 2015 Accessed 16 Dec. 2017. Available:http://www.adamawastate.gov.ng/content/3/2/17

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/26897