NUTRITIVE VALUE OF COCOA BEAN SHELL MEAL AND ITS EFFECT ON GROWTH AND HAEMATOLOGY OF WEANLING RABBITS

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ABSTRACT

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An experiment was conducted to determine the nutritive value of dietary cocoa bean shell meal (CBS) and its nutritional and economic effect on weanling rabbits. The feeding trial involved the use of one hundred weanling rabbits allocated to 5 diets of 20 rabbits of mixed sex per dietary group. Each rabbit represented a replicate in a completely randomized (CRD) experiment that lasted for 56 days. Feed and water were offered ad libitum. Final live weight and weight gain of rabbits were similar (P>0.05) up to 20% dietary inclusion of CBS meal. Both daily and total feed intakes were not significant (P>0.05). Above 10% level of inclusion, packed cell volume and white blood cells were significantly (P<0.05) reduced and increased respectively. Economic indices indicated that inclusion of 10% CBS meal in rabbit diets was economically viable.

Keywords*: Cocoa bean shell, economic indices, haematology, nutritive value, weanling rabbits*

INTRODUCTION

As the global population keeps increasing at geometric proportion, animal protein intake is far below the minimum recommendation of 65 g per day per person (FAO, 2008). This is most evident in the developing countries, particularly in Nigeria where an average citizen consumes between 8-15 g of animal protein per day compared with the 54 g per day of an average American (Nkrumah, 1988). This decline in animal protein consumption is attributable to the high cost of animal protein supply occasioned by the high cost of animal production, particularly feed cost which accounted for between 65-80% of the total cost of intensive non ruminant production (Longe, 2006; Ogunsipe *et al.*, 2015). To avert this animal protein, particularly meat must be available in sufficient quantity and quality to the citizens at affordable price so that their nutritional requirements could be met. This therefore calls for the exploitation of non-conventional feed resources particularly cocoa by-products to replace the expensive and competitive conventional feed resources in livestock diet.

World production of cocoa in 2011 stood at 4.05 million metric tons (ICO, 2012). Nigeria, being the fifth leading cocoa producing countries in the world produced about 160,000 metric tons (ICO, 2012). Consequent upon this, large quantities of cocoa wastes or by-products are generated. Cocoa bean shell (CBS); a by-product of cocoa bean in chocolate, beverage and cocoa factories, which is crispy brown with pleasant smell is estimated at about 10,500 metric tons per annum and forms about 70% of the waste (FAO, 2002). These wastes constitute environmental hazard to these factories and the immediate communities where they are sited.

Research has shown that inclusion of CBS in lamb diet up to 9% stimulated feed intake and growth while higher inclusion depressed feed intake and weight gain (TarkaJr *et al.,* 1981). In sheep and goat up to 15% led to reduce feed intake and weight gain (Alexander *et al.,* 2008) while cocoa pod husk at 30% inclusion in growing-finishing pig showed no detrimental effects on feed intake and growth rate (Oddoye *et al.,* 2010). Olubamiwa *et al.* (2006) reported poor egg production upon ingestion of up to 20% CBS by layers while Teguia *et al.* (2004) and Odunsi *et al.* (1999) observed detrimental effects on 10% and 15% CBS inclusion levels, respectively in broiler chicken diets. At present there is information on the performance of rabbits on dietary inclusion of CBS meal in place of maize as energy source. This study was aimed at evaluating the nutritive value of CBS and its effect on the performance of growing rabbits.

MATERIALS AND METHODS

Experimental location

The experiment was carried out at the Teaching and Research Farm, Adeyemi College of Education, Ondo, Ondo State, Nigeria. Ondo lies between latitude 07° 05´ N and 04° 55´ E in the forest zone of Nigeria. The temperature ranged from 22 - 35 °C with annual rain fall 1800-3600 mm, spreading between March and October.

Experimental material and diets

Cocoa bean shell for the experiment was collected from Stamack Cocoa Processing Industries, Ondo, Ondo State, Nigeria, bagged and kept in a dry place until used. They were analyzed for their chemical composition according to the method of AOAC (2002). Five experimental diets were formulated such that maize was replaced with CBS meal at 0, 10, 20, 30 and 40% levels on w/w basis for diets 1, 2, 3, 4 and 5, respectively.

