Nigerian J. Anim, Sci. 2025, 27 (2): 77 - 87

Response of Laying Japanese Quails (*Cotunix japonica*) to Sandbox (*Hura crepitans*) Seed Meal Based Diets

[1]Ukoha, O. A., [2]Nsa, E. E. and [2]Archibong, E. E.

[1]*Department of Animal Nutrition and forage science, College of Animal science and animal production, Michael Okpara University of Agriculture, Umudike.*
[2]*Faculty of Animal Science, University of Calabar*

Corresponding author: *onyedinma26@gmail.com (+2348063967602)*

Abstract

A 70-day study was carried out to assess the effects of sandbox (Hura crepitans) seed meal-based diets on haematology and egg production parameters of Japanese quail birds. A total of 200 seven weeks old female Japanese quails were selected from growing phase and randomly distributed to five dietary treatments with four replicates of 10 birds each in a completely randomized design. The diets were formulated to contain 0, 25, 50, 75 and 100% of sandbox seed meal (SBSM) at the expense of soybean meal to represent treatment diets 1, 2, 3, 4 and 5 respectively. Fresh drinking water was provided ad libitum throughout the laying phase. Blood samples were collected from two birds in each replicate at the end of the study for haematological studies. The results showed that hen day production, peak production, age at peak production and feed cost per dozen (N) were significantly ($p<0.05$) affected. Hen day production decreased at 100% sandbox seed meal replacement in the diets while, peak production decreased at 75 and 100% replacement level. Egg quality parameters were not significantly affected by treatment diets except the egg weight and yolk weight which had increased values with dietary increase in sandbox seed meal. Apart from packed cell volume and haemoglobin which showed significant ($p<0.05$) differences, only at T5 (100%SBSM), other blood parameters indicated no significant ($p>0.05$) differences across the treatment means. It could be concluded that sandbox seed meal can replace up to 75% of soya bean meal in Japanese laying quails without sacrificing egg quality, quantity indices and the health status of the birds.

Keywords: *Hura crepitans*, Japanese quails, egg parameters, haematology,

Description of Problem

Despite the great potential of quail production in Nigeria, uncontrolled increase in prices of conventional feed ingredients such as maize, soya bean and groundnut meal which serve as the principal sources of energy and protein has skyrocketed the cost of production of quail birds (Bekibe *et al.*, 2010). Soya bean accounts for about 25-35% of poultry feed (Nsa *et al.*, 2020), therefore replacing soya bean in poultry feed with less costly feedstuffs will significantly reduce cost of animal products (Edacheet *et al.*, 2007).

The search for locally available, unconventional, low cost but nutritionally adequate feedstuff has therefore become imperative. One of such is sandbox (*Hura crepitans*) seed meal.

Sandbox tree is 90-130 feet high tropical evergreen tree of the spurge family *Euphorbiaceae,* native to tropical regions of North and South America including the Amazon Rainforest (Borokini and Omotay, 2012). Apart from the name sandbox tree, it has several other names like Possum wood, monkey's dinner bell, monkey's pistol and Monkey no-climb (Owojuyibe *et al*, 2020). It grows on clay soil in moist areas near water courses and in flooded areas (Huxley *et al* 2010). Sandbox tree has been introduced in California, Florida, the Bahamas and various Tropical Countries around the world including Nigeria (Huxley *et al.*, 2010).

The seeds are rich in minerals like potassium (238.33mg/100g) and sodium (71.67mg). Both minerals play a vital role in active transport across the cell membrane and they are required for maintenance of osmotic balance (Hassan *et al* 2018; Mohammed *et al*., 2013). It is also rich in Magnesium and copper. The former activates enzymatic system responsible for calcium metabolism in the bone and nerves while the latter plays a role in haemoglobin formation and contributes to iron and energy metabolism (Hassan *et al*., 2018).

