Original Research

Performance and Egg Quality of Laying Hens Fed Variously Treated Cocoa (*Theobroma cacao*) Bean Shell Based Diets

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Abstract

Cocoa Bean Shell (CBS) is a potential source of protein and energy substitute for grains in livestock diets. However, there is paucity of information on the extent of its replacement value for maize in layers diet. The level to which CBS can be utilized by layers was evaluated.The Raw CBS, (RCBS), Enzyme Rovabio Treated CBS (ECBS) and CBS Fermented by solid state (FCBS) were evaluated for their contents of Crude Protein (CP), Crude Fiber (CF), Ether Extract (EE), Metabolisable Energy (ME) and Theobromine. Total of 140 laying hens at 6-week in lay was used in this experiment with 20 birds per treatment in a 2 x 3 factorial arrangement. The experiment lasted for eight weeks. Hen Day Production (HDP), internal and external egg quality characteristics were monitored. Data were analyzed using descriptive statistics and ANOVA. this study investigated the effect of treated cocoa bean shell based-diets on performance (Feed intake, Egg production, feed efficiency), egg quality (egg weight, egg shell thickness, Haught Unit, yolk Colour, egg length, egg width, egg shape index, shell weight and shell surface area, yolk weight, yolk height, yolk width, albumen weight, albumen height, yolk Colour, yolk index). No significant difference was observed in the crude fiber and ether extract values. The corresponding ME (Kcal/Kg) values were 2308.1 ± 3.1, 2415.0 ± 2.9 and 2470.0 ± 2.2 respectively. Fermentation and addition of enzymes reduce theobromine to 0.72 and 0.81 respectively while the highest value was recorded for RCBS (0.85). The FI (g/day) of layers on 10% RCBS (94.0) and ECBS (97.1) compared favorably with that of control (98.8). External egg quality parameter (egg shape index, shell weight and thickness) FCR, and Haught unit were not significantly different while the HDP (%) of birds fed 10% ECBS (85.3) compared with birds on the control (85.6). Enzyme-treated cocoa bean shell effectively replaced up to 10% maize in layers diets. Furthermore, substituting 10% maize with raw cocoa bean shell enhanced laying performance.

Key words: Cocoa Bean Shell, Growth Performance, Egg Quality, Layers

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Introduction

Now a days there has been arising issues on competition of conventional feed ingredients like maize between livestock's and man. This has necessitated the search for alternative ingredients. The upward rise in the prices of soybean meal and maize has led to an increase in the cost of compounded poultry feeds and consequently a rise in the final cost of poultry products like eggs and meat. (Odunsi and Longe, 1995). The importance of food in the development of any economy cannot be overemphasized. Animal protein deficiency in the diets of an average Nigerian has been well documented. (Awosanmi, 1999) The protein intake of most developing countries has not met the FAO (1994) recommendation of an average of 60g per caput per day. The bulk of protein intake of these countries comes from vegetable sources (FAO, 1994). It is the thin husk surrounding the cocoa bean. These CBS is high in nutritive potential but it is of limited use in animal feeds because of its theobromine content (Olubamiwa and Hamzat, 2005). Theobromine belongs to the same naturally occurring methylated xanthine group as caffeine (Ching and Wong, 1986). The amino acid profile of CBS compares favorably with palm kernel cake (Olubamiwa and Hamzat, 2005) suggesting that it could be utilized as a medium protein source to substitute grain protein in livestock diets. Previous study (Olubamiwa and Hamzat, 2005) has shown that higher dietary replacement of maize by CBS beyond 10% resulted in lower performance of birds. This limited use of CBS in animal feed had always been attributed to its theobromine content (Olubamiwa *et al.*, 2002; Olubamiwa and Hamzat, 2005). It can however, be reduced by heat, sun-drying and boiling but other treatment means have not been utilized or documented (Menon, 1982). This study investigated the effect of treated cocoa bean shell based-diets on performance (Feed intake, Egg production, feed efficiency) and egg quality (egg weight, egg shell thickness, Haught Unit, yolk colour, egg length, egg width, egg shape index, shell weight and shell surface area, yolk weight, yolk height, yolk width, albumen weight, albumen height, yolk colour, yolk index) of layer birds.

Materials and Methods

Experimental Site

This experiment was carried out at Kolmart Farm, Poultry Section, Erunmu, Ibadan, Oyo State, Nigeria. The birds were housed in an open-sided building in a thoroughly cleaned, washed and disinfected two tier cage system of 32 x 38 x 42 cm dimension. The birds were caged individually.

