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Performance and Organ Weights of Laying Hens Fed Diets Containing Graded Levels of Sun-dried Cocoa Bean Shell (CBS)

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Abstract: Response of laying hens fed different levels of cocoa bean shell (CBS) was investigated using eighty 18-weeks old shaver Brown pullets in a six weeks feeding trial. Five rations were formulated by addition of 0, 15, 20, 25 and 30% cocoa bean shell and allocated to five groups of bird (16 birds/group) in a completely randomized design of experiment. Each group was further subdivided into eight replicates of 2 birds per replicate. The control diet was a maize-soybean meal based diet formulated to meet the nutrient requirement of a laying bird with no sun-dried cocoa bean shell (CBS), diets 2, 3, 4 and 5 contained 15, 20, 25 and 30 percent sun-dried cocoa been shell, respectively. Compared with the control diet, average daily feed intake (ADFI), egg production per bird per week as well as percent hen day production (HDP, %) were lower in diet 2 (15% CBS) ($P < 0.05$). Increasing the level of CBS from 0 to 30% in the diets resulted in linear decreases in ADFI, egg production per week and percent HDP ($P < 0.05$). Intake of theobromine increased with increasing level of inclusion of cocoa bean shell in the diets. The weights of the spleen, kidney and ovary were similar in birds fed the control diet, diet 2 (15% CBS) and diet 3 (20% CBS) ($P > 0.05$). However, the weights of the spleen, kidney and ovary were depressed in birds fed diets 4 (25%) and 5 (30%) compared with those that received the control diet ($P<0.05$). The weights of the liver, spleen, kidney and ovary were significantly ($P < 0.05$) influenced by addition of sun-dried CBS. It was concluded that cocoa been shell cannot be included in the layers diet up to 15%, a lower level might be tolerated.

Key words: Cocoa been shell, pullets, theobromine, feed intake, percent hen day

INTRODUCTION

In most tropical countries (Nigeria inclusive), there is acute shortage of conventional protein and energy sources for use in formulating balance diet especially for monogastric animals that require highly digestible feed materials. This is consequent upon the fact that both legume and cereal grains that are available are keenly competed for by man for direct consumption and or for industrial uses. This resulted in high cost of such ingredients to a level that their ideal usage in feed formulation for livestock becomes almost uneconomical. In order to keep cost within reasonable margins, alternative uses of non-conventional feed ingredients has been advocated. Most agro- and industrial by-products are now been used with little or no processing in livestock feeding.

Cocoa bean shell is the seed coat covering the cocoa cotyledon and it constitutes nearly 10% of the bean weight resulting in disposal problems for the cocoa processing factories in Nigeria. The use of cocoa bean shells as animal feed would represent a significant gain to cocoa industry (Olupona *et al*., 2003). Earlier Odunsi *et al*. (1999), Olubamiwa *et al*. (2001) reported that cocoa-pods, cocoa dust and cocoa bean cake can be used in livestock feeding. However, cocoa bean shell utilization in livestock feeding have not been favoured as expected because of high theobromine content which is the anti-nutrient in cocoa been shell (Olubamiwa *et al*., 2000). These authors recommended 10% inclusion of unprocessed cocoa bean shell in the diet of layer birds. Caffeine and theobromine are purine alkaloids widely consumed as stimulants and snacks in coffee and cocoa based foods and most often as part of ingredients in drugs. Man has enjoyed a long history of consumption of caffeine and theobromine. Recent interest in these two alkaloids, however, is centered on their potential reproductive toxicities. The prominent effects of increasing concentrations of dietary theobromine were anorexia, decreases in body weight in mature rats, growth retardation in immature rats and atrophy of the thymus glands in rats of both sexes and testicular atrophy in male rats (Tarka *et al*., 1979). Caffeine and theobromine are now known to cross the placental and blood brain barrier thus potentially inducing fetal malformation by affecting the expression of genes vital in development. Apart from its reproductive toxicity, the presence of caffeine and theobromine in cocoa could limit its potentials as a nourishing food. This is an issue that needs to be addressed by nutritionists and the food industry at large. The objective of present study was to

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determine the effect of feeding graded levels of sun-dried CBS on the performance and weights response of internal organs of laying birds to intake of theobromine in cocoa bean shell.