Hura crepitans seeds also contain oil which enhances the energy density of a diet for normal maintenance and productive functions. It also serves as a source of essential fatty acids as well as carrier of the fat-soluble vitamins (Esonu *et al*., 2014). The dry matter of the seed (91-95%) is quite comparable to those of the conventional feedstuff, an indicator of having a long store life devoid of mold growth. The seed is moderate in crude protein 30.22% (Archibong *et al.*, 2023), high in ether extract of about 38.95-51.24% (Yaakugh *et al.*, 2001) over 100 times the value for the conventional oil seed. A real good source of oil and energy in livestock feed. However, the seed is known to contain some anti-nutritional factors like alkaloids (5.00mg/100g), tannins(5.11mg/100g), saponin (2.2mg/100g and trypsin inhibitor(30.27TIU/mg) however, there are all heat labile, which means if well treated could be a good source of both protein and energy in livestock feeds.

This research therefore was aimed to assess the response of laying Japanese quails (*Cotunix japonica*) to different replacement levels of soya bean seed meal with sandbox (*Hura crepitans*) seed meal

Experimental diets and feeding

Five experimental layer's diets (Table 1) were formulated to contain (0, 25, 50, 75 and 100%) of sandbox seed meal, at the expense of soya bean meal, to represent treatments 1,2,3,4 and 5 respectively. The diet provided the required nutrients of laying Japanese quails ration according to NRC (2012) recommendations. The quails were fed a known quantity of feed between 07:00-08:00am and also in the evening 16:00-17:00pm hours daily. Leftover feed was measured the next morning.

Data collection

During the laying phase, the initial weight of quails were taken at the start of the

Table 1. Gross composition of Japanese quail sandbox seed meal-based layer's diets.

Ingredients	Replacement levels of soya bean meal with sandbox seed meal				
	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)
Maize	42.40	42.40	42.40	42.40	42.40
SBSM	0.00	8.00	16.00	24.00	32.00
Wheat offal	7.00	7.00	7.00	7.00	7.00
Palm kernel cake	5.80	5.80	5.80	5.80	5.80
Soybean meal	32.00	24.00	16.00	8.00	0.00
Fish meal	2.50	2.50	2.50	2.50	2.50
Bone meal	5.50	5.50	5.50	5.50	5.50
Oyster shell	4.00	4.00	4.00	4.00	4.00
Salt	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
*Vit/.Min. Premixes	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated composition %					
Crude protein	24.60	24.10	23.76	23.42	23.08
Crude fiber	5.13	5.34	5.92	6.50	6.98
ME (Kcal/Kg)	2505.10	2516.18	2527.26	2538.34	2549.42
Analyzed Values %DM					
Crude protein	24.79	24.63	24.46	24.21	24.08
Crude fibre	5.11	5.34	5.49	5.97	6.23
Ether extract	3.36	3.92	4.50	4.98	5.23
ME(Kcal/kg)	2747.22	2750.87	2815.76	2828.43	2831.92
Calcium	3.32	3.26	3.24	3.23	3.30
Phosphorus	1.79	1.79	1.73	1.71	1.70

experiment and thereafter on a weekly basis. Weight gain was obtained by subtracting the initial weight from the final weight. Feed intake per group was determined by weighing the feed offered in grams and the left over in grams the next morning and finding the difference. These we used to calculate the following;

i. $$\text{Feed intake/bird/day} = \frac{\text{quantity of feed given(g)-leftover feed}}{\text{No of birds x 70 days}}$$

ii. $$\text{Weight gain/bird/day} = \frac{\text{final live weight-initial weight}}{\text{No of birds x 70days}}$$

iii. $$\text{Protein intake} = \frac{\text{CP content of the diet x quantity of feed consumed}}{100}$$

v. Protein efficiency = weight gain/Protein intake

Feed conversion ratio (kg of feed per dozen egg).

Egg production was recorded daily and pooled weekly to calculate the hen-day production. Cost per dozens of eggs was calculated based on the prevailing market prices of the feed ingredients. All eggs laid each day in a particular replicate group were weighed to determine average egg weight.

Eggs were collected daily and weighed throughout the 70 days of the laying phase, they were randomly selected per replicate for external and internal egg quality evaluation by methods described by Adikari *et al.* (2016).

Egg quality parameters

Two freshly laid eggs free of cracks were randomly selected from each replicate for weekly measurement of egg quality. Each egg was assessed separately for external and internal egg quality traits.

External egg parameters; these included; egg weight (measured by the use of Hana weighing scale), egg length (using Vernier sliding caliper) and egg diameter which was measured at three points; on the blunt end, equatorial region and at the pointed end using the same vernier sliding caliper.