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Experimental Birds and Layout of the Experiment

A total of 140 laying hens at 6-week in lay was used in this experiment with 20 birds per treatment in a 2 x 3 factorial arrangement. The cocoa bean shell was sourced from cocoa industry in Lagos, while other feed ingredients were purchased from a commercial feed miller in Ibadan. Seven diets were formulated as shown in Table 1, Diet A (control diet) contained no test ingredient (CBS). Diets B and C contained raw cocoa bean shell (RCBS) with a 5% and 10% maize replacement respectively. Diet D and E contained 5 and 10% CBS with the inclusion of Rovabio enzyme (ECBS) while diet F and G also contain 5 and 10% fermented cocoa bean shell (FCBS).

Table 1- Gross Composition (g/100gDM) of Cocoa Bean Shell-Based Layer Diets

Ingredient	**A (0%)**	**B (5%)**	**C (10%)**	**D (5%)**	**E (10%)**	**F (5%)**	**G(10%)**
Maize	55.54	52.76	49.98	52.76	49.98	52.76	49.98
RCBS	-	2.78	5.55	-	-	-	-
ECBS	-	-	-	2.78	5.55	-	-
FCBS	-	-	-	-	-	2.78	5.55
SBM	12.13	12.13	12.13	12.13	12.13	12.13	12.13
GNC	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Wheat offal	12.11	12.11	12.11	12.11	12.11	12.11	12.11
Bone Meal	2.55	2.55	2.55	2.55	2.55	2.55	2.55
Oyster Shell	8.67	8.67	8.67	8.67	8.67	8.67	8.67
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	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	0.30
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Rovabio	-	-	-	0.05	0.05	-	-
Total	100.00	100.00	100.00	100.05	100.05	100.00	100.00

Calculated Composition

Metabolisable Energy	2631.06	2602.82	2574.57	2602.82	2574.57	2602.38	2585.09
Crude Protein %	16.05	16.17	16.34	16.17	16.34	16.20	16.40
Crude Fiber %	4.34	4.72	5.09	472	5.09	4.55	4.75

**RCBS-Raw Cocoa Bean Shell, *ECBS-Enzyme-treated Cocoa Bean Shell, *FCBS-Fermented Cocoa Bean Shell **Composition Vitamin/Mineral Mix 1 kg (layers): Vitamin A 1000000IU, Biotin 40g, Vitamin B12 10mg.Folic acid 500mg, Manganese 4800MG, Zinc 58mg,Iron 5800mg, Selenium 120mg, Iodine 60mg, Cobalt 300mg. Composition of methionine 20,000mg, Butylated hydroxytolerance BHT 50,000mg.*

Management of Experimental Birds

The experimental birds were raised until point of lay on commercial diet and to six weeks in-lay. The birds were given adequate medication and vaccination before the commencement of the experiment. The birds were weighed individually at the beginning of the experiment before they were placed on

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experimental diets. Feed and water were supplied adequately and other daily routine managements were provided.

Data Collection

Data were collected on performance parameters like average daily feed intake, feed conversion ratio, hen daily production and egg weight. The internal and external egg quality were monitored and included egg length, egg width, egg shape index, shell weight, shell thickness, shell percentage shell surface area, yolk weight, yolk height, yolk width, albumen weight, albumen height, yolk colour, Haught unit and yolk index. Egg Collection was carried out thrice per day. Feed were weighed at the beginning of the week and left over (refusals) at the end of each week were monitored for the computation of average daily feed intake per bird. Egg weight, yolk weight and shell weight were measured with sensitive scale calibrated in grammes. The albumen weight was calculated by subtracting the sum of the weights of the shell and the yolk from the total egg weight. Shell thickness was measured with micrometer screw gauge. The eggs were carefully broken, the contents removed and the shells were air-dried. The mean of the measurements taken from these regions (broad, narrow and equatorial) was taken to ensure accuracy. Total of 50 eggs per treatment per week was taken for egg quality determination. For egg shell weight determination, the contents of the eggs were carefully removed and the shells air-dried for two days before the weights were taken. Percentage shell weights was measured by finding the ratio of the shell weight to the egg weight, expressed in percentage. The Shell surface area was determined using the method of Lewis and Perry (1987). Hen day production (HDP) in percentage was calculated by adding all the eggs per replicate on weekly basis. Egg yolks were separated from the egg albumen with yolk separator and yolk colour determined with the aid of Roche Yolk Colour Fan. The yolk colour of the fan was compared with the egg yolks and the number on the chart that best matched a particular yolk was taken. Yolk index was calculated as the ratio of the yolk height to the yolk width. Yolk height and width were measured with a ruler calibrated in centimeter with the aid of optical pins and mathematical compass. Yolk index and Haught Unit (HU) were determined (Majaro, 1999). Yolk weight percentage was calculated as the ratio of the yolk weight to the egg weight. The width and the length of the eggs were measured with the aid of vernier caliper calibrated in centimeters. Egg width (maximum) was divided by the maximum egg length to get the egg shape index. Albumen heights in millimeter were taken with the aid of optical pin which was used for the calculation of Haught Units.

