

Laying performance and egg characteristics of Isa brown pullets fed diets containing *Mucuna urens* (horse eye bean) meal as an alternative protein source

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Target Audience: Feed millers, Poultry farmers, Animal Nutritionists

Abstract

This study was conducted to determine the laying performance and egg characteristics of pullets fed diets with different levels of multi-processed Mucuna urens bean meal. The M. urens beans were cracked mechanically, soaked in fresh water for 48 hours, peeled, cooked for 90 minutes, rinsed in water, and sun-dried. The dried beans were toasted in an oven at 60°C for 30 minutes, milled on the 4mm screened hammer mill, and the proximate composition determined. The processed beans were used to formulate six-layer mash diets, with the test sample replacing soybean meal at 15, 30, 45, 60, and 75%. Two hundred and seventy (270) isa brown pullets at the point of lay (16 weeks old) were used for the study. The birds were randomly distributed into six groups, with forty-five (45) birds per group. Each group was randomly assigned to one of the six experimental diets in a completely randomized design. Results obtained showed that pullets on a 15% M. urens bean meal diet had a significantly ($P < 0.05$) higher percentage hen day production, while those fed 60% replacement level of M. urens recorded the highest egg weight. The feed efficiency and egg quality parameters were not significantly ($P > 0.05$) influenced by the treatments. The pullets on 15% M. urens recorded the highest returns on investment, with a sum of N 3189.26 obtained as profit. The study concludes that processed M. urens could replace soybean meal by up to 60% in pullets' diets without a deleterious effect on laying performance or egg quality.

Keywords: M. urens bean, anti-nutritional factors, cooking, toasting, pullets

Description of Problem

The need to produce more protein of animal origin in Nigeria has become necessary due to the ever-rising population. The human population in Nigeria is projected to grow at an annual rate of 3–6% by the year 2030, which has surpassed food production. The nation is already facing chronic food insecurity, particularly that of animal protein.

Poultry meat and eggs have been recommended among the livestock products to bridge this protein gap because of their short generation interval, high rate of productivity, quick turn-over rate, higher feed efficiency, and low labour and land requirements (1). In poultry production, maize and soybean meal are the major sources of protein and energy, and currently,

their prices have risen astronomically. For instance, the price of soybean in Nigeria is about five hundred and sixty thousand (N 560,000.00) naira per ton, compared to one hundred and sixty thousand (N 160,000.00) in 2015. Several researchers (2) had stressed the need for the utilization of alternative feed ingredients, which are far removed from human and industrial interests in order to reduce the cost of feeds and hence reduce also the cost of poultry products. A feedstuffs that could be considered as replacement for expensive ingredients like groundnut cake and soybean meal must not be a stable item of human food and should be readily available and inexpensive to produce and easy to process.

The alternative vegetable protein being considered in this study is *Mucuna urens* (horse eye beans). Horse eye bean is an important legume in many parts of the world. The leaves are mostly utilized as forage by grazing animals, and the beans are sometimes eaten by humans and animals in the southern and eastern states of Nigeria. (3, 4). However, there is a low sustained interest in *mucuna* cultivation due to its low utilization as food and feed and, subsequently, the lack of market for the beans. Besides, the use of *mucuna* either as human food or as animal feed is limited because the raw seed contains such anti-nutritional factors as trypsin inhibitors, tannins, cyanogenic glycosides, phytates, and others (4). Most of these anti-nutritional factors bind nutrients in plants making them unavailable to animals. However, nutritive value of the bean has been reported to improve by combining soaking, cooking, and toasting. This processing approach has been reported to inactivate, reduce, or destroy the inherent anti-nutritional components (5). This study was therefore designed to evaluate the laying performance and egg quality of

pullets fed diets containing graded levels of processed *M. urens* bean meal.

Materials and Methods

Study Location

The experiment was conducted at the Poultry Unit of the Teaching and Research Farm, Department of Animal Science, University of Calabar, Nigeria. Calabar is located between latitude 04.57°N and longitude 08.20°E, with annual rainfall ranging from 1260mm to 1280mm, temperature of 25-30°C with relative humidity between 70 and 90% and an elevation above sea level of 99m (6)

Source of the Experimental Material

The test samples used for the study were purchased from the local farmers in Akamkpa and Ikom Local Government Areas of Cross River State.