MATERIALS AND METHODS

Source of test ingredients and formulation of experimental diets: Sun dried cocoa bean shell was obtained from the Cocoa Research Institute of Nigeria (CRIN) Ibadan, Oyo State.

Animals and management: A total of eighty (80) 18-weeks old Shavers Brown pullets were divided into thirty groups of two birds per group and housed in an individual cage in an intensively managed in a conventional two-tier battery cage pen. Eight cages were assigned to each of the 5 dietary treatments in a completely randomized design to give 16 birds per treatment. Feed and water were supplied for *ad libitum* intake. Feed remaining at the end of each week was measured and used to calculate feed consumption. Birds were weighed on arrival and then at a weekly interval thereafter. Routine management operations as applicable to the study area were carried out in the course of the experiment.

Experimental diets: Diets were mixed at the Ladoke Akintola University of Technology Feed mill unit, which is part of the Teaching and Research Farm located at Ogbomoso. Five diets were assigned in a completely randomized design to give 8 replicates (2 birds per replicate) cages per diet. The facilities allowed for free and continuous access to water and feed. Feeders were checked twice daily to ensure adequate feed was available. Feed remaining at the end of each week was measured and used to calculate Average Daily Feed Intake (ADFI).

A maize-soybean basal diet formulated to contain adequate nutrient concentrations for laying hens as recommended by NRC (1994) served as the control diet (D1). Sun-dried Cocoa Bean Shell (CBS) was added at 15 (D2), 20 (D3), 25 (D4) and 30% (D5) at the expense of corn bran and palm kernel cake in the control diet to make 5 dietary treatments. The experiment lasted eight weeks.

Sample collection and preparation

Percentage hen day production: Eggs were collected once daily from each replicate at 13:00h. Hen day production (%) was Calculated as:

$$\frac{\text{Number of eggs produced}}{\text{Number of hen x Number of day}} \times \frac{100}{1}$$

Organ characteristics: After defeathering, the birds were opened up and the following organs liver, gizzard, heart, lungs, pancreas, spleen, kidney and the ovary were neatly removed, weighed and expressed as a percentage of the carcass weight.

Sample preparation and chemical analysis: All analyses were performed in duplicate. The experimental diets along with cocoa bean shell sample were finely ground to pass through a 1-mm screen before chemical analysis. Diets and cocoa bean shell meal samples were analyzed for DM, gross energy, ether extract, ash and crude protein. Dry matter and ether extract were determined according to the AOAC procedures (AOAC, 1990). Crude protein (N x 6.25) content was determined using a Leco NS 2000 Nitrogen Analyzer (LECO Corporation, St. Joseph, MI). Gross energy was measured using a Parr adiabatic oxygen bomb calorimeter (Parr Instrument Co., Moline, IL) that had originally been calibrated.

Statistical analyses: The data were analyzed by analysis of variance. When analysis of variance indicated a significant treatment effect, means were compared using the Duncan multiple range test (Duncan, 1955; Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The gross composition of the experimental diets is presented in Table 1. The table shows that the crude protein content falls within the range recommended for laying birds. The proximate composition of the cocoa bean shell is presented in Table 2. The chemical composition of the sun dried CBS showed that the dry matter of 94.25%, crude protein 13.63%, ether extract 10.25%, crude fibre 12.75%, ash 8.42% and Nitrogen Free Extract (NFE) 54.95%. This result is in agreement with the reports of others Olupona *et al*. (2003), Apata and Ogundele (2005). The high values of ether extract and NFE obtained in the sun-dried CBS used in this study are indicative of its being a potential energy source. Although the proximate composition of cocoa bean shell can vary depending on the types of bean, the quality of fermentation, drying and the subsequent processing of the bean.