Chemical Analysis

Proximate analysis of the feed was carried out and the anti – nutritional factor, theobromine, in the diet was also determined (AOAC, 1990).

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Statistical Analysis

Data collected were analyzed using descriptive statistics and analysis of variance (ANOVA) and significant means where significant separated using Duncan Multiple Range Test (Gomez and Gomez. 1985). Statistical Analysis Software (SAS, 1999) computer package was used.

Results

The gross composition of the layer diets is presented in Table 1. Metabolisable energy decreased from 2609.96 kcal ME/kg in diet A (control diet) to 2566.39 kcal ME/kg in diet G (10% FCBS). Table 2 shows the determined analysis of experimental diets. Crude protein ranged between 17.00–17.40% (diet E). Crude fiber increased from 4.10% (diet A) to 4.8% (diet G). Ether extract values decreased from 3.49% (diet A) to 3.39% (diet G). The values obtained for ash ranged from 5.16 (diet G) – 10.00 (diet C).

Performance of Layers Fed Variously Treated CBS-Based Diets

The feed intake of the birds varied from 89.40–98.80 g/bird/day for variously treated CBS-based diets. (Table 3) Treatment effects on Hen day productions were significant. Values for birds on diet A (control), D and E (5% and 10% ECBS) were similar. Egg weight value varied from 60.06 (5% RCBS) for diet B, to the highest value of 66.56 in diet D (5% ECBS), while the FCR of birds on the control diet compared with the birds on diet C (10%RCBS) and E (10%ECBS). The values of feed conversion ratio obtained were not significant. However, significant differences occurred when 10% of the RCBS, ECBS and FCBS diet were fed to the birds. The feed intake using 10% of the variously treated CBS-based diets ranged from 89.40 – 98.79 with the birds on diet G (10%FCBS) having the lowest feed intake of 89.40. Although, birds on diet C (10%RCBS) and E (10%ECBS) compared favorably with the birds on the control diets (A).

Table 2 - Proximate Composition of Cocoa Bean Shell-Based Diet

Parameters	**A** **0%**	**B** **5%**	**C** **10%**	**D** **5%**	**E** **10%**	**F** **5%**	**G** **10%**
Crude Protein (%)	17.00	17.15	17.30	17.20	17.40	17.18	17.38
Crude Fiber (%)	4.10	4.46	4.82	4.44	4.76	4.51	4.80
Ether Extract (%)	3.49	3.46	3.40	3.46	3.44	3.44	3.39
Ash (%)	5.48	8.05	10.00	4.89	5.77	5.32	5.16
Nitrogen Free Extract (%)	69.93	68.88	64.48	70.01	68.63	69.55	69.27
Metabolisable Energy Kcal/kg/DM	2620.10	2601.00	2573.83	2610.0	2590.03	2608.53	2589.32
Theobromine %	0.00	0.03	0.06	0.02	0.04	0.01	0.03

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Table 3- Performance Characteristics of Layers Fed Variously Treated CBS Based Diet

Parameters	A 0%	B 5%	C 10%	D 5%	E 10%	F 5%	G 10%	SEM
Feed Intake (g)	98.80[a]	95.38[bc]	93.96[cd]	98.00[a]	97.06[ab]	92.16[d]	89.40[e]	0.46
Hen Day Production %	85.56[ab]	83.01b	81.51[c]	86.68[a]	85.27[ab]	81.01[c]	78.17[d]	0.53
Egg Weight (g)	61.37[bc]	60.06[c]	60.49[c]	65.56[a]	64.61[a]	63.24[b]	62.26[b]	3.19
Feed Conversion Ratio	2.44	2.47	2.55	2.43	2.48	2.53	2.65	0.05
Mortality (%) Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-

a, b, c: Means along the same row with any identical superscripts are not significant (P > 0.05)