Processing of the *M. urens*

The *M. urens* beans were cracked mechanically, soaked in fresh water for 48 hours at room temperature (37°C) measured using thermometer, peeled, rinsed, cooked for 90 minutes on an open fire at 100°C (timing started from the point of boiling), rinsed in clean, cool water, and sun-dried. The dried beans were toasted in an oven at 60°C until they turned brown after 30 minutes. The processed beans were milled on a 4mm screened hammer mill and analyzed for their proximate composition prior to feed formulation. The processing techniques adopted in the current study were such that they could be easily replicated by local farmers.

Experimental diets

Six (6) diets were formulated to provide 16.5% crude protein and a metabolizable energy of about 2,650 kcal/kg as shown in Table 1. Diet 1 was the control,

containing no test sample, while diets 2 to 6 had soybean meal replaced with *M. urens* meal at 15, 30, 45, 60, and 75%, respectively.

Table 1: Composition of layer mash

Ingredients	<i>Levels of M. urens meal (%)</i>					
	0	15	30	45	60	75
Maize	54.32	53.12	51.70	50.00	48.03	45.60
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00
Soybean meal	15.38	14.09	12.60	10.80	8.67	6.00
Horse eye bean meal	-	2.49	5.40	8.90	13.00	18.10
Wheat offal	13.00	13.00	13.00	13.00	13.00	13.00
Palm kernel cake	7.00	7.00	7.00	7.00	7.00	7.00
Bone meal	2.40	2.40	2.40	2.40	2.40	2.40
•Vit./mineral premix	0.30	0.30	0.30	0.30	0.30	0.30
Lime stone	6.00	6.00	6.00	6.00	6.00	6.00
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100	100
Calculated analysis						
Crude protein (%)	16.50	16.50	16.50	16.50	16.50	16.50
ME (Kcal/kg)	2,678	2,680	2,682	2,684	2,686	2,688
Determined analysis						
% Crude protein	16.51	16.48	16.47	16.45	16.43	16.40
ME(Kcal/kg)	2663	2663	2682	2688	2689	2690

•Layer Vitamin/mineral premix containing the following per kg. Vitamin A 10,000,000IU; Vitamin D3 2,000,000IU; Vitamin E 10,000IU; Vitamin K 2,000mg; Thiamine 1,500mg; Riboflavin B 4,000mg; Pyridoxine B6 1,500mg; anti-oxidant 125g; Niacin 15,000mg; Vitamin B12, 10mg; Panthotenic acids 5,000mg; Biotin 50mg; Choline chloride 400g, manganese 80g; Zinc, 20g; Iron, 50g; copper, 20g; Iodine 1.5g; Selenium 200mg; Cobalt 200mgr; Folic acid 500mg; Vitamin C 100mg.

Experimental birds and management

Two hundred and seventy (270), 16-week-old Isa brown pullets were selected from the base population for the experiment, which lasted for 12 weeks. The birds were randomly distributed into six groups, with

forty-five (45) birds per group. Each group was randomly assigned to one of the six experimental diets. Each treatment was replicated three times, with fifteen birds per replicate. The birds were housed in a deep litter system, with nesting boxes provided in

each pen. Water and feed were provided ad libitum, with routine medication and vaccination, typical of laying hens, administered periodically.

Measurement of relevant parameters

The average daily feed intake of each replicate was determined by the difference between the feed given in a day and the feed left over the following morning. Feed efficiency ratio (kilogram of feed per kilogram of egg), percentage hen day production, and egg quality parameters (egg weight, shell weight, yolk weight, albumen weight, shell thickness, yolk height, albumen height, yolk, and albumen diameter) were monitored.

The percentage hen-day production was calculated as follows:

$$\frac{\text{Number of eggs produced}}{\text{Number of hens} \times \text{Numbers of days}} \times \frac{100}{1}$$

The weight of the eggs and the egg shell were measured with the sensitive electronic weighing scale to the nearest 0.01g. Shell thickness was measured by breaking the egg shell into smaller pieces, removing the shell membrane, and measuring the thickness of the eggshell using a micrometer screw gauge expressed in millimeters. Yolk weight (g) was determined by separating the yolk from the albumen using a plastic egg separator and thereafter weighed on an electronic sensitive scale to the nearest 0.01g.