The performance characteristic of layers fed diets containing graded levels of cocoa bean shell is presented in Table 3. The final live weights of birds were not different among treatments ($p>0.05$). Feed intake (ADFI) was influenced ($p<0.05$) by the inclusion level of sundried CBS. Birds fed the control diet (D 1) consumed more feed than those that received diet containing 15% CBS ($p<0.05$). Increasing the level of sun dried CBS from 15 to 30% resulted in linear decreases in ADFI. The reduced ADFI by birds fed higher levels of CBS is probably a consequence of the high fibre and theobromine content. A reduction in feed intake and weight gain has been reported in poultry fed cocoa by-

Table 1: Gross composition of experimental diets

	Dietary treatments				
Ingredients	1	2	3	4	5
Maize	40.00	40.00	40.00	40.00	40.00
Soybean meal (42%)	14.00	14.00	14.00	14.00	14.00
Cocoa bean shell	0.00	15.00	20.00	25.00	30.00
Corn bran	24.00	14.00	10.80	7.60	4.40
Palm kernel cake	14.00	8.00	6.44	4.63	2.81
Fish meal (68%)	2.00	2.00	2.00	2.00	2.00
Bone meal	3.50	3.50	3.50	3.50	3.50
Oyster shell	2.50	2.50	2.50	2.50	2.50
Premix	0.30	0.30	0.30	0.30	0.30
Salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated chemical composition					
Crude protein (%)	16.60	16.5	16.32	16.14	16.12
ME (kcal/kg)	2713.00	2693.00	2679.00	2700.00	2696.00

Premix composition/kg diet. Vitamin A - 10,000,000 i.u, Vit D3 - 200, 000 i.u, Vit E - 23,000 mg; Vit K_3 2000 mg, Vit B_1 - 3000 mg, Vit B_2-6000 mg, Niacin 50,000 mg, calcium pantotherate - 10,000 mg, Vit B_6 - 5000, Vit B_{12} - 25 mg, folic acid 1000 mg, Biotin - 50 mg, choline chloride - 400,000 mg, Mn - 120000 mg, Fe 100000 mg, Zn - 80,000 mg, Cu - 8,500 mg, I - 1500 mg, Co - 300 mg, Se - 120 mg, Anti-oxidant - 120000 mg

Table 2: Proximate composition of cocoa bean shell

Nutrients	Composition (%)
Dry matter	94.25
Crude protein	13.63
Crude fibre	12.75
Ether extract	10.25
Ash	8.42
NFE	54.95
Theobromine	1.76
ME (kcal/kg)	2400.00

products by Odunsi and Longe (1995). Similarly, Menon (1982), reported that intake of more than 0.027 kg is injurious to animal. This toxicity is consequent upon the fact that more of theobromine was consumed with increase in the level of inclusion of CBS (Table 3).

Compared with the control diet, egg production per bird per week as well as percent hen day production (HDP, %) were lower in diet 2 (15% CBS) ($p<0.05$). Increasing the level of CBS from 0 to 30% in the diets resulted in linear decreases in egg production and percent HDP ($p<0.05$). Intake of theobromine increased with increasing level of inclusion of cocoa bean shell in the diets. The number of eggs produced per week and percent HDP decreased from 5.68 and 80.88% to 1.37 and 19.54% for diets 1 (0% CBS) and 5 (30% CBS), respectively. These observations are suggestive of the depressive effect of theobromine in the sun-dried CBS on the productions in laying birds. The fact that Diet 1 (0% CBS) had higher ($p<0.05$) number of eggs produced as well as percentage hen production per week in this study suggest that sun-dried CBS cannot be included in the layer diet up to 15% which was minimum inclusion level in this study. Olubamiwa *et al.* (2000) and Olubamiwa *et al.* (2002) had earlier reported that 10% sun dried CBS did not adversely affect the egg quality and productive performance of laying birds. It can therefore be inferred that 15% CBS inclusion in layer diet perhaps is too high.