Internal egg quality; these were determined using the following parameters; Albumen index (determined by using micrometer screw gauge to obtain the height and weight of the albumen), yolk index (obtained as ratio and height to the width of the yolk using vernier sliding caliper), yolk colour (obtained by matching the color of the yolk with Roche yolk color fan), Haugh unit; measured by the use of spherometer screw gauge and applying the formula;

$$100 \log (H+7.57-1.7W^{0.37})$$

Where, H is the observed albumen height in millimeter

W is the observed weight of egg in gram (Haugh, 1937), and shell thickness (measured with a micrometer screw gauge).

Cost of production

Cost analysis using appropriate formulae were used to determine the economics of production based on the prevailing local market price of feedstuff.

$$\text{Feed cost/kg} = \frac{\text{sum of prices of ingredients}}{100\text{kg}}$$

Total feed cost = total feed intake x feed cost/kg

Total cost of feed consumed/kg (N) = cost of feed/kg (N) x total feed consumed (kg/bird)

$$\text{Cost of feed/kg live weight gain (N)} = \frac{\text{Total cost of feed consumed/kg (N)}}{\text{Total weight gain (g/bird)}}$$

Haematological analysis.

At the end of the feeding trial, two quails per treatment were selected for blood analysis. Blood samples were collected from the veins of the wings web with the use of hypodermic syringe into a clean test tube containing anticoagulant-Ethylene Diamine Tetra Acetate (EDTA) and used for the determination of haematological parameters. The concentration of red blood cells, white blood cells, packed cell value and haemoglobin were evaluated as described by Ewuola and Egburike (2008). Other haematological indices including mean corpuscular haemoglobin concentration (MCH), Mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC), platelet and lymphocytes, were determined using appropriate formulae as described by Jain (1986).

Statistical analysis

Data collected were analyzed using one-way analysis of variance of (SAS, 2010) statistically package and the significant differences between means were compared at 5% confidence level using Duncan multiple range test.

Results and Discussion

Egg production parameter of quail birds fed sandbox seed meal (SBSM) based diets are represented in table 2. The eggs laid per quail ranged from 47.00- 59.00g and showed no significant (P>0.05) differences across the various treatments. The dozen egg per quail ranges from 3.92-4.92g of birds in the various treatments with significant decrease (P<0.05) only at 100% replacement level of soya bean meal with sand box seed meal. This observation could imply that quail birds can be fed with sandbox seed-based diets up to 75% level of replacement conveniently without having negative effect on egg produced. And is in line with findings by Ozeudu *et al*. (2020), who worked with layer chicken with the same test ingredients but observed a drop in egg production, as the level of soya bean replacement with sand box seed meal increases above 25%. Quail birds are hardy birds, can tolerate more fibrous and less nutritious feeds (Sogunle *et al*., 2007). Sand box seed meal is of higher fibre content than soya bean meal as shown in table 1, this could explain why the drop was only after 75% replacement level of Soybean meal.

The mean daily feed intake of birds ranged between 27.09-29.02g and did not differ (P<0.05) significantly among the dietary treatments. However, there was an observed lower value recorded for birds on T5. This observation is in tandem with the report of Ukachukwu and Akpan (2007) who observed significant lower feed intake of layer birds on fibrous feedstuff than the control diet. Sandbox seed meal had crude fibre level of (12%) relatively lower than soya bean meal. Therefore, increment of the sandbox seed meal in the diet, will definitely lead to increase in the fibre level of the diet. Sandbox seed meal has higher oil content than soya bean meal (Table 1), hence high energy density as the meal increases in a diet, which is in line with separate findings of Odunsi and Gbadamosi (2001); Agida *et al*. (2020) that monogastric animals are expected to consume less of high energy diet in attempt not to overshoot their energy requirements. An earlier report by Aduku and Nuhu (1996) also supported this view on broiler birds fed diets containing oil sludge, which showed a slight but non-significant (p>0.05) decrease in feed intake as the dietary oil level increased. In support of this, Longe and Adekoya (1998) also reported that addition of oil to a diet that is otherwise adequate in energy, lower feed intake.

The mean feed conversion ratio (Feed/dozen egg) was not significantly (p>0.05) affected by the dietary treatments. However, the hen-day production was significantly (p<0.05) affected by dietary treatments with birds fed diet 100% replacement of soya bean meal with sandbox seed meal having the least HDP, while other treatment diets including the control had statistically similar but higher (p>0.05) values.

