

INCLUSION RATE AND PHYSIOLOGICAL EFFECTS OF PROLONGED FEEDING OF COCOA BEAN CAKE ON LAYERS

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Received 04 October, 1994; Accepted 19 November, 1996.

ABSTRACT

The effect of inclusion of cocoa bean cake (CBC) on productive performance and physiological response of Isa Brown pullets to prolonged feeding of CBC were investigated. Dietary inclusions of CBC (0, 50, 100 and 200g kg⁻¹ diet) were monitored in typical poultry diets from day old to 51 weeks of age. Sexual maturity and attainment of 50% Hen-day production were delayed with increasing level of CBC. Egg quality indices were higher ($P < 0.05$) at 200g Kg⁻¹ CBC diet but with reduced ($P < 0.05$) shell thickness. CBC had no significant influence on yolk or whole egg cholesterol, follicular weight and number. Layers on 0 and 50g Kg⁻¹ CBC diets had higher ($P < 0.05$) percentage of yellow follicles but lower white follicles. Liver and pancreatic hypertrophy were observed for CBC-fed layers but with reduced ($P < 0.05$) abdominal fat and oviduct length. The long term feeding of CBC at levels more than 50g kg⁻¹ diet progressively had a deteriorating effect on laying performance and follicular development.

Key Words: Cocoa bean cake, inclusion rate, layers, egg quality, follicular measurements.

INTRODUCTION

Increasing cost of conventional feedstuffs has contributed immensely to the low level of animal protein intake in the diets of people of tropical Africa. This is more apparent because animals compete with man for similar foodstuffs. The situation is likely to worsen if unconventional sources of ingredients are not identified and evaluated at all stages of animal life.

Cocoa bean cake is a fat-extracted residue and by-product of industries processing low grade cocoa beans. It is an unconventional

feed ingredient that could be utilized by poultry and is not consumable by man. It contains 23% crude protein, 16.5% ether extract, 5.75% crude fibre and 2.24% theobromine (Odunsi and Longe, 1995a). Previous reports (Odunsi and Longe, 1995a; Owusu-Domfeh *et al.*, 1970; Black and Barron, 1943) had indicated its toxicity and suggested feeding at low levels or its detheobrominisation. Alternatively, it could be gradually introduced (Hutagalung and Chang, 1978) or fed to older animals (Braude, 1943). Odunsi and Longe (1995a,b) observed that pullet chicks can only tolerate up to 200g kg⁻¹ CBC at the starter and grower phases.

This trial, therefore, aimed at providing information on the productive performance, and some physiological responses of long-term feeding of cocoa bean cake to layers.

MATERIALS AND METHODS

The origin and collection of cocoa bean cake used has been described (Odunsi and Longe, 1995a). Sixty Isa brown pullets (20 weeks old) were randomly selected from groups of birds reared from day old on diets containing either 0, 50, 100 or 200g kg⁻¹ CBC at starter and grower phases. Fifteen pullets per dietary treatment were individually caged with each bird acting as a replicate. They were maintained on the same levels of CBC received during the rearing stage but now on a layers dietary regime (18% CP and 10.9 MJ kg⁻¹ ME) as shown in Table 1 until 54 weeks of age. Feed and water were provided *ad libitum*. Sexual maturity and egg weights at maturity were noted. Body weight changes and egg quality indices were monitored at 2-week intervals while egg production and egg weights were determined weekly. Egg yolk and whole egg cholesterol were determined in triplicates per week by the procedure of Folch

TABLE 1: COMPOSITION OF DIETS CONTAINING GRADED LEVELS OF COCOA BEAN CAKE FED TO LAYERS DURING 20 - 54 WEEKS

Ingredients	LEVEL OF CBC IN DIETS (g KG ⁻¹)			
	0	50	100	200
Yellow maize	191.50	161.50	131.00	370.50
Groundnut cake	180.00	160.00	140.50	101.00
Cocoa bean cake	0.00	50.00	100.00	200.00
Fixed ingredients	328.50	328.50	328.50	328.50
Total	1000.00	1000.00	1000.00	1000.00
Determined analysis				
(g kg ⁻¹ dry matter				
Crude protein	180.00	181.20	180.70	180.60
Ether extract	26.00	29.40	30.50	25.90
Ash	54.00	61.20	58.60	57.30
(Gross Energy (MJ kg ⁻¹))	15.24	15.02	14.97	14.95

¹ Fixed ingredients supplied to each diet g kg⁻¹; palm kernel meal, 189.0; blood meal, 20.00; Oyster shell, 70.008 ; Bone meal, 40.0; Salt, 5.0; Methionine, 2.0 Vitamin-mineral premix², 2.0.

