The performance and egg quality traits of Nigerian local hens fed varying dietary levels of palm kernel cake with added palm oil

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Primary Audience: Poultry Farmers, Poultry Nutritionists, Poultry Feed Millers, Oil Palm Processors

SUMMARY

A total of 120 local hens at the point of lay were randomly assigned, 2 per cage, with 10 replicates per diet in a completely randomized design, to 6 palm kernel cake (PKC)-based layer diets that contained 20% CP and 2,700 kcal of ME/kg of feed. The PKC was included at levels of 10, 20, 30, 40, and 50% in diets 2, 3, 4, 5, and 6, respectively. Diet 1 without PKC served as the control. To make the diets isocaloric, 0.5, 1.48, 3.35, 5.22, 7.11, and 8.98% palm oil was added to diets 1, 2, 3, 4, 5, and 6, respectively. Feed and water were offered ad libitum for 12 wk. The hen-day production (53.8 to 63.3%) peaked at dietary PKC levels of 20 to 40%. Feed conversion ratio was also the lowest in hens fed the 20 to 40% PKC-based diets, but it was poorer than the control diet for those fed 50% PKC. The least hen-day production was obtained for birds on the 50% PKC-based diet. The albumen height (3.16 to 3.73 mm) was highest for eggs laid by hens fed the control and 10% PKC diets. The egg yolk indexes obtained for hens fed 0 to 10% dietary PKC (0.2) were significantly higher than those obtained for hens fed 20 to 50% PKC (0.13 to 0.15). The yolk color score increased significantly ($P < 0.05$) across the diets (from 1.0 to 5.9) as the level of palm oil increased. The egg weight, egg circumference, eggshell thickness, egg shape index, and weights of the albumen and yolk were similar across diets. Feeding up to 40% PKC with added palm oil had no adverse effect on the performance of Nigerian local hens and the quality of their eggs.

Key words: egg quality, local hen, palm kernel cake, palm oil, performance

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DESCRIPTION OF PROBLEM

Humans and livestock, especially poultry, compete for cereals and other grains as food. The cost of cereals and other conventional feed ingredients is increasing in Nigeria because of their diverse use and the high cost of importation resulting from the high exchange rate. This has been reducing the profit margin of poultry farmers or making the business less attractive in Nigeria. Palm kernel cake (**PKC**), the by-product of or residue from oil extraction from the en-

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dosperm of the oil palm fruit (*Elaeis guineensis* Jacq.), is cheap, nontoxic, and readily available in southern Nigeria. The protein requirements of Nigerians have not been able to be met by depending solely on exotic or imported breeds of livestock, especially chickens; hence, the need exists to exploit the potential of local breeds to supplement meat production for the populace. Local or indigenous fowl are abundant, outnumbering all other livestock species in Nigeria; their number was estimated to be about 123.9 million in 1978 [1], 115.9 million in 2003 [2], and 84 million in 2006 [3]. Nigerian local hens are widely reared on free range in Nigeria because of their highly valued eggs and adaptability to the local environment. Even though little or no adequate care is given in term of housing, nutrition, and medication, they serve as the major source of dietary protein and as an important source of dietary protein for low-income rural and indigenous dwellers. There is a paucity of information on feeding PKC to local hens kept under an intensive system of management. The performance and egg quality traits of Nigerian local fowl fed varying dietary levels of PKC with added vegetable oil were assessed over a period of 12 wk.

MATERIALS AND METHODS

Experimental Birds and Design

The study was carried out at the Zartech unit of the Teaching and Research Farm of the University of Ibadan, Ibadan, Nigeria. Nigerian local hens and cocks on free range were procured from local markets in the state of Oyo, Nigeria, and allowed to breed. The birds were multicolored, black, brown, or off-white in plumage color with thin, scaled, feathered or unfeathered, black-, yellow-, or white-colored shanks [4–7]. Fertile eggs laid by these hens were hatched in the hatchery, and the emerging chicks were fed chick and grower mash. The chicks were later sexed and raised to the point of lay (24 wk of age). During the course of rearing from 1 d old to the point of lay, the birds were vaccinated against infectious bursal disease, Newcastle disease, and fowlpox infection. Prophylactic antibiotics and a coccidiostat with electrolytes or antistress were also administered. A high level of hygiene and sanitation was maintained throughout the period of study. A total of 120 local birds at the point of lay weighing 861.10 to 1,015.20 g were randomly selected and their BW were equalized across dietary treatments before assigning them to cages, at 2 per cage, with 10 replicates per diet in a completely randomized design. The dimensions of the cage were 33.2 cm in length, 39 cm in breadth, 45.5 cm at the front height, and 39.5 cm at the back height per cubicle. The house was roofed with asbestos, and wire netting was fixed around the house for proper ventilation. The experimental procedures were approved by the lecturers and postgraduate committee of the Department of Animal Science, University of Ibadan, Ibadan, Nigeria, before the experiment commenced.