The hen-day production (HDP) of the birds on the control groups and birds on diet 2, 3 and 4 were significantly ($p<0.05$) higher than birds on T5. This is observation supports the reports by Odetola *et al.* (2017) for Japanese quail birds fed kenaf seed meal. This means that replacing soybean meal with sandbox seed meal in laying Japanese birds up to 75% replacement with soya bean meal have no effect on hen-day production.

The peak egg production showed significant ($p<0.05$) differences, with birds on the control(T1), T2 and T3 having numerically ($p>0.05$) similar values that were significantly ($p<0.05$) higher than T4 and T5.

Age at peak of production showed significant ($p<0.05$) differences. Birds on the control group and T3 diets reached peak of production earlier than birds on other diets. It took birds on treatment 5, 10 days later when compared with the control to reach their peak of production.

Mortality percentage across the treatments were low and showed no significant ($p>0.05$) difference. An indication that sandbox seed meal is not lethal to Japanese birds.

Cost per dozen egg production (N) showed significant ($p<0.05$) differences. Birds on the control and 100% SBSM had similar ($p>0.05$) values that were higher than T2. Birds on T3 and T4 had the least cost per dozen egg production (N)

The observed reduction of cost per dozens of eggs produced for birds on sandbox-based diets apart from birds on T5 could be attributed to the high cost of soya ben meal and the corresponding number of eggs laid.

Table2. E gg production parameters of Japanese quail birds fed sandbox seed meal - based diets.

	percentage inclusion level of sandbox seed meal					
Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM
Egg laid/bird(g/b)	59.00	58.00	53.00	50.00	47.00	1.88
Dozen egg/bird(g/b)	4.92	4.83	4.42	4.17	3.92	0.06
Feed/hen/day(g/b/d)	28.88	28.41	29.02	27.82	27.09	0.91
FCR;feed/egg(g)	4.33	4.21	4.19	4.14	5.11	0.30
Hen-day production (%)	76.00^{a}	75.77^{a}	72.00^{ab}	70.65^{ab}	65.43^{b}	3.11
Peak egg production (%)	85.00^{a}	84.99^{a}	81.57^{a}	76.67^{ab}	70.43^{b}	7.09
Feed cost/bird(N)	8.58^{a}	8.16^{b}	8.01^{b}	7.38^{c}	6.86^{d}	0.71
Feed cost per dozen egg(N)	265.45^{a}	233.32^{b}	219.40^{c}	218.90^{c}	269.51^{a}	6.98
Age at peak production day	128^{b}	130^{b}	134^{ab}	134^{ab}	141^{a}	3.99
% Mortality	2.25	1.50	1.65	2.65	3.00	0.32

[abc]Means within the same row with different superscripts are significantly different from one another($p<0.05$)

Egg quality parameters of quail birds fed dietary levels of SBSM are represented in Table 3. There were no significant ($p>0.05$) differences in the external and internal egg quality parameters except on the egg weight, yolk weight and yolk color. The non-significant (($p>0.05$) Differences in values of egg quality parameters were expected since the birds were of the weight and mature at the same age. This observation supports the findings of Abdullah *et al. (*2003); Perez-Bomilla *et al*. (2012) who reported that age of the hen strongly influenced the egg size and the proportion of its components. The egg yolk weights tended to be significantly ($p<0.05$) higher as the level of sandbox seed meal increased in the diets. There was a significant ($p<0.006$) increase at T3, T4 and T5. The observed improvement in the yolk weight as sandbox seed meal increased in the diet could be a result of high content of oil in the diet, as contributed by sandbox seed meal which is known to be of higher oil content than soya bean meal (Table 1).This observation is in consonance with that of Garba and Omojala (2010) who worked on the effect of increasing metabolizable energy of pearl miller of corn and found out that higher metabolizable energy in diets of laying hens increased egg yolk weight.

Egg yolk is mainly made of carbohydrate, oil and protein (Adedeji *et al*., 2008).

The egg height, shell weight, yolk height, yolk diameter, yolk index, albumen weight and albumen height showed no significant ($p>0.05$) difference across dietary treatments.