² Odunsi and Longe (1995b)

TABLE 2: PERFORMANCE OF LAYERS FED DIFFERENT LEVELS OF CBC AT 20 - 32; 33 - 44; 45 - 54 AND 20 - 54 WEEK PERIODS.

Parameters	LEVEL OF CBC IN DIETS G KG ⁻¹				
	0	50	100	200	SEM
Age at first egg (days)	157.00	174.00	186.00	191.00	-
Weight of first egg (gm)	44.50	46.50	54.24	49.10	-
Hen day production %					
20 - 32 weeks	41.31 ^a	35.84 ^a	17.62 ^b	8.99 ^b	3.24
33 - 44 weeks	67.59 ^a	59.88 ^a	41.93 ^b	40.24 ^b	3.17
45 - 54 weeks	64.64 ^a	65.86 ^a	46.25 ^b	33.33 ^b	2.79
20 - 54 weeks	54.93 ^a	56.27 ^a	33.42 ^b	14.24 ^c	3.18
Egg Weight (gm)					
20 - 32 weeks	57.39 ^{ab}	56.15 ^{ab}	60.49 ^a	51.11 ^b	0.79
33 - 11 weeks	60.31 ^a	57.37 ^{ab}	58.55 ^a	54.23 ^b	0.62
45 - 54 weeks	60.70	58.95	60.00	57.40	0.58
20 - 54 weeks	59.27 ^a	57.65 ^a	59.87 ^a	54.12 ^b	0.50
Feed intake (gm/bird/day)					
20 - 32 weeks	94.86 ^{ab}	96.70 ^a	91.08 ^b	82.83 ^c	1.17
33 - 44 weeks	108.75 ^a	104.47 ^{ab}	87.66 ^b	78.40 ^c	2.32
45 - 54 weeks	109.27 ^a	102.06 ^b	91.94 ^c	45.83 ^c	2.98
20 - 54 weeks	102.27 ^a	101.01 ^a	90.11 ^b	82.08 ^c	1.58
Body Weight gain (kg)					
20 - 32 weeks	0.31 ^c	0.42 ^{bc}	0.56 ^{ab}	0.62 ^a	0.03
33 - 44 weeks	0.18 ^c	0.14 ^a	0.01 ^b	-0.05 ^b	0.02
45 - 54 weeks	-0.03	-0.15 ^b	0.13	-0.10	0.04
20 - 54 weeks	0.45 ^{ab}	0.39 ^b	0.60 ^a	0.47 ^{ab}	0.03
Feed Efficiency					
20 - 32 weeks	5.12 ^b	7.06 ^b	11.35 ^b	54.67 ^a	4.10
33 - 44 weeks	2.68 ^b	2.73 ^b	3.84 ^a	4.00 ^a	0.10

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TABLE 3: MEAN EGG QUALITY AND CHOLESTEROL VALUES OF EGGS FROM LAYERS FED DIFFERENT LEVELS OF CBC (20-54 WEEKS).

Parameters	LEVEL OF CBC IN DIETS (g KG ⁻¹)				SEM
	0	50	100	200	
Haugh unit (%)	73.79 ^b	73.95 ^{ab}	78.11 ^{ab}	80.49 ^a	0.93
Shell thickness (mm)	0.38 ^a	0.35 ^b	0.34 ^b	0.32 ^c	0.04
Yolk colour (Roche Fan No)	7.49 ^d	7.69 ^c	7.84 ^b	8.65 ^a	0.14
Yolk index	0.41	0.42	0.43	0.44	0.01
Mean egg yolk cholesterol (mm/gm egg)	13.53	13.02	12.87	n.a	0.38
Whole egg cholesterol (mm/gm egg)	3.72	3.81	3.64	n.a	0.07

n.a - not available

Means without common superscripts in horizontal rows are significantly different ($P < 0.05$).

et al (1956) as modified by Washburn and Nix (1974) during the last 4 weeks of study. At the 54th week of age, 5 birds per treatment were sacrificed except for the birds on 200g kg⁻¹ CBC diet for which mortality had reached 100%. The liver, pancreas, oviduct and abdominal fat were carefully removed and weighed. Follicular number and type were counted with the aid of hand lens while diameter was measured using vernier caliper, and grouped into ranges between 0-3. 0mm. Proximate analysis of the diets were carried out (AOAC, 1990) and gross energy values determined with a Parr adiabatic bomb calorimeter.