The yolk diameter (cm) was measured around the widest horizontal circumference using a Vanier caliper. The yolk index was determined by dividing the yolk height by the yolk diameter. Albumen height was measured using a tripod micrometer calibrated at 0.01 millimeters. The dimension measured was taken between the yolk edge and the external edge of the

thick albumen. The egg weight and albumen height were used to compute the Haugh unit using the simple formula: $H.U = 100 \log (H + 7.5 - 1.7W^{0.37})$ (7).

Where HU = Condition of the thick albumen in haugh units, H = Height of thick albumen in millimeters, and W = Weight of egg in gram

Statistical Analysis

Data generated were subjected to a two-way analysis of variance utilizing the SAS (8) general linear model (GLM) method. Duncan's multiple range tests were used (9) to find substantial variations between averages at different levels.

Results and Discussion

The effect of feeding diets with graded levels of multi-processed M. urens bean meal on the laying performance and egg quality characteristics of the pullets is presented in Table 2.

Percentage hen day production

Comparatively, pullets fed a diet containing 15% M. urens meal recorded a significant ($P < 0.05$) higher hen day production, with the value corresponding to 83.33%. The values between pullets on the control diet and those on diets with 30, 45, 60, and 75% M. urens were, however, not significant ($P > 0.05$). The lower values observed among pullets on the control diet and those on higher levels of M. urens could be attributed to the reduced feed intake, resulting in a relatively lower nutrient intake. This translates to lower nutrient availability for egg production (10, 11). The birds thus reduced egg production because the only available nutrients would also be required for their other physiological needs. Several researchers (10, 11, and 12) reported an average percentage hen day production of

94.34, 76.38, and 55.32, respectively, whereas (13, 14) reported 55.32 and 35–82.1 as the percentages of hen day production. The values reported by (13, 14) were comparable to those obtained in this experiment.

Variation in the feed efficiency (kg feed/kg egg) was not significant ($P > 0.05$) among the treatment groups, indicating that pullets fed *M. urens* meal diets converted their feed efficiently to the same unit weight of egg as those of the pullets on the control diet. (15) reported feed conversion ratios/kg egg mass of 2.33 and 2.61 for pullets and spent layers, respectively, while (16) gave a range of 1.90 to 2.06 as feed efficiency (kg feed kg⁻¹ egg) for laying hens fed a diet containing sprouted malted sorghum. The values reported by these authors were lower than those observed in this experiment.

Feeding pullets with diets containing graded levels of processed *M. urens* meal significantly ($P < 0.05$) influenced the average daily egg weight. Pullets on the 60% *M. urens* meal diet recorded the highest average egg weight of 60.95g, while the least egg weight of 55.99g was observed in birds placed on the control diet. Birds fed 15 and 75% *M. urens* meal and 30 and 45% *M. urens* meal diets had average egg weights that were statistically similar. Egg weight is a function of so many factors, notably the quality and quantity of feed, strain of the birds, stage of lay, and management system. The increase in egg weight as the level of *M. urens* in the diets increased is an indication that the test sample was rich in nutrients capable of increasing the egg weight. The increase in the level of lysine could lead to an increase in egg weight. (17) noted that each 0.1 unit of extra lysine increased egg weight by 1.16g. The report of this author agree with the findings of this current study. 40

Dietary increase in the level of *M. urens* did not significantly ($P > 0.05$)

influenced the shell weight, indicating that the test sample did not contain substances whose effects were detrimental to the egg shell weight. The values obtained in this experiment were similar to 6.27–6.54 g reported by (17), but higher than the range (4.84–6.32 g) and 5.8g reported by (16) and (18), respectively. Differences in the shell weight may be attributed to the age of the birds and the weight of the eggs. A number of studies have shown that egg shell weight increases as the bird grows older (19, 20, and 15).

Egg shell thickness ranges from 0.34mm in birds fed a 60% *M. urens* meal diet to 0.37mm for birds on a 15% *M. urens* meal diet. The level of *M. urens* meal in the diets did not, however, affect this parameter significantly ($P > 0.05$). This implies that the test diets did not contain any material whose toxicity could impair this egg quality index. (21) stated that a decline in the shell thickness could be a result of an increase in egg size, thereby causing the shell to be spread thinner and forcing shell quality to decline. The values obtained in this experiment were generally lower than the ranges of 0.59–0.67mm (17) and 0.50–0.58mm (22), but similar to 0.34–0.37mm (23) and 0.35mm (21). It is estimated that a shell thickness of 0.33mm is needed if the egg is to have a more than 50% chance of moving through normal market handling without breaking (24).