Table 4- Performance Characteristics of Layers Fed 5% Variously Treated CBS Based Diets

	Treatments				
Parameters	**A (0%)**	**B (5%)**	**D (5%)**	**F (5%)**	**SEM**
Feed Intake (g)	98.79	95.38	98.00	92.16	1.46
Hen Day Production (%)	85.56	83.01	86.68	81.01	4.70
Egg Weight (g)	61.37	60.06	66.56	63.24	5.70
Feed Conversion Ratio	2.44	2.47	2.43	2.53	0.02

a, b, c :Means along the same row with any identical superscripts are not significant (P > 0.05)

Table 5: Performance Characteristics of Layers Fed 10% of Various Treated CBS Based Diets

Parameters	A (0%)	C (10%)	E (10%)	G (10%)	SEM
Feed Intake (g)	98.79[a]	93.96[ab]	97.06[a]	89.40[b]	1.27
Hen Day Production %	85.56[a]	81.51[b]	85.27[a]	78.17[c]	1.77
Egg Weight (g)	61.37	60.49	64.60	62.26	1.29
Feed Conversion Ratio	2.44[b]	2.55[ab]	2.45[b]	2.65[a]	0.03

a, b, c: Means along the same row with any identical superscripts are not significant (P > 0.05)

Egg Quality Parameters of Layers fed CBS - based Diets

External Egg Quality of Layers Fed CBS Based Diets

Variations observed in the egg length and width were significant (P > 0.05) (Table 5). The egg length varied from 5.54 – 5.77cm while that of the width varied from 4.25 – 4.33cm. Although the egg length of the bird fed with the control diet A is not significantly different from the eggs of those fed diet B and C. Also the egg width of the birds in the control diet A was not significantly different from those on diets B, C, D, E and F except for those on diet G. There were no significant differences in the values observed for egg shape index, shell weight and shell thickness (P > 0.05). The shell percentage ranged between 10.70 and 11.77. The lowest value (10.70) was obtained from the birds fed diet D while the highest was

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obtained from bird fed diet B. The value obtained for the shell surface area for the birds on the control diet A was not significantly different from those obtained for diet C and A, but differ from those obtained from diet B and F.

Table 6 - Egg Quality Characteristics (External) of Laying Birds Fed Cocoa Bean Shell Based Diets

	Treatments							
Parameters	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**SEM**
Egg Length (cm)	5.61[b]	5.69[b]	5.66[b]	5.77[a]	5.54[c]	5.56[c]	5.73[a]	0.01
Egg Width (cm)	4.29[a]	4.33[a]	4.29[a]	4.28[a]	4.28[a]	4.29[a]	4.25[b]	0.06
Egg shape index	1.09	1.06	1.01	1.03	1.01	1.05	1.03	0.02
Shell Weight (g)	7.18	7.15	7.12	7.12	7.12	7.12	7.13	0.05
Shell Thickness (mm)	0.33	0.32	0.32	0.31	0.31	0.29	0.28	0.01
Shell %	11.71[ab]	11.91[a]	11.77[ab]	10.70[e]	11.01[de]	11.26[dc]	11.44[bc]	0.08
Shell Surface Area	69.80[ab]	68.00[c]	69.70[ab]	69.25[b]	70.19[a]	68.15[c]	69.50[b]	2.51

a, b, c, d, e: Means along the same row with any identical superscripts are not significant (P > 0.05)