Experimental Diets

Six layer mash diets (herein referred to as diets that were isonitrogenous and isocaloric) containing 20% CP and 2,700 kcal of ME/kg of feed were formulated with varying dietary levels of PKC. Diet 1 without PKC served as the control. The other 5 diets contained 10, 20, 30, 40, and 50% PKC, which was used to replace corn, soybean meal, and wheat bran (tagged diets 2, 3, 4, 5, and 6, respectively). Palm oil was included (0.5 to 8.98%) to balance the energy content so that the diets remained isocaloric (i.e., 2,700 kcal of ME/kg). As the inclusion level of PKC in the diets increased from 0 to 50%, the CF progressively increased (Table 1), which was a result of the increasing fiber content of the test ingredient (PKC). Birds were given access to feed and water ad libitum. The composition of the experimental diets is as shown in Table 1.

Data Collection

Indices measured included ADFI, daily egg production, hen-day production (**HDP**; %), FCR (kg of feed/kg of egg), egg weight or mass (g), circumference or eggshell surface area (cm), egg length (cm), egg width (cm), egg shape index, eggshell thickness (mm), eggshell weight (g), yolk weight (g), yolk height (cm) and width (cm), yolk index, albumen weight (g), albumen height (mm), Haugh units, and yolk color score.

Table 1. Composition of experimental diets with varying dietary levels of palm kernel cake (PKC) fed to Nigerian local hens

	Diet					
Item	1	2	3	4	5	6
Ingredient, %						
Corn	47.06	41.38	32.03	22.68	13.29	3.92
Soybean meal	30	28.70	27.00	25.36	23.26	21.96
PKC[1]	—	10	20	30	40	50
Wheat bran	10.4	6.4	5.58	4.70	3.97	3.10
Palm oil	0.5	1.48	3.35	5.22	7.11	8.98
Fish meal (72% CP)	1.30	1.30	1.30	1.30	1.30	1.30
Bone meal	3	3	3	3	3	3
Oyster shell	7	7	7	7	7	7
Sodium chloride	0.30	0.30	0.30	0.30	0.30	0.30
Layer premix[2]	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.09	0.09	0.09	0.09	0.09	0.09
Total	100	100	100	100	100	100
Calculated analysis, % or as indicated						
ME, kcal/kg	2,701.70	2,700.49	2,700.24	2,700.48	2,700.41	2,700.42
CP, %	20.01	20.02	20.03	20.05	20.05	20.08
CF, %	3.79	4.45	5.28	6.11	6.95	7.78
Calcium, %	3.71	3.73	3.74	3.76	3.78	3.79
Phosphorus, %	0.74	0.73	0.73	0.72	0.72	0.71
Methionine, %	0.41	0.40	0.44	0.45	0.45	0.46
Lysine, %	1.19	1.17	1.16	1.14	1.13	1.12
CF,[3] %	9.00	9.50	10.60	11.10	11.80	12.00

[1]The PKC used contained 17.75% CP, 23.90% CF, 11.75% EE, 8.60% ash, 38.00% nitrogen-free extract, 46.10% NDF, 32.00% ADF, and 5.2% lignin [22].

[2]Supplied the following per kilogram of diet: vitamin A, 4×10^6 IU; vitamin D_3, 8×10^5 IU; tocopherols, 4×10^3 IU; vitamin K_3, 800 mg; folacin, 200 mg; thiamine, 600 mg; riboflavin, 1,800 mg; niacin, 600 mg; calcium pantothenate, 2 g; pyridoxine, 600 mg; cyanocobalamin, 4 mg; biotin, 8 mg; manganese, 3 g; zinc 20 g; iron, 3 g; choline chloride, 80 g; copper, 2 g; iodine, 480 mg; cobalt, 80 mg; selenium, 40 mg; butylated hydroxytoluene, 25 g; and anticaking agent, 6 g.