Yolk weight ranged from 12.41g in birds fed the control diet to 12.59g in birds on a 15% *M. urens* diet, while albumen weight ranged from 23.98g among pullets fed the control diet to 27.64g for the group on a 60% *M. urens* meal. The treatments did not significantly ($P > 0.05$) influence these parameters, although albumen weight is known to increase with an increase in egg weight.

The Haugh unit (Hu) is an expression of the relationship between egg weight and height of thick albumen (7), and it is the most widely used research measurement of albumen quality (10). Its values had proved to be more significantly correlated to quality measurements than any other parameter (25). In this experiment, Hu values were between 75.09% for the pullets fed 75% M. urens meal and 84.04% for those fed the control diet. These values were, however, not significantly ($P > 0.05$) different. A Haugh unit of 72% and above is regarded as an indicator of freshness in eggs (18). None of the values obtained for different treatments were below 72, indicating that eggs from all the treatments were fresh.

Values for yolk index ranged from 0.31 in birds fed a 60% M. urens meal diet to 0.40 in birds fed a 75% M. urens meal diet. Pullets fed control and those on 15 and 45% M. urens meal diets recorded similar yolk index values. The values were statistically similar ($P > 0.05$) in all the treatment groups. The absence of significant changes in the yolk index showed that the processed M. urens meal did not contain any toxic material that could impair this egg quality index.

No mortality incidences were observed in any of the treatment groups throughout the experimental period, indicating that the processed M. urens meal did not have any significant detrimental effect on the laying pullets.

Table 2: Laying performance and egg quality evaluation of pullets fed diets containing graded levels of multi-processed M. urens bean meal.

Parameters	Replacement levels (%)						
	0	15	30	45	60	75	SE
Hen day production (%)	64.67 ^b	83.33 ^a	69.25 ^b	72.34 ^b	72.27 ^b	68.02 ^b	± 2.09
Daily feed intake/bird(g)	66.67	89.28	69.28	67.14	75.23	72.02	± 0.26
Feed conversion ratio (kg feed/kg egg)	3.33	2.91	2.65	3.32	3.30	3.24	± 0.21
egg weight (g)	55.99 ^b	58.07 ^{ab}	58.53 ^a	59.42 ^a	60.95 ^a	57.83 ^b	±0.50
Shell weight (g)	6.71	7.07	6.52	6.58	6.54	6.83	± 0.08
Shell thickness (mm)	0.36	0.37	0.36	0.35	0.34	0.35	± 0.02
Yolk weight (g)	12.41	12.59	12.83	12.99	12.85	12.98	± 0.09
Albumen weight (g)	23.98	26.39	26.44	26.34	27.64	26.10	± 0.45
Haugh unit	4.04	81.52	75.12	76.94	79.13	75.09	± 1.35
Yolk index	0.34	0.34	0.33	0.34	0.31	0.40	0.07
Mortality	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Means with different superscripts within the same row are significantly ($p < 0.05$) different SEM-standard error of mean

Economic efficiency of feeding processed M. urens meal to laying pullets

The economic efficiency of feeding processed M. urens meal to laying pullets is presented in Table 3. Pullets fed a 15% M.

urens meal diet recorded the highest total feed intake of 7.50 kg, while those on the control diet recorded the least total feed intake of 5.60kg. The variations in feed intake were, however, not significant ($P >$

0.05) among the treatment groups. The cost per kg of feed decreased as the dietary level of *M. urens* meal replacing soybean meal increased from 15 to 75%. The differences among the treatment groups were statistically similar. Laying pullets fed a 15% *M. urens* meal diet recorded the highest cost for the feed consumed, amounting to N 553.31, while birds fed a diet containing 45% *M. urens* meal recorded the least cost of feed consumption, amounting to N 404.90 variation in the cost of feed consumed differed significantly ($p < 0.05$) among the groups. The cost of feed consumed by laying pullets in the control diet and those on 30, 60, and 75% *M. urens* meal diets were statistically similar. The higher cost of feed consumed for birds fed diet containing 15% *M. urens* meal was due to the higher feed intake.