The effect of different levels of sun-dried CBS on the weights of internal organ of laying birds is presented in Table 4. Significant ($p<0.05$) differences existed among treatments in the values of liver, spleen, kidney and ovary, but no effect was obtained on the pancreas, gizzard, heart and the lungs. The weight of the liver in birds fed diets 1 (0%), 2 (15%) and 3 (20) were comparable and were higher than those that received diets containing 25% (diet 4) and 30% (diet 5) ($p<0.05$). At higher inclusion levels of sun-CBS in the diet, the liver weight decreases. This may be due to the toxic effect of theobromine at higher level of inclusion. The spleen weights obtained for birds fed diet 1 was significantly ($p<0.05$) higher than those that received diets 3, 4 and 5 but similar with value obtained in birds that received diet 2 (CBS, 15%). The values reported for diets 2, 3, 4 and 5 were not different ($p>0.05$). These results suggest that the inclusion of CBS and by implication intake of theobromine in diets of 2, 3, 4 and 5 depressed the weight of the spleen. The kidney weights for birds on diets 1, 3, 4 and 5 were comparable but significantly ($p<0.05$) lower than the weight of the kidney for birds on diet 2. The weights of the ovary 3.80, 3.24 and 2.92 for diets 1, 2 and 3, respectively, were comparable and were higher ($p<0.05$) than the weight of ovaryin birds fed diets 4 and 5. At higher levels of inclusion of sun-dried CBS, the ovary weight decreases and this may have effect on the productive and reproductive performance of the birds. Earlier studies Wong *et al.* (1986) had reported that increases in the level of cocoa bean shell

Table 3: Performance characteristics of laying hens feed on diets containing graded levels of cocoa bean shell

	Dietary treatments					
Parameters	1	2	3	4	5	SEM
Initial live weight	1400.00	1400.00	1400.00	1400.00	1400.00	
Final live weight	1566.00	1483.00	1475.00	1455.00	1400.00	
ADFI (g/wk)	118.20^{a}	102.60^{b}	93.93^{bc}	83.34^{c}	70.70^{d}	27.54
Av. Egg prod./wk	5.68^{a}	4.51^{b}	3.52^{c}	2.60^{d}	1.37^{d}	0.18
HDP (%)	80.88^{a}	64.34^{b}	50.20^{c}	37.16^{d}	19.54^{c}	2.60
Theobromine intake (g/wk)	0.00	189.30^{a}	231.00^{b}	256.20^{c}	260.30^{d}	10.34

^{a,b,c,d}Means on the same row with different superscripts are significantly different ($p<0.05$). SEM = Standard Error of Mean

Table 4: Weight of organs of laying hens fed different levels of diets containing varying levels of cocoa bean shell

	Dietary treatments						
Parameters	1	2	3	4	5	SEM	p-value
Liver	3.15^{a}	3.56^{a}	3.20^{ab}	2.77^{b}	2.62^{c}	0.19	0.014
Pancreas	0.30	0.36	0.36	0.37	0.42	0.03	0.32
Gizzards	6.27	5.84	5.55	5.79	5.70	0.34	0.68
Spleen	0.17^{a}	0.14^{ab}	0.09^{b}	0.12^{bc}	0.12^{bc}	0.01	0.05
Kidney	1.24^{ab}	1.37^{a}	1.11^{b}	0.94^{bc}	0.84^{c}	0.11	0.03
Heart	0.75	0.75	0.69	0.65	0.66	0.04	0.32
Lung	0.77	0.79	0.73	0.68	0.62	0.06	0.29
Ovary	3.80^{a}	3.24^{a}	2.92^{ab}	1.88^{c}	1.86^{c}	0.37	0.008

^{a,b,c}Means on the same row with different superscripts are significantly different ($p<0.05$). SEM = Standard Error of Mean

in the diet of laying hens have deleterious effect on important organs that regulate osmotic, metabolic, reproductive mechanism of laying hens. The result obtained in this study for the weight of agrees with the report of Wong *et al*. (1986).

Conclusion: From the result of this study, it appears that inclusion of cocoa bean shell at 15%, 20%, 25% and 30% cannot be recommended in the diet of laying hens. A lower level may give a different result.

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