Table 1: Composition of experimental diets (g per 1000g)

Ingredients	Diet 1 (0)	Diet 2 (10)	Diet 3 (20)	Diet 4 (30)	Diet 5 (40)
Maize	562.00	505.80	449.60	393.40	337.20
Cocoa bean shell	-	56.20	112.40	168.60	224.80
Soybean meal	140.00	140.00	140.00	140.00	140.00
Wheat offal	90.00	90.00	90.00	90.00	90.00
Ground nut cake	80.00	80.00	80.00	80.00	80.00
Palm kernel cake	70.00	70.00	70.00	70.00	70.00
Fish meal	25.00	25.00	25.00	25.00	25.00
Bone meal	15.00	15.00	15.00	15.00	15.00
Oyster shell	5.00	5.00	5.00	5.00	5.00
Premix*	5.00	5.00	5.00	5.00	5.00
Lysine	1.50	1.50	1.50	1.50	1.50
Methionine	1.50	1.50	1.50	1.50	1.50
Salt	5.00	5.00	5.00	5.00	5.00
Total	1000	1000	1000	1000	1000
Calculated composition (g per 1000g)					
Crude protein	179.3	180.4	181.5	182.5	183.4
Crude fibre	104.7	125.6	137.3	148.9	152.7
ME kcal kg^{-1}	2481.6	2412.2	2398.5	2391.3	2381.8

**vitamins A 10000IU, vitamins B 2000IU, vitamins E 13000IU, vitamin K 1500mg, vitamin B12 10mcg, Riboflavin 500mg, Pyridoxine 1300mg, Thiamine 1300mg, Pantothenic acid 800mg, Nicotinic acid 280mg, Folic acid 500mg, Biotin 20mcg, Copper 700mg, Manganese 480mg, Iron 5800mg, Zinc 5800mg, Selenium 129mg, Iodine 60mg, Cobalt 300mg, Chlorine 27500mg.*

Experimental design and management of animals

One hundred (100) weaned rabbits of cross breeds and mixed sexes were used for the experiment. The rabbits were between 6-8weeks of age and weighed 370-650g. They were randomly assigned to five treatment diets such that each treatment was replicated twenty (20) times of a rabbit per replicate. The rabbits were given one week adaptation period after procurement, during which they were fed commercial grower diet and treated against worm infestation and coccidiosis by given each 0.2 ml ivermectin by injection and topcoc forte, through drinking water respectively. They were thereafter weighed, allocated to their respective diets in a completely randomized design (CRD) and fed *ad-libitum* for 56days. Water was supplied in plastic containers and feed in tins which were properly fixed to the cage to avoid tipping over by the rabbits. Daily feed consumption was determined by deducting their left over from the feed given, while weekly weight gain was taken by subtracting the weight of the present week from the preceding week. Feed conversion ratio was determined as:

$$\text{Feed conversion ratio} = \frac{\text{Average feed intake (g)}}{\text{Average weight gain (g)}}$$

Blood collection and determination

At the end of the feeding period, blood was collected into labeled sterile universal bottles containing Ethylene-Diamine-Tetra-Acetic acid (EDTA) as anticoagulant. This was used to determine haematological parameters. The PCV was determined using the Wintrobe'smicrohaematocrit technique while the RBC and haemoglobin concentration values were determined using the improved Neubauerhaemocytometer and cyanomethane-moglobin method, respectively (Coles, 1986). The mean corpuscular haemoglobin concentration (MCHC), mean corpuscular haemoglobin (MCH) and mean corpuscular volume (MCV) were calculated as described by Jain (1986)

Cost evaluation

The cost evaluation was determined using economical tools such as cost of feed (₦ per kg), cost of feed consumed (₦), cost of feed (₦ per kg weight gain), cost differential and relative cost benefit (%).

Data analysis

Data collected were subjected to one way Analysis of Variance (ANOVA) using SAS (2005) and where significant differences existed the means were separated using Duncan new Multiple Range Test at 5% level of probability (Duncan, 1955).

RESULTS AND DISCUSSIONS

The chemical composition of CBS as shown in Table 2 shows a crude protein content of 15.38%, crude fibre 39.25% and gross energy 20.82 kcal/kgDM. The theobromine level was 2.88 g kg^{-1}. The CP recorded in this study was similar to the 16.0% reported by Aregheore (2002) and close to 17.6 and 17.2% reported by Mahyuddin (1995) and Hamzat and Adeola (2011), respectively but higher than 5.9% reported by Meffeja *et al.* (2006). The CF was higher than the 15.1, 21.3 and 32.5% reported by Yeong *et al.* (1989), Meffeja *et al.* (2006) and Donkoh