The total number of eggs produced by the pullets on different treatment groups differed significantly ($P < 0.05$), with the highest (70 eggs) recorded among birds fed a

15% *M. urens* meal diet, while the least number of eggs (56) was reported for the group of pullets on the control diet. 42

Differences in the total number of eggs laid per bird between groups fed a control diet and those on treatments containing 75% processed *M. urens* meal were statistically the same.

The revenue from the sale of eggs was significantly ($P < 0.05$) higher for pullets on a diet containing 15% *M. urens* meal as compared to the rest of the treatment groups. Revenue from the sale of eggs for the control diet group was the least (N 982.40). The birds on 15 percent *M. urens* meal had significantly ($P < 0.05$) higher returns on investment, followed by birds on 60 percent *M. urens* meal, while pullets on the control diet had the least returns on investment. Differences in returns on investment for treatment groups containing 30, 45, 60, and 75 percent *M. urens* meal were statistically similar.

Table 3: Economic efficiency of feeding processed *M. urens* bean meal to laying pullets

Parameters	Replacement levels (%)						
	0	15	30	45	60	75	SEM
Cost/kg of feed (N)	260.00	259.21	258.21	257.22	255.93	254.30	± 0.79
Total feed intake/bird(kg)	5.60	7.50	5.82	5.64	6.32	6.05	± 0.26
Cost of feed consumed(N)	1,456.00 ^b	1944.07 ^a	1502.78 ^b	1450.72 ^{bc}	1617.48	1538.51 ^b	± 20.63
Total egg produced/bird	56.00 ^b	70.00 ^a	60.00 ^b	61.00 ^b	61.00 ^b	59.00 ^b	±1.75
Revenue from egg (N)	4,106.67 ^b	5,133.33 ^a	4,440.00 ^b	4,473.33 ^b	4,473.33 ^b	4,326.67 ^b	±46.48
Profit (N)	2650.67 ^{bc}	3189.26 ^a	937.22 ^b	3,022.61 ^b	2855.85 ^b	2788.16 ^b	±27.11

Table Means with different superscripts within the same row are significantly ($P < 0.05$) different

SEM- standard error of mean

Note: Price of a dozen of egg = N 880

Conclusion and application

From the result of this study, it is concluded that:

The partial replacement of soy bean meal with the *M. urens* did not adversely influence the performance and egg quality characteristics of the pullets.

About 60% of the soybean can be replace with *M. urens* for optimum performance of the laying pullets.

References

1. Ojedapo. L.O., Akinokun O., Adedeji, T. A., Olayeni, T. B., Ameen, S. A., Ige, A. O. and Amao, S. R. (2008). Evaluation of growth traits and short-term laying performance of three different strains of chicken in the derived savannah zone of Nigeria. *International Journal of Poultry Science*, 7(1): 92-96.
2. Effiong, O. O. and Jimmy, N. P. (2019). Chemical composition of toasted and fermented earth ball (*Ipomoea pes-caprae*) meal: determination of its feeding value using broiler chickens. *Global Journal of Agricultural Sciences* 18 (1):13-18.
3. Osaniyi, C. B. and Eka, O. U. (1978). Studies on chemical composition and nutritive value of horse eye bean (*Mucuna urens*). *West African Journal of Biology and Applied Chemistry*, 32:228-229.
4. Umoren, U. E. Effiong, O. O. and Akpan, I. A. (2007). Nutritional Evaluation of the horse eye bean (*Mucuna urens*): Effect of processing on the chemical composition. *Journal of food Agriculture and Environment* 5 (2):128-131.
5. Effiong, O. O. and Umoren, U. E. (2011). Effect of multi- processing techniques on the chemical composition of horse eye bean (*Mucuna urens*). *Asian Journal of Animal Sciences*. 5(5): 340–348.
6. N M A (2 0 1 6) . N i g e r i a n Meteorological Agency, Margaret Ekpo International Airport, Calabar.
7. Haugh, R. R. (1937). The Haugh units for measuring egg quality. *U. S. Egg Poultry management*, 43:552-555.
8. Statistical Analysis System (SAS) (2000) *SAS User's Guide*. Version 8.1, SAS Institute Inc., Cary.
9. Duncan, D.B. (1955) Multiple Range and Multiple F-Test. *Biometrics*, 11, 1-5.
10. Togun, V. A., Farinu, G. O., Ojebiyi O. O., Akinlade, J. A., and Laogun, T. A.O. (2006). Performance of brown egg-type pullets feed diets containing graded levels of wild sun flower (*Tithonia diversifolia*, Hemsl. A. Gray) forage meals as replacement for maize. *World Journal of Agricultural Science*, 2(4): 443-449.
11. Li, F.; Xu, L. M., Shan, A. S., Hu, J. W., Zhang, Y. Y., Li, Y. H. (2011). Effect of daily feed intake in laying period on laying performance, egg quality and egg composition of genetically fat and lean lines of chickens. *British Poultry Science*, 52(2):163-168.
12. Eniolorunda, O. O. Taiwo, B. B. A, Oyewumi, O. O. and Adeyemi, O. A. (2007). Performance of laying hens fed graded levels of indomie waste as replacement for maize in a humid tropical environment. *Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production*. 32:264-267. 44
13. Adebimpe, O. M., Bamgbose, A. M. and Oso, I. (2007). Performance of layers fed full-fat soybean at various energy levels. *Proceedings of the 32nd Annual Conference of the*