The shell thickness was not also affected ($p>0.05$) by dietary treatments. This is in line with research by *Ozeudu et al.* (2020) who reported a non-significant ($p>0.05$) difference in shell thickness of layer birds fed cooked sandbox seed meal. Shell thickness is a good indicator of shell strength and is important in the handling and marketing of eggs to minimize breakage. It therefore appears that sandbox seed is not lacking in essential minerals and vitamins which are directly involved in formation of strong egg shell.

The yolk color became less yellowish as the level of sandbox seed meal inclusion increased in the diets, an indication of reduced presence of Vitamin A precursor in Sandbox seed meal.

Haugh unit ranged from 79.95 – 84.44 in line with the report of Ukachukwu and Akpan (2007) and showed no significant ($p>0.05$) differences across the treatment means and indicate high quality eggs.

Haugh unit is the major parameter for determining egg quality. According to United State of America Department of Agriculture, a Haugh unit score of 72 and above (Score AA) is acceptable and connotes freshness in egg. Lowman and Ashwell (2016) reported Haugh unit range of 76.90 to 78.24 and 78.98 to 79.10 respectively for layer birds.

The haemoglobin values obtained in this study ranged from 13.17g/dl to 20.09g/dl. These were higher than the normal range for chickens (7-13g/dl) as reported by Banergee (2009) and 8.7 to 9.3g/dl as reported by Ikhiomiioya *et al*. (2000) for indigenous chickens, but within the range reported by Agina *et al*.(2017) for healthy quail birds. The observed differences in Hb values could be attributed to differences in bird type and test ingredients used.

Eggun (1989) reported that, high or low Hb could be attributed to a state of

Table 3. Egg quality parameters of Japanese quail birds fed sandbox seed meal -based diets.

Parameters	Replacement levels of soybean meal with sandbox seed meal					
	T_1 (0%)	T_2 (25%)	T_3 (50%)	T_4(75%)	T_5 (100%)	SEM
Egg weight(g)	10.23^b	10.26^b	10.33^{ab}	10.39^{ab}	10.42^a	0.88
Egg height(mm)	30.90	30.92	30.89	30.90	30.90	0.45
Shell weight(g)	0.81	0.81	0.80	0.80	0.81	0.01
Yolk weight(g)	3.11^b	3.11^b	3.15^{ab}	3.17^a	3.18^a	0.21
Yolk height(mm)	1.38	1.37	1.38	1.38	1.38	0.02
Yolk diameter(mm)	2.09	2.09	2.08	2.08	2.06	0.09
Yolk index	0.51	0.57	0.54	0.63	0.59	0.01
Yolk color	2.64^a	2.54^b	2.50^b	2.21^c	2.00^d	0.02
Albumen weight(g)	6.47	6.47	6.50	6.50	6.51	0.47
Albumen Height(mm)	6.45	6.49	6.50	6.50	6.58	0.36
Shell thickness (mm)	0.26	0.26	0.25	0.25	0.25	0.01
Haugh unit	84.44	81.31	81.12	80.79	79.95	5.66

^{abcd} means within the same row with different superscripts are significantly di fferent from one another($p<0.05$)

nutritional anaemia in birds and the quality of protein fed to the birds. Therefore, the observed lower Hb obtained by birds on diet T5 was in line with the report of pellet and Young (1980) that Hb levels were positively correlated with protein quality than sandbox seed meal, this is reflected in the Hb levels of the different diets. Increase in the haemoglobin level may be accompanied by a rise in the red blood cells and packed cell volume (Moss, 1999).

The RBC, MCV, MCH and MCHC values obtained in this study were within the ranges reported by Ikhiomioya *et al.* (2009) for a healthy chicken. This shows that, the bone marrow of the birds were functioning normally, also the normal values obtained for MCV and MCHC in this study indicated that, there was no negative interaction between energy and protein levels in the diets (Akinola and Onwunari (2007). A reduction in MCV occurs when iron deficiency becomes severe, which triggers anaemia. This was not a case here as its level was within a normal range for poultry birds.

Table 4. Ha ematological indices of laying Japanese quail birds fed sandbox seed meal - based diets.