[3]Determined by analysis [37].

Data Analysis

All data obtained were subjected to ANOVA using the GLM of SAS software [8]. Treatment means were compared by the Duncan option of the software.

RESULTS AND DISCUSSION

Performance Traits

The performance traits of Nigerian local hens fed varying or graded levels of PKC are shown in Table 2. The ADFI of local hens (63.97 to 73.44 g/bird per 12 wk) increased with PKC inclusion and was significantly ($P < 0.05$) higher for hens fed PKC-based diets than those obtained for birds fed the control diet (64.02 g/bird per day) except for those fed the 30% PKC-based diet, whose feed intake values were similar. The increase in feed intake could be due to the fibrousness (4.45 to 7.78% CF) of the feed because PKC has been reported to contain about 16.2 to 25.3% CF [9–11] and 81% of PKC carbohydrate is in the form of nonstarch polysaccharides, of which insoluble-cellulose polysaccharide accounts for 33.6% of the DM [12]. Fibrous feeds that contain PKC have been reported [10, 13] to have high bulk density, low viscosity, and low water-holding capacity and thus exhibit a faster passage rate in the digestive tract. The nutrients in fibrous feeds are diluted with fiber components and would not easily be released during digestion; this will cause hens to adjust their feed intake to obtain the necessary energy and other nutrients required for optimal performance. It has been reported that birds eat to meet their energy requirement [5, 14, 15].

Table 2. Performance traits of Nigerian local hens fed diets containing varying levels of palm kernel cake (PKC)[1]

	Diet						
Parameter	1	2	3	4	5	6	SEM
Daily feed intake, g/bird per 12 wk	64.02^{b}	69.42^{a}	71.97^{a}	63.97^{b}	69.28^{a}	73.44^{a}	0.48
Hen-day production, %	53.80^{c}	56.77^{abc}	62.26^{ab}	61.78^{ab}	63.33^{a}	55.47^{bc}	0.71
FCR, kg of feed/kg of egg	3.02^{b}	3.06^{b}	2.89^{bc}	2.63^{c}	2.84^{bc}	3.47^{a}	0.10

[a–c]Mean values within the same row with different superscripts are significantly different ($P < 0.05$).

[1]Diets 1, 2, 3, 4, 5, and 6 contained 0 (control), 10, 20, 30, 40, and 50% PKC, respectively.

Inclusion of dietary fat has also been indicated to increase the palatability of the diet, decrease dustiness, and improve the texture of the feed, feed intake, and utilization of dietary nutrients [16, 17].

Local hens fed PKC-based diets (10 to 50% PKC) had a significantly ($P < 0.05$) higher HDP (55.47 to 63.33%), which peaked at dietary PKC levels of 20 to 40%, compared with the HDP obtained (53.80%) for those fed the control diet. Therefore, PKC inclusion had no adverse effect on bird performance in term of egg production. The percentage of HDP obtained in this study (53.80 to 63.33%) compared with the 55.1 to 64.54% HDP reported by Onwudike [18, 19] when feeding the Harco strain of laying hens 0 to 50% PKC for 8 to 10 mo. Longe and Adekoya [20] obtained 56.9 to 69.9% HDP in layers fed 0 to 31.8% PKC-based diets for 12 wk. However, a higher HDP (70.4 to 80.1%) was reported [11] when 0 to 50% palm kernel meal was fed to Single Comb White Leghorn hens for 20 wk.

The FCR also varied significantly ($P < 0.05$), from 2.63 to 3.47, with hens fed 20 to 40% PKC-based diets, giving a lower, better, more efficient, and more favorable FCR; however, the FCR of hens fed 50% PKC was poorer than that of hens fed the control diet. This can be attributed to the inclusion of palm oil in the diets, coupled with the fact that the diets were balanced for nutrients because they were isocaloric and isonitrogenous. The inclusion of synthetic sources of methionine and lysine helped balance and improve the quality of the amino acid profile, cancelling the negative effect of the lysine:arginine ratio of PKC and thus meeting the requirements of the birds for maintenance and egg production. Onwudike [19] obtained FCR of 3.09 to 3.12 and had a better HDP when feeding the Harco strain of laying hens diets containing up to 40% PKC and 2% methionine. Palm kernel cake has been shown to be deficient in methionine, lysine, leucine, and isoleucine [13, 21].