et al. (1991), respectively but was lower than 45.9% reported by Aregheore (2002). The gross energy (GE) was lower than 22.6 kcal kg^{-1} DM reported for cocoa dust (Aregheore, 2002). The high energy value recorded for CBS attest to the report by Mahyuddin (1995) that CBS is a good energy source. The theobromine content obtained in CBS in this study was lower than the 10.0 g kg^{-1} reported by Obiakor and Nwanko (1977) but higher than the 1.6 g kg^{-1} reported by Mahyuddin (1995). The theobromine level (2.88 g kg^{-1}) in cocoa bean shell reported in this study was in the range of 2-3 g/kg reported by Merck (1998) and 2.0 g kg^{-1} reported by Oddoye *et al.* (2010) on air-dry cocoa pod husk. The differences in chemical composition of CBS compared with previous studies could be attributed to cocoa variety or species from which the CBS was obtained as observed by Sobamiwa and Longe (1993).

Table 2: Chemical composition of cocoa bean shell

Parameters	%
Dry matter	93.46
Crude protein	15.38
Crude fibre	39.25
Crude fat	8.49
Ash	5.17
Nitrogen free extract	25.17
Gross energy	20.82 kcal kg^{-1}DM
Theobromine	2.88 g kg^{-1}

Results of growth performance in Table 3 shows a significant ($P<0.05$) decrease in final live weight, total weight gain and average weight gain in rabbits fed 30 and 40% CBS meal when compared with those on 0-20% CBS meal inclusion . Thus, inclusion of 30 and 40% CBS meal significantly reduced live weight by 10.62%. This in line with broiler chickens (Olubamiwa *et al.,* 2006), poultry (Yang *et al.,* 1997; Adeyina *et al.,* 2010), growing snail (Owosibo *et al.,* 2008) and rabbits (Hamzat *et al.,* 2007) fed above 20% CBS meal. Decrease in weight gain has been attributed to decrease in nutrient digestibility occasioned by the reduction in time of food passage in the digestive tract due to high fibre content (Kass*et al.,* 1980; Alemawor *et al.,* 2009). High fibre has also been implicated to increase the secretion of mucous in rabbits thus preventing the lining of the digestive tract to absorb nutrients (Meffeja *et al.,* 2006). Another principal causative factor that could result in decrease weight gain of livestock fed dietary inclusion of CBS meal is the theobromine content (3,7-dimethylxanthine) (Gans, 1984; Alexander *et al.,* 2008), which could be due to low rate of theobromine degradation in the digestive tract (TarkaJr *et al.,* 1981). Total feed consumption and daily feed consumption of rabbits fed the control and test diets were similar. Rabbits fed 30 and 40% CBS meal-based diets utilized their diets poorly ($p<0.05$) compared with those fed 0 and 10%. The similar feed intake in this study is in agreement with previous studies on cattle (Mahyuddin, 1995), broiler chickens (Adeyina *et al.,* 2010) and rabbit (Hamzat *et al.,* 2007) but contrary to the reports by Atuaheme *et al.* (1985), Odunsi and Longe, (1995) and Odunsi *et al.* (1999) on broiler chickens. The numerical increase though not significant of rabbits fed dietary inclusion of CBS meal could possibly be attributed to the pleasant smell or chocolate flavor of cocoa bean shell which has been identified to stimulate ingestion in animals (Choi *et al.,* 1996). Rabbits fed 30 and 40% CBS meal utilized their feeds poorly ($P<0.05$) as against those fed 0-20% CBS meal inclusion. The poor feed conversion ratio of rabbits fed higher CBS meal-based diet was evidenced in the significant reduction in weight gain. The depressed feed utilization at higher dietary inclusion of CBS meal could be attributed to high fibre (Alemawor *et al.,* 2009), destruction of the intestinal lining caused by theobromine (Yeong *et al.,* 1989) or the effect of theobromine to impair the digestion and absorption of nutrients as reported by Oluokun and Olalokun (1999).

Results in Table 4 show that only the packed cell volume (PCV), white blood cell (WBC) counts, lymphocytes and monocytes of the rabbits were significantly ($p<0.05$) influenced. The PCV of rabbits fed 20, 30, and 40% dietary CBS meal were significantly ($p<0.05$) lower than those fed 0 and 10%. The WBC counts were significantly ($p<0.05$) higher in rabbits fed 20 and 40% CBS meal compared to those fed 0 and 10%. The values for the various haematological parameters determined in this study were within the normal physiological range for healthy rabbits (RAR, 2009). Although, decrease in PCV had been reported to be due to nutritional deficiencies, over dehydration, liver and kidney diseases among others (Gernsten, 2009) while high WBC, lymphocytes and monocytes could be an indication of nutritional stress (Minka and Ayo, 2007). The non-significant values of RBC observed here corroborate the value range 4.8-6.3 (x 10^6 per mm^3) reported by Harkness and Wagner (1989). The similar Hb values observed corroborate the normal range of 8-17g dl^{-1} reported by PGCVS (1990). Normal range of Hb indicated that the vital physiological relationship of haemoglobin with oxygen in the transport and exchange of oxygen and carbon dioxide to and from the tissues of the body has been functional and was normal (Njidda *et al*., 2006).