Internal Egg Quality of Layers Birds Fed CBS Based Diets

The variations observed in the internal egg quality are as shown in Table 6. The values obtained from the yolk weight, yolk height, yolk width, yolk percentage and the yolk index were significantly different (P > 0.05). Although the value obtained for egg yolk weight on the control were not significantly different from those obtained in diet C. On the yolk height, the birds from diets B, C, D, and G were comparable with those of the control. The eggs of the birds in the control were comparable in the egg width value with those from other treatments. Variations exist in the values obtained for albumen weight. The value ranges from 33.02 (5% FCBS) and 37.92 (5%ECBS). Birds on diet A (control i.e. 0% CBS) and diet E (10% ECBS) gave the highest value of albumin height (0.72cm) while birds on diet G (10%FCBS) gave the lowest value of 0.69cm. The yolk colour score was the same, 1.0 across the dietary treatments. Haught unit value were (p<0.05) not significantly different across the dietary treatment and the values ranges from 80.70-85.10. The yolk percentage ranges from 24.67–8.23. The albumen percentage ranged from 52-56 to 63.32 with the highest value obtained from birds on diet C (10% RCBS) and least value obtained from birds on diet F (5% FCBS). The yolk index was similar across the dietary treatments with yolk from eggs laid by birds on diet F having a value of 0.34. Yolk of eggs from other dietary treatments had yolk index value of 0.33 with the exception of yolk from birds on diet E with 0.32.

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Table 7 - Egg Quality Characteristics (Internal) Of Laying Birds Fed Cocoa Bean Shell Based Diets

	Treatments							
	RCBS			ECBS		FCBS		
Parameters	A 10%	B 5%	C 10%	D 5%	E 10%	F 5%	G 10%	SEM
Yolk Weight (g)	15.97^{b}	16.37^{a}	16.25^{ab}	16.40^{a}	15.50^{d}	15.42^{d}	15.80^{c}	0.31
Yolk Height(cm)	1.30^{b}	1.29^{b}	1.30^{b}	1.28^{b}	1.25^{c}	1.34^{a}	1.28^{b}	0.01`
Yolk Width(cm)	3.86^{b}	3.92^{ab}	3.88^{ab}	3.91^{ab}	3.92^{ab}	3.88^{ab}	3.94^{a}	0.05
Albumen Weight (g)	36.40a	37.67a	36.45a	37.92a	36.37a	33.02b	34.85b	0.37
Albumen Height(cm) Haught unit	0.72	0.71	0.70	0.71	0.72	0.70	0.69	0.01
Yolk Colour	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00
Yolk %	26.02^{b}	27.05^{b}	28.23^{a}	25.34^{c}	24.67^{c}	24.79	25.67	0.01
Albumen %	59.31^{c}	62.26^{b}	63.32^{a}	58.60^{bc}	57.89^{c}	52.56^{a}	56.63	3.8
Yolk Index	0.33^{b}	0.33^{b}	0.33^{b}	0.33^{b}	0.33^{b}	0.33^{c}	0.34^{a}	0.33^{b}

a, b, c, d: Means along the same row with any identical superscripts are not significant (P > 0.05)

Discussion

Proximate Composition of Experimental Diets

Birds on the control diet recorded the highest calculated metabolisable energy, ME (kcal/kg) and this decreased with increased contents of CBS in the diets. The analyzed proximate composition (g/100DM) of the experimental diets revealed that the percentage crude protein increases as the level of inclusion of various CBS increases in the diet. The crude fiber level in the diet also increases with increase in the level of CBS in the diet while the ether extract values reduce accordingly. No particular trend was observed in the ash value obtained. Nitrogen free extract did not follow any particular trend but the values obtained were close for all the dietary treatments. The highest values for crude protein were obtained for diet E (17.40%) while the least values were obtained for the control diet (17.00). The control diet (A) has the lowest crude fiber value (4.10%) while the highest value was obtained with diet C (4.82%). The highest ether extract value of 3.49% was obtained in the control diet. The metabolisable energy (kcal/kg) values of all the diets met the levels recommended by Olomu, (1979) and Fetuga (1984). Although the dietary crude protein levels in all the diets met the values recommended by National Agricultural Extension and Research Liaison Services (NAERLS) (1990) and Olomu (1995). The crude fibre was within 3–5% recommended by NRC (1994) for layers.

Performance Characteristics

Variations observed in the feed intake (FI), hen day production (HDP) and Egg Weight were significant except feed conversion ratio. The feed intake of the birds on the control diet were higher and similar to those on diet D and E (5 and 10%ECBS). This is in line with the findings of Iyayi and Okhankhuele,