- Nigerian society for animal production. 32:303-304
14. Madubuike, F. N. and Obidimma, V. N. (2009). Brewers' dried grain as energy source on external and internal egg qualities of laying hens. Proceedings of the 34th Annual Conference of the Nigerian Society of Animal Production, 34:362-365.
 15. Yasmeen, F., Mahmood S., Hassan M., Akhtar, N. and Yaseen, M. (2008). Comparative reproductive performance and egg characteristics of pullets and spent layers. Pakistan Veterinary Journal, 28(1): 5-8.
 16. Fafiolu, A. O., Oduguwa O. O., Ikeobi, C. O. N., and Onwuka, C. F. I. (2006). Utilization of malted sorghum sprouts in the diet of rearing pullets and laying hens. Archivos de zootecnia, diciembre, ano/vol. 55. numero 212: 361 – 371.
 17. Onyimonyi, A. E. and Ugwu, S. O. C. (2007). Performance of laying hens fed varying dietary levels of bambara (*Voandzeia subterrennea* thouars) offal. International Journal of Poultry Science, 6(3): 223-226.
 18. Karaman, M., Yilmaz and Uluocak, A. N. (2006). Effects of different group sizes on egg production and quality in early laying stage of laying hens. Research Journal of Animal and Veterinary science, 1(1): 9-11.
 19. Suk, Y. and Park, C. (2001). Effects of broiler breeder age and length of egg storage on albumen characteristics and hatchability. Poultry Science, 80: 855-858.
 20. Roberts, J. R. (2004). Factors affecting egg internal quality and egg shell quality in laying hens. Journal of Poultry Science, 41: 161-177.
 21. Olayeni, T. B., Farinu, C. O., and Ojebiyi, T. (2007). Replacement value of biscuit waste on the performance and egg quality parameters of laying hens. Proceedings of the 32nd Annual Conference of the Nigerian Society for Animal Production. 32: 313-315.
 22. Iyayi, E. A. and Taiwo, V. O. (2005). The effect of diets incorporating mucuna (*Mucuna pruriens*) seed meal on the performance of laying hens and broilers. Tropical and Subtropical Agroecosystems, 1(2-3): 239-246.
 23. Eniolorunda, O. O. Taiwo, B. B. A., Oyewumi, O. O. and Adeyemi, O. A. (2007). Performance of laying hens fed graded levels of indomie waste as replacement for maize in a humid tropical environment. Proceedings of the 32nd Annual Conference of The Nigerian Society for Animal Production, 32:264-267.
 24. Stadelman, W. J., and Owen J., Cotterill (1977). Egg science and technology (2nd edition.) AVI Publishing Company INC. WestPoint. Connecticut, 29. 45
 25. Ekweozor, I. K. E., Granville A. W., Nkanga E. E., W and Ogbalu, O. K. (2002). The effects of crude oil contaminated feeds on the yield and quality of eggs of poultry (*Gallus domesticus*). Journal of Agriculture, Tropical and Sub tropics, 103: 89-97.