Egg Quality Traits

The egg quality traits of Nigerian local hens fed varying or graded levels of PKC are shown in Table 3. Egg weights (38.42 to 40.49 g) were similar across diets, with no significant differences in weights ($P > 0.05$). The inclusion of varying levels (0 to 50%) of PKC did not have a negative effect on egg weight, egg circumference, or egg length, meaning that the dietary PKC was nutritious and useful despite its fibrousness and imbalanced amino acid profile. The mean egg weight (38.88 to 40.49) obtained in this study was larger than that obtained (33.20 to 37.40 g) in another study [22] probably because of the addition of palm oil, as many researchers have reported [23, 24]. The increase in egg weight has been suggested to be a response to a higher intake of linoleic acid or the presence of fat in the diet per se [23] as well as increased plasma estradiol [24]. The egg weights so obtained were within the observed range and values (35.80 to 42.84 g) reported for local eggs by Udeh and Omeje [25], Asuquo et al. [26], Olori and Sonaiya [27, 28], and Oluyemi et al. [29]. The physical characteristics of the egg play an important role in the process of embryo development and successful hatching. Nurashin and Romanov [30] identified egg weight, eggshell thickness and porosity, egg shape index (described as the maximum breadth-to-length ratio), and the consistency of contents as the most influential egg parameters.

The values for egg surface area or circumference obtained in this study (55.63 to 57.16 cm) were higher than the 49.6 ± 4.1 to 53.0 ± 3.2

Table 3. Egg quality traits of Nigerian local hens fed varying dietary levels of palm kernel cake (PKC)

Parameter	Diet						SEM
	1	2	3	4	5	6	
Egg weight, g	40.49	40.47	39.66	39.43	38.88	38.42	0.29
Egg circumference, cm	57.16	57.13	56.39	56.20	55.63	55.21	0.28
Egg length, cm	5.01	4.95	5.02	5.05	4.95	4.95	0.01
Egg width, cm	3.87[a]	3.75[ab]	3.78[ab]	3.77[ab]	3.78[ab]	3.72[b]	0.01
Egg shape index	0.77	0.76	0.75	0.75	0.76	0.75	0.002
Eggshell thickness, mm	0.33	0.34	0.33	0.33	0.32	0.33	0.003
Eggshell weight, g	4.12[ab]	4.22[a]	3.86[ab]	3.87[ab]	3.73[b]	4.05[ab]	0.04
Albumen weight, g	21.33	21.49	20.41	20.59	19.78	19.55	0.21
Albumen height, mm	3.61[ab]	3.73[a]	3.34[bc]	3.28[c]	3.16[c]	3.34[bc]	0.03
Haugh units	74.39[a]	75.34[a]	71.97[b]	71.28[b]	69.97[b]	71.06[b]	0.25
Yolk weight, g	15.05	14.76	14.50	14.97	15.37	14.82	0.13
Yolk height, cm	0.96[a]	0.99[a]	0.79[b]	0.80[b]	0.76[b]	0.79[b]	0.01
Yolk width, cm	5.14[bc]	5.08[c]	5.49[a]	5.39[ab]	5.63[a]	5.37[ab]	0.03
Yolk index	0.20[a]	0.20[a]	0.15[b]	0.15[b]	0.13[b]	0.15[b]	0.003
Yolk color score	1.00[f]	2.13[e]	3.40[d]	4.30[c]	4.86[b]	5.85[a]	0.06

[a–f]Mean values within the same row with different superscripts are significantly different ($P > 0.05$).

[1]Diets 1, 2, 3, 4, 5, and 6 contained 0 (control), 10, 20, 30, 40, and 50% PKC, respectively.

cm reported by Olori and Sonaiya [27, 28] for eggs from Nigerian indigenous chickens. Yeasmin and Howlider [31] reported eggshell surface areas of 52.60 ± 0.60 to 53.46 ± 0.60 cm for eggs from normal and dwarf indigenous hens from Bangladesh.

