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THE EFFECT OF REPLACEMENT LEVELS OF BOILED AND FERMENTED CASTOR SEED *(RICINUS CUMMUNIS*) MEAL ON THE PRODUCTIVE PERFORMANCE, NUTRIENT DIGESTIBILITY, CARCASS CHARACTERISTICS AND COST EFFECTIVENESS IN BROILERS

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ABSTRACT

The objective of the study is to determine the effect of boiled and fermented castor seed meal on the productive performance, nutrient digestibility, carcass characteristics and cost effectiveness in broilers. Feeding trial was conducted for broilers using diets containing 0, 5, 10, 15 and 20 % boiled and fermented castor seed meal (BFCSM). The experiment lasted 9 weeks using 225 Anak mixed sexed broilers. Diets and water were provided to the birds *ad libitum*. The indices recorded include daily feed intake, weekly body weight gain, feed conversion ratio (FCR), mortality, carcass characteristics and apparent digestibility. The feeding of BFCSM to broilers showed decreased feed intake, daily feed weight gain and carcass characteristic with the increased in the replacement levels of BFCSM. The apparent nutrient digestibility of the broilers on the control diet (0 % BFCSM) was consistently higher than those on BFCSM-based diet. The lowest digestibility value were recorded in birds feed on 20 % BFCSM. The dressed weight and cut-up parts of economic importance (back, thigh, breast and the drumstick) showed decreased in weight by increasing the replacement levels of BFCSM in the diets, but the internal organs such as the liver, kidney, gizzard, spleen and proventiculus) increased in weight by the replacement of BFCSM in the diets. It was concluded that the best and most economical cost per unit weight gain was obtained in the starter phase at 0 % BFCSM replacement, while at the finisher and overall phases these were at 5 % levels of replacement.

KEYWORDS: Castor seed meal, anti-nutritional factors, detoxification, boiling and fermentation.

INTRODUCTION

Protein is an essential food component which is necessary for growth. High cost of conventional protein sources like fish meal, soya bean meal and groundnut cake has necessitated to look inwards for other non-conventional sources like castor seed meal, which is locally available and relatively cheaper, for animals/poultry. The use of castor seed meal as an alternative source of protein for livestock and poultry is limited by the presences of anti-nutritional factors, primarily ricin, ricinine (Liener, 1986) and extremely potent allergen (Gohl, 1981) in the meal. These limitations could be overcome by detoxification of the anti- nutritional factors in the meal by various methods. Gohl (1981) reported that ricin (the major anti-nutritional factor in castor seed meal) could be destroyed by autoclaving the meal for 15 mins at 125ºC. If no autoclaving is available, the meal is boiled in three times the volume of water for 10 mins after which the water is discarded and treatment repeated. The cake is then dried in open air at 70 – 80º C. Similarly, Anandan *et al.* (2004) has also investigated and reviewed the detoxification of castor seed meal by a number of physical treatments which include soaking for 3, 6 and 12 hours, steaming (30 and 60 min), boiling (30 and 60 min), autoclaving 15 psi, 30 min; 15 psi, 60 min and heating at 100ºC for 30mins or at 120ºC for 25 min. Mustapha *et al* (2015) revealed that feeding of detoxified castor seed meal by boiling in water for 30 minutes and fermenting for 3 days to broilers appeared to lower the anti-nutritional factors in the meal and improved daily feed intake, daily body weight gain and feed conversion ratio more than those fed on the meal boiled in water for 30 minutes, soaked in water for 72 hours and soaked in water for 72 hours followed by boiling for 20 minutes. The objective(s) of this study is to determine the effect of boiled and fermented castor seed meal (BFCSM) on the productive performance, nutrient digestibility, carcass characteristics and cost effectiveness in broiler chickens.

MATERIALS &METHODS

Sources and processing of castor seed meal

Large seeded castor seeds for the experiment were locally sourced in Damaturu main market, Yobe State, Nigeria. These seeds were multiplied for the research. The castor seeds were boiled at the temperature of 100ºC for 30 minutes and later sun-dried for three (3) days which was aimed at detoxifying the meal. The meals were obtained after the extraction of the oil manually from the seeds.