Results were evaluated by analysis of variance with significant differences between treatment means assessed by the Duncan's Multiple range test (Steel and Torrie, 1980). Data on some parameters were subjected to linear regression analysis (Gomez and Gomez, 1985).

RESULTS AND DISCUSSION

Performance data (Table 2) show a delay in sexual maturity (age at first egg) by about 17, 29 and 34 days for pullets on 50,100 and 200g kg⁻¹ CBC diets respectively. Hen day production (HDP) was better ($P < 0.05$) for 0 and 50g kg⁻¹ CBC diets compared to 100 and 200g kg⁻¹ CBC diets which were similar. Feed consumption declined ($P < 0.05$) with inclusion of CBC even though layers on 0 and 50g kg⁻¹ CBC diet had similar ($P > 0.05$) intake except during the 45-54 week period. During the rearing phase, decreases in feed and energy

intakes by pullets on CBC based - diets were observed which could be likened to a feed restriction model (Johnson *et al.* 1984) consequently resulting in lower body weights at 20 weeks and a delay in sexual maturity. Pullets on 0, 50, 100 and 200g kg⁻¹ CBC diets attained 50% HDP by 24, 25, 31 and 34 weeks of age respectively. The low egg production at levels more than 50g kg⁻¹ CBC seemed to be associated with reduced feed consumption due to the theobromine content and changes in dietary profile. The low chemical score and essential amino acid index for cocoa products (Owusu - Domfeh, *et al.* 1970) may also be contributory factors to reduced performance. Theobromine is known to reduce intake due to its bitter taste and becomes toxic when it accumulates in the body (Greenwood - Barton, 1965), as the rate of excretion is low. The higher weight gain for 100 and 200g kg⁻¹ CBC fed-layers during 20-32 week and 33-44 week periods was an indication that the nutrients consumed were principally used for maintenance and tissue lay-down (Degen *et al.* 1988) leaving little for egg production. This was further reflected on the poor feed efficiency (kg feed/kg egg) recorded during the 20-32 week period for 200g kg⁻¹ CBC diet. Feed efficiency allowed CBC to be included up to 100g kg⁻¹ level.

Egg quality data (Table 3) show an increase in the Haugh unit and yolk colour while shell thickness decreased with increasing levels of CBC. Cocoa contains traces of oxalic acid (Harland, 1989) which combine easily with calcium to form calcium oxalate, hence, the

TABLE 4: EFFECT OF DIETARY LEVELS OF CBC ON FOLLICULAR PARAMETERS, ABDOMINAL FAT, OVIDUCT LENGTH AND ORGAN WEIGHTS (AS A PERCENT OF LIVEWEIGHT).

Parameter	LEVEL OF CBC IN DIETS G KG ⁻¹			SEM
	0	50	100	
Liveweight (kg)	1.88 ^a	1.66 ^b	1.70 ^b	0.03
Liver (5)	1.76 ^b	2.12 ^a	2.21 ^a	0.07
Pancreas (%)	0.163 ^b	0.231 ^a	0.213 ^a	0.04
Abdominal fat (%)	2.90 ^a	1.05 ^b	1.04 ^b	0.28
Oviduct (%)	3.19 ^b	4.06 ^a	3.30 ^b	0.15
Oviduct length (cm)	68.80 ^a	59.10 ^b	56.60 ^b	1.51
Follicular weight (%)	2.07	1.59	2.05	0.13
% Yellow Follicles	24.05 ^a	22.90 ^a	11.12 ^b	1.05
% White follicles	76.03 ^b	77.10 ^b	88.88 ^a	1.04
Follicular number	34.60	37.60	38.10	1.06
Follicular range (mm) ¹				
0 - 0.5	61.98 ^b	67.18 ^b	77.23 ^a	2.47
0.5 - 1.0	8.46	14.31	8.78	1.72
1.0 - 1.5	6.21	6.34	7.35	0.97
1.5 - 2.0	6.07 ^a	6.93 ^a	2.51 ^b	0.92
2.0 - 2.5	5.30	6.10	3.18	0.71
2.5 - 3.0	7.02 ^a	2.63 ^b	2.57 ^c	0.84
≤3.0	6.36	3.20	3.63	0.05

Means without common superscripts in horizontal rows are significantly different ($P < 0.05$).