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(2002) who reported that birds on enzyme supplemented diets performed significantly better than those on other diets, in cassava leaf meal based diets supplemented with enzyme. However, the average daily feed intakes of the birds on the RCBS were lower than those on the control diets A, D and E (ECBS). This could be as a result of the anti-nutritional factor theobromine in the diet. As the level of CBS in all the diet increased the feed intake declined. Several reports (Yeong *et al.,* (1989); Odunsi *et al.*, 1999; Olubamiwa *et al.,* 2002) depicted reduced feed intake by laying birds fed CBS and cocoa bean cake based-diets due to the theobromine content of the diet. Reduced feed intake is believed to be due to destruction of the intestinal lining and severe indigestion in the birds (Yeong *et al.,* 1989; Olubamiwa *et al., 2000)*. Although, differences in HDP of birds on diet D and E (ECBS) were not significant compared with control, the birds on diet D had the highest hen day production followed by those on diets A and E. This apparent increase in egg production could be due to the enzyme added to diets D and E. Also, Olukosi and Adeola, (2007) reported that supplementation of wheat based diet with combination of xylanase and phytate improved growth performance of broiler chickens. However, the HDP and egg weight obtained in this study were higher than those reported elsewhere (Keshavarz and Nakajima, (1995). This could be due to the fact that the protein requirement of these birds was met at lower level of 10% CBS as noted (Junqueira *et al.* (2006). The slight decrease in metabolisable energy/ (kcal/kg) and ether extract, and increase in crude fibre with increased levels of substitution could be responsible for slight numerical decreases in HDP obtained with increased levels of substitution of CBS for maize. This is in line with the report (Reid *et al.*, 1984) which observed an increase in egg production of single comb white leghorns pullets fed 16% dietary protein. As metabolisable energy increased from 2.42 to 2.64 and from 2.68 to 3.08 kcal ME/g diet there was a 2.25% increase in egg production for every 0.22 kcal ME/g increase in the diet. Egg production was however not affected by dietary energy level. (Harms *et al.*, 2000). The values of ADFI (87.00–98.80g/bird/day) and HDP (78.17–86.68%) obtained in this study were higher than the corresponding values with spent sorghum grain and whole cassava meal (Aderemi *et al.,* 2006) The HDP of 77– 78% obtained at the peak production (9–10 weeks) of Nera (Majaro, 1999) were lesser than those obtained in this study. However, while higher ADFI was obtained for birds fed kola pod-based meal by Olubamiwa *et al.,* (2000), the percentage HDP (64.5–71.3) recorded by these authors were far below the values obtained in the present study. The egg weight of birds on the RCBS was lower than all other treatments; this could be attributed to the presence of theobromine. Previous studies have shown that theobromine reduces feed intake which leads to lower laying rate and egg size (Hatagalung and Chang, 1978, Odunsi *et al.*, 1999, Olubamiwa *et al.*, 2002). Egg weight of birds on diet with enzyme CBS diets D and E (5 and 10%) has higher egg weight compared with the control diet. This shows that addition of enzyme Rovabio effectively reduce the anti-nutritional factor in cocoa bean shell. According to Viveros *et al.*, (2002) effect of anti-nutrients is markedly reduced when diets are

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supplemented with enzymes by interfering with the antinutrients-protein complexes and thereby releasing these proteins for digestion. This improved performance of birds on enzyme-supplemented diets is brought about by improved absorption of fats and fatty acids as well as fat-soluble micronutrients contained in the diet (Danicke *et al*., 1999). The FCR obtained in this study 2.43–2.65 were lower when compared with that recorded by Kwari *et al.,* (1999). 4.14–4.92 but fall within the same range with that of Fasuyi *et al.*, (2005) 2.38–2.76. The absence of mortality throughout the period of this experiment further attested to the suitability of CBS as a substitute for maize in layers diet. This also indicates that layer can tolerate CBS based diet than broilers. When all the performance of the laying birds fed 5% of the various forms of CBS based diet was compared, there were no significance difference in value of ADFI, HDP, egg with and FCR but when compared at 10%, significant difference ($P > 0.05$) was observed in the ADFI, HDP and FCR.

Egg Quality Parameters

The mean values of egg shape index, shell weight, shell thickness, albumen height, yolk colour score and Haught unit of eggs laid by birds fed all levels of variously treated CBS based diets were not different ($P>0.05$) from the control. The egg length, egg width, shell percentage, shell surface area, yolk weight, yolk height, yolk width, albumen weight, yolk percentage, albumen percentage and yolk index were, however, significantly ($P< 0.05$) affected by dietary treatments. The egg length and width of birds on diet D and G were higher than those of others, although the egg length of the birds on the control diet was comparable with those on diet B and C (5 and 10% RCBS). The egg shape index was similar for all dietary treatments and slightly higher than the ideal value reported by Smith (2001). Egg shape index is important when eggs are packed in specialized containers. Abnormally shaped eggs do not fit into trays and get broken in handling process. Dietary treatment did not have any effect on shell weight. This showed that shell deposition was similar in all dietary treatments. Smith (2001) reported that the same amount of shell is deposited in eggs irrespective of size of egg. Egg shell thickness values were very close and the variations observed were not significant ($P>0.05$).