Parameters	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	T5 (100%)	SEM	Ref. ranges(Agina *et al* (2017)
PCV (%)	56.00a	54.08a	53.11a	49.89a	30.67b	1.04	25-66
RBC($X10^3L$)	4.03	4.00	3.96	3.93	3.90	0.05	2.02-6.99
Hb(g/dl)	20.09a	20.00a	19.87a	19.22a	13.17b	0.65	8.61-20.57
WBC($X10^6/L$)	120.22	119.02	117.41	121.00	118.65	10.05	100.00-125.00
MCV(fl)	118.20	120.11	122.03	130.31	130.66	8.62	64.68-131.99
MCH(g/dl)	48.72	49.38	59.62	60.54	60.73	4.11	20.72-69.08
MCHC(g/dl)	39.09	39.21	40.55	45.29	47.66	1.54	20.77-64.28
Lymphocytes	56.20	56.90	54.12	70.71	60.40	9.98	30.05-88.50
Platelet ($x10^9L$)	30.21	35.02	32.28	36.41	36.82	5.81	22.65-45.60

Ab Means within the same row with different superscript are significantly different ($p<0.05$)

Conclusion

This study showed that up to 75% of soybean meal could be replaced with Sandbox seed meal in laying Japanese quails' diet without any adverse effect on their haematological indices and egg production parameters.

References

SAS Institute, 2010. SAS Proprietary Software, Release 9.2 Cary, NC, SAS Inst. Inc.

Adindu, F. A., Elekwa, I and Ogwo, J. J. (2016). Phytochemical comparative screening of aqueous extracts of the leaves, stem barks and roots of *Hura crepitans(L)* using GC-FID. *IOSR Journal of Biotechnology and Biochemistry*, 2:2455-2463. {Google Schorlar}

Aduku, A. O. and Nuhu, A. (1996). A comparative evaluation of cotton seed meal oil sludge and palm oil in broiler in broiler diets. *Tropical Agriculture.* (Trinidad) Volume 73(3):206-210.

Adedeji, O. S., Farinu, G. O., Olayemi, T. B., Ameen, S. A. and Babatunde, G. M. (2008). Performance and egg quality parameters of laying hens fed different dietary inclusion levels of bitter kola (Garcina kola). *Resource Journal of Poultry Science.*2 (4):75-77.

Agida, C. A., Amaduruonye, W., Nsa, E. E. and Nathaniel, J. (2020). Serum biochemistry, haematological profile and organ proportion of broiler starter chicks fed graded levels of palm oil mill effluent (POME). *Journal of Animal Science and Veterinary medicine*, 5(1):202-211.

Alamuoye, O. F. and Ojo, J. O. (2015). Comparison of carcass characteristics of sexed Japanese Quails (*Coturnix coturnix japonica*) *Scientific Journal of Agriculture and Veterinary Science*, 2(5):342- 344.

AOAC (2010). Official Method of Analysis. Association of Official Analytical Chemists. 23rd Edition. Washington D. C.

Archibong, E. E., Nsa, E. E. and Umoren, U. E. (2018). Nutritional evaluation of tigernut (*Cyperus esculentus*) meal as a replacement for maize in broiler diets. *Nigerian Journal of Animal Production, Vol.45. No4. Pp90-98.*

Borokini, T. I. and Omotayo, F.O. (2012). Phytochemical and ethnobotanical study of some selected medicinal plants from Nigeria. *Journal of Medicinal Plant Research*, 6(7):1106-1118.

Edachet, J. A., Musa, U., Karsin, P. D., Esilonu, J. O., Yisa, A.,Okpala, E. J. and Zwandor, N. J. (2007). Evaluation of the performance of growing Japanese Quails (*Coturnix coturnix japonica*) fed graded levels of banana peel meal. In: Sustainability of the livestock industry in an oil Economy. (Editor, Agiang, E.A., Agwunobi, L.N. and Olawoyin, O. O.). Proceedings of the 32rd annual conference of the Nigerian Society for Animal Production, Calabar, March, 18-21, 2007, 342-346.

Eggun, B.O. (2009). Blood urea measurements as a technique for assessing protein quality. *British Journal of Nutrition,* 24:983-988.

Esonu, B. O., Ozeudu, E., Emenalom, O.O.., Nnaji, C. and Onyeikegbulem, I. K. (2014). Nutritional value of sandbox (*Hura crepitans*) seed meal for broiler finisher birds. *Journal of Natural Sciences Research.* 4(23); 89-99.