Experimental birds and their management

A total of two hundred and twenty-five (225) day-old mixed sexed Anak breed of broilers purchased from ECWA Farm, Jos, were used for the study. From day-old to 4 weeks of age, all the birds were brooded using kerosene lantern and stove to provide necessary brooding temperature

TABLE 1: Ingredients composition (%) and calculated analysis of broiler starter diets

	Levels of replacement of boiled and fermented castor seed meal %				
Ingredients	0	5	10	15	20
Maize	53.50	53.50	53.50	53.50	53.50
Wheat offal	9.00	9.00	9.00	9.00	9.00
Castor seed meal	0.00	5.00	10.00	15.00	20.00
Groundnut cake	13.00	10.85	9.85	10.00	5.00
Soya bean meal	12.85	10.00	6.00	0.85	0.85
Fish meal	7.00	7.00	7.00	7.00	7.00
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Salt(NaCl)	0.20	0.20	0.20	0.20	0.20
*Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME (Kcal/kg)	2933.77	2914.96	2894.31	2870.46	2856.21
Crude protein (%)	24.05	23.97	23.61	23.44	23.11
Crude fibre (%)	3.22	3.98	4.74	5.49	6.25
Calcium (%)	1.25	1.27	1.29	1.31	1.33
Phosphorus (%)	0.69	0.71	0.72	0.72	0.76
Lysine (%)	1.22	1.26	1.27	1.28	1.34
Methionine (%)	0.40	0.42	0.44	0.45	0.47

** Bio-mix starter, manufactured by Bio- organics Nutrients System Ltd, Lagos, supplied/kg: Vit A = 10,000,000.00 IU; Vit D_3 = 2,000,000.00 IU; Vit E = 23,000.00mg; Vit K_3 = 2,000.00mg; Vit B_1 = =1,800.00mg; Vit B_2 5,000.00mg; Niacin = 27,500mg; Pantothenic Acid = 7,500.00mg; Vit B_6 = 3,000.00mg; Vit B_{12} = 15.00mg; Folio Acid = 750.00mg; Biotin H_2 = 60.00mg; Choline Chloride = 300,000.00mg; Cobalt = 200.00mg; Copper = 3,000.00mg; Iodine = 1,000.00mg; Iron = 20,000.00mg; Manganese = 40,000.00mg; Selenium = 200.00mg; Zinc = 30,000.00mg; Antioxidant = 1,250.00mg.ME = Meatabolizable energy.*

TABLE 2: Ingredients composition (%) and calculated analysis of the experimental broiler finisher diets

Levels of replacement of boiled and fermented castor seed meal (%)					
Ingredients	0	5	10	15	20
Maize	61.00	61.00	61.00	61.00	61.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Castor seed meal	0.00	5.00	10.00	15.00	20.00
Groundnut cake	10.85	9.85	9.85	5.85	1.00
Soya bean meal	11.00	7.00	2.00	1.00	0.85
Fish meal	2.50	2.50	2.50	2.50	2.50
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Salt(NaCl)	0.20	0.20	0.20	0.20	0.20
*Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
ME (Kcal/kg)	2976.61	2955.93	2933.71	2917.86	2902.01
Crude protein (%)	20.30	20.11	19.93	19.64	19.31
Crude fibre (%)	3.21	3.97	4.73	7.09	6.24
Calcium (%)	0.95	0.96	0.99	0.89	1.04
Phosphorus (%)	0.53	0.51	0.55	0.65	0.59
Lysine (%)	0.95	0.85	0.91	0.92	1.02
Methionine(%)	0.32	0.33	0.35	0.44	0.39