¹ Values in percentage.

may reduce availability of calcium for egg formation resulting in thin shells. There is dearth of information on the effect of CBC based-diets on egg cholesterol which was found to decrease ($P > 0.05$) with increase in CBC. It appears that mechanisms of absorption, synthesis, catabolism and excretion of cholesterol by layers (Attia *et al*, 1988) in the eggs may have been ably maintained thus accounting for the little variations observed.

Data on liveweight and organ weights are shown in Table 1. Liver and pancreatic hypertrophy implicated theobromine (Odunsi and Longe, 1995a). Symptoms associated with theobromine poisoning had been described (Odunsi and Longe, 1995a; Woodman, 1911). The liver of affected birds, apart from being enlarged, had a deep mahogany colour while the kidneys were mottled. The low abdominal fat deposit on CBC fed layers may be due to caloric intake and additional call on body reserves for egg production. Follicular number and weight were not affected ($P > 0.05$) by dietary treatments while follicular type revealed reductions ($P < 0.05$) at the 100 g

kg⁻¹ CBC diet for yellow follicles and increase for white follicles. Egg production exhibited a direct relationship with follicular size and type. Layers fed 100 g kg⁻¹ CBC diet had more white follicles in the lower size range hence fewer numbers attained the size necessary for further egg development (Hookings *et al*, 1989) compared to layers on 0 and 50g kg⁻¹ CBC diets which had more yellow follicles and produced more eggs. It is possible that CBC exhibited its effect on follicular development by decreasing the rate at which yellow follicles are formed or by increasing the rate of atresia of the white follicles. Table 5 shows the regression equations between levels of CBC and some parameters. There were positive correlations ($r = 0.96, 0.93, 0.95, 0.71$) with age at first egg, feed efficiency, Haugh unit and liver weight respectively but negative correlations for HDP, DFI, shell thickness and abdominal fat respectively. (Table 5)

Inclusion of CBC up to 200g kg⁻¹ level caused heavy mortality and a reduced performance while birds on 50g kg⁻¹ CBC diet performed equally as good as those on the

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TABLE 5: LINEAR REGRESSION EQUATIONS AND CORRELATION COEFFICIENTS (R) BETWEEN DETERMINED PARAMETERS (Y) AND LEVEL OF CBC IN LAYER DIETS (X)

Dependent variable	LEVEL OF CBC IN LAYER DIET AS INDEPENDENT VARIABLE (X)			
	Regression equation	R	SER	Significance
Age at first egg (day)	Y = 162.8 + 1.62X	0.92	5.71	ns
Weight of first egg (gm)	Y = 46.33 + 0.26X	0.52	3.41	ns
Hen-day production (%)	Y = 56.48 - 2.25X	-0.96	6.62	x
Daily feed intake (gm)	Y = 103.73 - 1.11X	-0.97	2.15	x
kg feed/kg eggs	Y = 1.66 + 0.50X	0.93	1.56	ns
Haugh unit (%)	Y = 73.10 + 0.36X	0.95	0.03	x
Shell thickness (cm)	Y = 0.37 - 0.003	0.75	0.004	x
Yolk colour (Fan No)	Y = 7.41 + 0.06X	0.40	0.20	x
Liveweight (kg)	Y = 1.83 - 0.02	-0.62	0.04	x
Liver (%)	Y = 1.80 + 0.05X	0.71	0.08	x
Pancreas (%)	Y = 0.18 + 0.005X	0.49	0.02	ns
Abdominal fat (%)	Y = 2.59 - 0.19x	-0.73	0.32	ns
Egg yolk cholesterol (mg/gm egg).	Y = 13.47 - 0.07X	-0.95	0.64	x

X = P < 0.05;

ns = not significant

control diet. Observations revealed that 46.6% of the birds on 200g kg⁻¹ CBC diet died within 20-32 week, 40% during 33-44 week and the rest at 45-54 week periods. Layers on 50g kg⁻¹ CBC diet had no mortality while 20% and 6.7% were recorded for 100 and 0 g kg⁻¹ CBC diets respectively. This study showed that follicular development was impeded by the presence of theobromine in CBC based-diets which ultimately affected egg production. Further studies that would aim at reducing the level of theobromine in CBC or neutralise it completely are advocated.

ACKNOWLEDGEMENT

The author thanks Mr Sunny Ituen for his assistance during the feeding trial.

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