Ewuola, E.O. and Egburike (2008). Physiological response to growing west African goats fed groundnut shell base diets as the concentrate supplements. *Bowen Journal of Aquaculture*, 1(1):611-69.

Fafiolu, A. O., Oduguwa, O. O., Ikeobi, C.O.N. and Onwuka, C. F. I. (2006). Utilization of malted sorghum in the diet of rearing pullets and laying hens. *Arch. Zootechnology*, 55 (212):361-371.

Ukoha et al

Hassan, L. G. Sokoto, A. M., Ngaski, M. N., Anka, S. A., Chanchangi, B. M., Umar, K. J. and Keay, R.W.J. (2010). Trees of Nigeria. *Nordic Journal of Botany*, 11: 322.

Longe, O. G. and Adekoya, O. E. (1988). Response of laying hens to different inclusion levels of palm kernel meal and vegetable oil. *Nigerian Journal of Animal Production*, 15:111-117.

Muhammed, N. A., Isiaka, A.A. and Adeniyi, O. A. (2013). Chemical Composition of *Hura crepitans* seeds and anti-microbial activities of its oil. *International Journal of Science and* Research. 2 (3):2319-2324.

Nsa, E.E., Ozung, P.O., Archibong, E.E. & Eburu, P.O. (2020). Comparative evaluation of palm oil and lard as partial replacement for maize in broiler chicken diets. *EC Veterinary Science*, 5 (9):56-62.

Odetola, O. M., Adejinmi, O.O., Akingbade, A. O. and Adekanmbi, A. O. (2017). Performance and egg quality parameters of Japanese quail (*Coturnix coturnix japonica*) fed kenaf *(Hibiscus cannabinis* L.) seed meal-based diets subjected to varying cooking periods. *Nigerian Journal of Animal Production*, 44(4):225-231.

Odunsi, A.A. & Gbadamosi, A.J. (2001). Effects of dietary inclusion of palm oil and shea butter fat on growth and sexual maturity of pullets. *Nigerian Journal of Animal Production*, 28(1):26-30.

Ogbiko, C. (2018). Nutritional and Anti-nutritional analyses of *Hura crepitans* seeds cultivated in Sokoto North L.G.A., North-Western Nigeria. *Journal of Pure and Applied Sciences*. 11 (1):126-130

Oke, D.B., Tewe, O.O. & Fetugar, B.L. (2019). The nutrient component of cowpea species. *Journal of Animal Production*. 22 (1):32-36.

Owojuyigbe, O. S., Firemp, C., Laribie, C. and Komlaga, K. (2020). A Review of Ethnomedical Phytochemical and Pharmacological Studies. *Journal of Complementary and Integrative Medicine*, 9(2):1-10.

Ozeudu, E., Esonu, B.O., Udebibie,

A.B.I., Ojike, F. C., Uchegbu, M. C., Emenalom, O. O. and Chibuike, C. E. (2020). Substitution value of cooked sandbox (*Hura crepitans*) seed meal in layers diets. *Nigerian Journal of Animal production*, 42(1):79-84.

Perez-Bomilla, A. S., Novoa, J., Garcia, M., Mohifi-Ashi, M. and Meteos, G. G. (2012). Effects of energy concentration of the diets on the productive performance and egg quality of brown egg lay hens differing in initial body weight. *Poultry Science*.91:3156-3166.

Shehab, A.E., Kamelia, M.Z., Khedr, N.E., Tashia, E.A. & Eshaeil, F.A. (2012). Effect of dietary enzyme supplementation on biochemical and haematological parameters of Japanese quail. *Journal of Animal Sciences Advances*, 2(9):734-739.

Sogunle, O. M, Fanimo, A. O., Abiola, S.S. and Bamgbose, A. M. (2007). Growth response, body temperature and blood constituents of pullet chicks fed cassava peel meal supplemented with cashew nut reject meal. *Nigerian Journal of Animal Production*, 34(1)32-44.

Yaakugh, I.D.I., Tuleum, C.D. & Kaankuka, F.G. (2001). MSc. Thesis. Nutrient Composition of *Hura crepitans*. Deptartment of Animal Production, University of Agric, Makurdi, Nigeria.