Table 3: Performance and cost analysis of growing rabbits fed dietary inclusion of cocoa bean shell meal

CBS (%)	0	10	20	30	40		
Diets	1	2	3	4	5	SEM	Sig
Performance indices							
Initial live weight (g rabbit^{-1})	490.00	473.33	495.00	436.67	495.33	42.15	0.95
Final live weight (g rabbit^{-1})	1566.67a	1575.00a	1691.67a	1446.67b	1433.33c	126.38	0.04
Weight gain (g rabbit^{-1}d^{-1}	19.23a	19.67a	21.37a	18.04b	16.75c	1.78	0.03
Total feed intake (g rabbit^{-1})	3571.67	3570.00	4310.00	4301.67	4210.00	361.32	0.39
Average feed intake (g rabbit^{-1}d^{-1})	63.78	63.75	76.97	76.81	75.18	6.45	0.39
Feed conversion ratio	3.31a	3.24a	3.60ab	4.25b	4.48c	0.24	0.02

abc Means with different letters along the same row are significant at P<0.05

Table 4: Haematological profile of rabbits fed dietary inclusion of cocoa bean shell meal

CBS (%)	0	10	20	30	40		
Diets	1	2	3	4	5	SEM	Sig
Parameters							
PCV (%)	37.49a	37.72a	35.84b	34.77b	35.97b	9.48	0.01
RBC (x 10^6 mm^{-3})	6.14	5.88	5.65	5.85	5.93	0.22	0.64
Hb (gdl^{-1}	11.59	11.88	11.70	11.68	11.91	0.26	0.88
MCV (fl)	61.51	64.18	63.60	59.44	60.65	2.13	0.51
MCH (pg)	19.07	20.23	20.81	19.95	20.07	0.97	0.79
MCHC (g dl^{-1})	30.95	31.52	32.67	33.57	33.11	0.90	0.27
WBC (x10^3 mm^{-3})	6.40b	6.81b	7.93a	8.13a	8.82a	0.35	0.04
Differential counts (%)							
Lymphocytes	56.55c	56.44c	56.97b	57.96b	58.20a	0.30	0.02
Monocytes	1.60c	1.63c	2.17b	2.53a	2.37a	0.63	0.03
Neutrophils	38.12	38.20	37.11	36.15	36.12	0.98	0.23
Eosinophils	0.24	0.20	0.23	0.21	0.20	0.03	0.86
Basophils	3.49	3.57	3.52	3.15	3.11	0.21	0.47

abc Means with different letters along the same row are significant at P<0.05

The economics of rabbit production (Table 5) shows that while cost of feed progressively decreased with increased dietary CBS meal, cost of feed per weight gain increased progressively beyond the optimal 10% level resulting to negative cost differential. The relative cost benefit is indicating 2.76 – 20.66% additional cost incurred per weight gain for using CBS meal at 20 to 40% in rabbit diets.

Table 5: Cost implications of rabbits fed cocoa bean shell meal-based diets

CBS (%)	0	10	20	30	40		
Diets	1	2	3	4	5	SEM	Sig
Cost indices							
Cost of feed (₦kg^{-1})	97.71a	95.07b	92.43c	89.78d	87.14e	0.00	0.01
Cost of feed intake ₦	348.98	339.40	398.35	386.35	366.86	32.79	0.93
Cost of feed (₦kg^{-1} weight gain)	324.14b	308.26b	333.08ab	382.43ab	391.12a	21.28	0.03
Cost differential	-	15.88	-8.94	-58.19	-6.96		
Relative cost benefit (%)	-	4.90	-2.76	-17.95	-20.66		

abcde Means with different letters along the same row are significant at p<0.05

CONCLUSION AND RECOMMENDATION

The results on the performance, haematology and cost of feed per weight gain, which is a measure of the economic efficiency of feed utilization, suggest that the optimal and economic level of CBS as a feed ingredient in rabbit diet should not exceed 20% as this level did not compromise the performance and general well-being of the animal.

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