The width of eggs from hens fed the corn-soybean diet (control diet) without PKC (3.87 cm) was significantly higher than the width (3.72 to 3.78 cm) of eggs from hens fed the diets with PKC. The egg length (4.95 to 5.05 cm), egg shape index (0.75 to 0.77), eggshell thickness (0.32 to 0.34 mm), albumen weight (19.55 to 21.49 g), and yolk weight (14.50 to 15.37 g) were similar ($P > 0.05$) across diets. The egg lengths (4.95 to 5.05 cm) were similar to those (5.05 ± 0.27 cm) reported by Olori and Sonaiya [27]. The width of eggs from hens fed the PKC-based diets (3.75 to 3.78 cm) was significantly ($P < 0.05$) lower than the width of eggs obtained from hens fed diet 1 (control diet), which were higher than 3.66 ± 0.12 to 3.72 ± 0.13 cm, as reported by Olori and Sonaiya [27]. The egg shape index (0.75 to 0.77) was similar for hens fed the PKC-based diets, but the values obtained were higher than the 0.72 ± 0.03 reported previously for eggs from local Nigerian fowl reared on free range [28, 29].

The eggshell thickness of eggs from local hens fed the PKC-based diets (0.32 to 0.33) was adequate for egg protection and was within the range of values (0.29 ± 0.01 to 0.39 ± 0.04 mm) reported for indigenous or local hens by Agaviezor et al. [32], Yeasmin and Howlider [31], Asuquo et al. [26], and Oluyemi et al. [29]. Some dietary fats have been shown [33] to impair calcium absorption and thus affect eggshell thickness. However, the palm oil used in this study, which is known to be rich in saturated fatty acids, did not result in a significant reduction in eggshell thickness at the inclusion levels tested. The eggshell weight varied from 3.73 g in hens fed the 40% PKC-based diet to 4.22 g in those fed the 10% PKC-based diet.

The albumen weights (19.55 to 21.49 g) were also similar across treatments. The albumen weights (19.55 to 21.33 g) recorded in eggs from local hens fed PKC-based diets were within the range of 17.2 ± 2.8 and 23.17 g reported for Nigerian local chickens by Asuquo et al. [26] and Olori and Sonaiya [27, 28] but were lower than the 34.10 to 35.31 g reported by Keshavarz and Nakajima [23], obtained in eggs from a commercial strain of Single Comb White Leghorn pullets fed 2 levels each of energy (2,816 and 3,036 kcal of ME/kg), protein (14 and 18%), and fat (0 and 4%). Asuquo et al. [26] also reported that the eggs of ISA-Brown layers contained 34.01 ± 1.13 to 39.98 ± 1.28 g of albumen. The yolk weights of local eggs obtained in this study

(14.50 to 15.37 g) were similar to those reported by various researchers who have investigated local or indigenous chicken eggs, indicating that dietary PKC at varied levels had no negative effects on the yolks of the eggs. Weights of the egg yolks were lower than the weights of the albumen, a relationship that is true for most table eggs. Rose [34] asserted that heavier eggs have proportionately less yolk and more albumen.

The albumen height (3.16 to 3.73 mm), which dictates the Haugh units, varied significantly ($P < 0.05$) across diets. Higher values were obtained in eggs from hens fed the control and 10% PKC-based diets than for those from hens fed the other diets. The Haugh units (69.97 to 75.34) also varied significantly ($P < 0.05$); the eggs of local hens fed 0 to 10% PKC-based diets had significantly higher ($P < 0.05$) values (74.39 to 75.34) than those obtained (69.97 to 71.97) for hens on the other diets. The Haugh units (69.97 to 75.34) fell within the range classified by Brandt et al. [35] as being high-quality eggs (≥70 and above) and were far greater than the value of very inferior-quality eggs (≤40). The egg weight, albumen height, and Haugh units are directly related, and they determine the quality and market value of eggs.

The yolk height was significantly ($P < 0.05$) higher for the eggs of hens fed the 0 and 10% PKC-based diets (0.96 to 0.99 cm) than for the eggs of hens fed 20 to 50% PKC-based diets (0.76 to 0.80 cm). The egg yolk widths of birds fed the 20 to 50% PKC-based diets (5.37 to 5.63 cm) were higher than those obtained for hens fed the control and 10% PKC-based diets. The egg yolk index varied significantly ($P < 0.05$) from 0.13 to 0.20. The egg yolk index, expressed as the ratio of yolk height to yolk width, decreased significantly, from 0.20 to 0.13, as the level of PKC inclusion level increased beyond 10% in the diets of Nigerian local hens. The values (0.13 to 0.20) were similar to those obtained in local hens fed varying levels of energy and protein [22] but were lower than the 0.33 to 0.50 reported by Ihekaronye and Ngoddy [36] as the accepted range for the yolk index of fresh eggs from exotic chickens.