The values obtained in this study were similar to the values reported for layers by Smith (2001). A negative correlation between shell thickness and laying rate observed in different Sudanese indigenous chicken types by Mekki *et al.*, (2005) did not hold in this study probably because the nutrient requirements particularly calcium and phosphorus have been met. There were no significant variations observed in the shell percentage. The shell thickness in the present study were not significantly different from the control, this is in line with the findings of Olubamiwa *et al.*, (2006) that reported reduced egg and delay in egg production and depressed weight gain, egg quality content and thin shelled eggs on birds fed 20% CBS based diets. The shell surface area of the egg of birds on diet C, and D were comparable to

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those of eggs of diet A (the control), although, significant variation exist within the diets. As the level of the CBS in the diet increases, the shell surface area increase as well. The values obtained for yolk weight were significantly different. Although the eggs of the birds fed with the control diet (A) were not significantly different from those on C (10% RCBS). Variations also occur in the values of yolk height, width and albumen weight. This could be due to the effect of the diet although no specific trend was shown with the yolk width and albumen weight. Albumen height of the eggs laid by birds fed CBS based diets reduces as the percentage inclusion of CBS (RCBS and EBBS) increases but reduces with increase in the level of FCBS for maize in the diets.

The yolk colour score of 1.0 obtained was due to the fact that white maize was used in the formulating the diets. White maize and other ingredients used lack coloring pigments which would have impacted colour to the yolk. Similar low yolk colour scores were obtained from layers fed maize offal, cassava peel and reject cashew nut meal by Onifade *et al.,* (1999). El Boushy and Raterink, (1987) reported that the degree of pigmentation of egg yolk depends on the Xanthophyll concentration in the feed, the composition of the feed, and health of the birds. Carotenoid pigments are usually transferred to the yolk from carotenoid rich plants consumed by the hen since birds and animals generally do not have ability to synthesize carotenoid. The National Agricultural Extension and Research Liaison Services (NAERLS) (1990) confirmed that yellow maize was preferable to white maize in poultry rations because yellow maize contains the yellow substance (xanthophyll) which makes the skin of the chickens and the yolk of eggs yellow. Udebibie and Igwe (1989) reported that 10% of pigeon pea (*Cajanus cajan*) leaf meal was required to give a yolk colour score of 8 on the Roche colour fan in white maize based layers' diets. The generally accepted measurement of albumen is the Haught Unit (HU) value and higher HU value is desirable. The HU value did not follow a particular trend with the increase of CBS in the diets. Eggs laid by birds fed the control diet A had the highest ($P<0.05$) average HU value followed by with 5% RCBS and then 5% ECBS based diets. Although, the HU values were not significantly different from each other ($P>0.05$). The HU value was almost similar for all the dietary treatments, since Haught unit is the measurement most commonly used in measuring internal quality of eggs (Haugh, 1937). The result indicated that the dietary treatments did not affect internal quality of eggs. The HU values fell within the range acceptable for good quality eggs. High quality eggs usually have HU values of 70 or more while those of inferior quality have values of less than 40 (Smith, 2001*)*. While larger chicken eggs in this study contained larger amount of albumen than smaller eggs in agreement with the submission of Skala and Milo (1962) larger eggs were however not better in their HU contrary to the report of these authors. The yolk and albumen percentage were significantly different from each other. The yolk index value varies from 0.32–0.34. Yolk index is the ratio of yolk height to yolk width and a high yolk index implies

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that the yolk will be firm and will not spread out on breaking the egg (Akinpelu, 2002). The yolk index value fell within the accepted range of 0.33–0.50 for fresh eggs (Ihekoronye and Ngoddy, 1995).

Conclusion and Recommendation

Results of these investigations showed that CBS is a suitable alternative for maize in the diets of layers. Its nutritional qualities could further be enhanced to allow for incorporation into the diets of poultry at higher levels than adopted in the present study. It is therefore concluded that cocoa bean shell can be used to replace maize up to 10% in the diet of commercial layers without any deleterious effects on the performance and egg quality parameters.

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