The yolk color score increased significantly ($P < 0.05$), from 1.00 in eggs laid by hens fed the control diet through 2.13, 3.40, 4.30, and 4.86 for eggs from hens on diets 2, 3, 4, and 5, respectively, to reach the peak (5.85) in diet 6 as the level of palm oil in the diets increased. The highly significant ($P < 0.01$) increase in yolk color score across diets can be attributed to the increasing dietary level of palm oil, which is very rich in xanthophyll, a lipid-like compound. Rose [34] reported that the yellow color of the yolk is caused by xanthophyll and that the xanthophyll content in the yolk is almost completely dependent on the xanthophyll content of the diet. Hence, the higher the level of palm oil in the diet, the greater the intensity of yolk yellow pigment and the higher the yolk color score.

CONCLUSION AND APPLICATIONS

Nigerian local laying hens can use PKC up to a 40% level of inclusion with added palm oil in their diets without any adverse effect on the laying performance and egg quality.

REFERENCES AND NOTES

1. Akinwumi, J. A., I. A. Adegeye, and S. O. Olayide. 1979. Economic analysis of Nigerian poultry industry. Pages 114–118 in Fed. Livest. Dept. Publ. Federal Livestock Department, Lagos, Nigeria.

2. Federal Ministry of Agriculture and Rural Development. 2006. Highly Pathogenic Avian Influenza Standard Operating Procedures, February 2006. Federal Department of Livestock and Pest Control Services, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.

3. Poultry International. 2006. Nigeria's first HPAI outbreak in Africa causes concern. Poultry production in Nigeria. Poult. Int. April:52–53.

4. Adebambo, O. A. 2005. Indigenous poultry breeds genetic improvement for meat and eggs. Pages 1–8 in Proc. 1st Niger. Int. Poult. Summit (NIPS), Ota, Nigeria. World's Poult. Sci. Assoc., Educ. Organ. Res., Nigerian Branch, Abeokuta, Nigeria.

5. Oluyemi, J. A., and F. A. Roberts. 2003. Poultry Production in Warm Wet Climates. 2nd ed. Spectrum Books Limited, Ibadan, Nigeria.

6. Nwosu, C. C., F. A. Gowen, F. C. Obioha, T. A. Akpan, and G. I. Onuora. 1985. A biometrical study of the conformation of native chicken. Niger. J. Anim. Prod. 12:141–146.

7. Oluyemi, J. A. 1974. Evaluation and improvement of the indigenous fowl of Nigeria. PhD Thesis. University of Ibadan, Ibadan, Nigeria.

8. SAS Institute. 1999. SAS User's Guide: Statistics. SAS Inst. Inc., Cary, NC.

9. Ezieshi, E. V., and J. M. Olomu. 2004. Comparative performance of broiler chickens fed varying levels of palm kernel cake and maize offal. Pak. J. Nutr. 3:254–257.

10. Onifade, A. A., and G. M. Babatunde. 1998. Comparison of the utilization of palm-kernel meal, brewer dried grains and maize offal by broiler chicks. Br. Poult. Sci. 39:245–250.

11. Perez, J. F., A. G. Gernat, and J. G. Murillo. 2000. The effect of different levels of palm kernel meal in layer diets. Poult. Sci. 79:77–79.

12. Knudsen, K. E. B. 1997. Carbohydrate and lignin contents of plant materials used in animal feeding. Anim. Feed Sci. Technol. 67:319–338.

13. Onwudike, O. C. 1986. Palm kernel meal as a feed for poultry. 1. Composition of palm kernel meal and availability of its amino acids to chicks. Anim. Feed Sci. Technol. 16:179–186.

14. Harms, R. H., G. B. Russell, and D. R. Sloan. 2000. Performance of four strains of commercial layers with major changes in dietary energy. J. Appl. Poult. Res. 9:535–541.

15. Leeson, S., J. D. Summers, and L. J. Caston. 2001. Response of layers to low nutrient density diets. J. Appl. Poult. Res. 10:46–52.

16. Parsons, C. M., K. W. Koelkebeck, Y. Zhang, X. Wang, and R. W. Leeper. 1993. Effect of dietary protein and added fat levels on performance of young laying hens. J. Appl. Poult. Res. 2:214–220.

17. Gillespie, J. R. 1998. Animal Science. 1st ed. Delmar Publishers ITP, Albany, NY.

18. Onwudike, O. C. 1988. Palm kernel meal as a feed for poultry. 4. Use of palm kernel meal by laying birds. Anim. Feed Sci. Technol. 20:279–286.

19. Onwudike, O. C. 1992. Effect of blood meal on the use of palm kernel meal by laying birds. Pages 55–58 in Proc. XIX World's Poult. Congr., Amsterdam, the Netherlands.

20. Longe, O. G., and O. E. Adekoya. 1988. Response of laying hens to different inclusion levels of palm kernel meal and vegetable oil. Niger. J. Anim. Prod. 15:111–117.

21. Sundu, B., A. Kumar, and J. Dingle. 2006. Palm kernel meal in broiler diets: Effect on chicken performance and health. World's Poult. Sci. J. 62:316–325.

22. Afolabi, K. D. 2009. Energy and protein requirements of the Nigerian local fowl (*Gallus domesticus*) fed palm kernel cake-based diets. PhD Thesis. University of Ibadan, Ibadan, Nigeria.

23. Keshavarz, K., and S. Nakajima. 1995. The effect of dietary manipulations of energy, proteins and fat during the growing and laying periods on early egg weight and egg components. Poult. Sci. 74:50–61.

24. Whitehead, C. C., A. S. Bowman, and H. D. Griffin. 1993. Regulation of plasma estrogen by dietary fats in the laying hen: Relationships with egg weight. Br. Poult. Sci. 34:999–1010.

25. Udeh, I., and S. I. Omeje. 2005. Heterosis for egg production in native by exotic inbred chicken crosses. Niger. J. Anim. Prod. 32:7–20.

26. Asuquo, B. O., B. Okon, and A. O. Ekong. 1992. Quality parameters of ISA-Brown and Nigerian local chicken eggs. Niger. J. Anim. Prod. 19:1–5.

27. Olori, V. E., and E. B. Sonaiya. 1992. Composition and shell quality of white and brown eggs of the Nigerian indigenous chicken. Niger. J. Anim. Prod. 19:12–14.

28. Olori, V. E., and E. B. Sonaiya. 1992. Effect of length of lay of Nigeria indigenous chickens on their egg composition and shell quality. Niger. J. Anim. Prod. 19:95–100.

29. Oluyemi, J.A., O. Longe, and T. Songu. 1982. Requirement of the Nigerian indigenous fowl for protein and amino acids. Ife J. Agric. 4:105–110.

30. Narushin, V. G., and M. N. Romanov. 2002. Egg physical characteristics and hatchability. World's Poult. Sci. J. 58:297–303.

31. Yeasmin, T., and M. A. R. Howlider. 1998. Comparative physical features, egg production and egg quality characteristics of normal and dwarf indigenous (Deshi) hens of Bangladesh. J. Appl. Anim. Res. 13:191–196.

32. Agaviezor, B. O., O. A. Adebambo, M. O. Ozoje, S. O. Peters, and M. A. Adeleke. 2007. Genetic evaluation of laying performance of pure exotic and indigenous crossbred pullets. Pages 114–118 in Proc. 2nd Niger. Int. Poult. Summit (NIPS), Abeokuta, Nigeria. A. O. Fanimo, O. M. O. Idowu, S. O. Peters, O. M. Sogunle, and A. V. Jegede, ed. World's Poult. Sci. Assoc., Educ. Organ. Res., Nigerian Branch, Abeokuta, Nigeria.

33. Ogunmodede, B. K., and B. Ogunlela. 1971. Utilization of palm, groundnut and melon seed oils by pullets. Br. Poult. Sci. 12:187–196.

34. Rose, S. P. 1997. Principles of Poultry Science. CAB Int., Wallingford, Oxon, UK.

35. Brandt, A. W., A. W. Otte, and K. H. Norris. 1951. Recommended standards for scoring and measuring open-egg quality. Food Technol. 5:355–361.

36. Ihekaronye, A. T., and P. O. Ngoddy. 1985. Integrated Food Science and Technology for Tropics. Macmillan Press Ltd., London, UK.

37. AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Off. Anal. Chem., Washington, DC.