** Bio-mix finisher, manufactured by Bio- organics Nutrients System Ltd, Lagos, supplied/kg: Vit A = 8,500,000.00 IU; Vit D_3 = 1,500,000.00 IU; Vit E = 10,000.00mg; Vit K_3 = 1,500.00mg; Vit B_1 = =1,600.00mg; Vit B_2 4,000.00mg; Niacin = 20,000mg; Pantothenic Acid = 5,000.00mg; Vit B_6 = 1,500.00mg; Vit B_{12} = 10.00mg; Folio Acid = 500.00mg; Biotin H_2 = 750.00mg; Choline Chloride = 175,000.00mg; Cobalt = 200.00mg; Copper = 3,000.00mg; Iodine = 1,000.00mg; Iron = 20,000.00mg; Manganese = 40,000.00mg; Selenium = 200.00mg; Zinc = 30,000.00mg; Antioxidant = 1,250.00mg. ME = Mtabolizable energy.*

During the brooding period (0-4 weeks), birds were fed with broiler starter containing graded levels of boiled and fermented castor seed meal, which replaced 0 (control), 5, 10, 15 and 20 % of groundnut cake and soya bean meal in the respective diets.. Water and the experimental diets were provided *ad libitum*. All the birds were vaccinated against Gumboro disease at 2 weeks and 5 weeks of age, while the vaccination against New castle disease was at 3 and 6 weeks of age. From 5 to 9 weeks of age the feeding continued with broiler finisher diets containing the respective graded levels of the BFCSM. Daily washing and cleaning of drinkers was undertaken throughout the experiment. There were five (5) experimental groups/treatments. Each group consisted of 45 birds with three (3) replicates of 15 chickens per replicate.

Experimental diets

Five (5) experimental diets were formulated consisting of the test material – (boiled and fermented castor seed meal), which replaced 0 (control), 5, 10, 15 and 20 % of groundnut cake and soya bean meal in the diets. All the diets have similar crude protein (23 - 24 % for starter's and 19 - 20 % for finishers) and energy (3000 Kcal/kg) levels which conformed to the recommended levels for normal growth of broilers at both starter and finisher phases. The calculated composition of the broiler starter and finisher diets are presented in Tables 1 and 2.

Chemical analysis

The diets, faeces and castor seed meal were subjected to chemical analysis to determine the proximate composition namely the dry matter (DM), crude protein(CP), crude fibre(CF), ash, ether extract(EE) and nitrogen-free extract(NFE) using (AOAC, 2000) at the University of Jos, Jos, Nigeria. The metabolizable energy (ME) in Kcal/kg was calculated according to the formula of Pauzenga (1985) as:

$$\text{ME (Kcal/kg)} = 37 \times \%\ \text{CP} + 81 \times \%\ \text{EE} + 35.5 \times \%\ \text{NFE}$$

Other parameters measured

During the period of the experiment the daily feed intake and weekly body weight gain were recorded. The feed conversion ratio was calculated from these data. Daily mortality and observed abnormalities were recorded. Postmortem examination was also carried out on birds that died.

The digestibility was determined through the proximate analysis of the formulated diet as well as the faeces for the different experimental groups. The difference between the former and the later help in explaining the retention or the digestibility of the various components of the diet. The percentage digestibility was then calculated as

$$\%\ \text{Digestibility} = \frac{\text{Nutrients in feeds x FI}) - (\text{Nutrients in faeces x FO})}{\text{Nutrients in Feed X F I}}$$

Where FI = Feed intake

FO = Faecal output

At the end of the experiment, 6 birds were randomly picked from the respective treatment for carcass characteristics or parameters. The birds were deprived of feed but not water for 12 hours. At the end of the 12 hours the fasted body weight of the bird were recorded before slaughter (slaughter weight). The birds were defeathered manually after immersion in hot water. Each bird was eviscerated and various organs were excised and weighed.

Cost effectiveness

The cost effectiveness of feeding BFCSM was also determined. This was by knowing the unit cost of each ingredient that made up the diet. The cost of feed per unit body gain was also calculated. This was done for the different experimental groups

Statistical Analysis

The data obtained from the study were subjected to analysis of variance (Randomized complete block design) using Statistix 9.0 software statistical package and significant difference among treatments means were separated by Duncan's Multiple Range Test (Duncan 1955).

RESULTS

Experimental diet

The analyzed proximate composition of the experimental broiler starter and finisher diets are presented in Tables 3 and 4 respectively. In all the diets, the composition showed decrease in metabolizable energy (ME) and crude protein (CP) contents as the replacement levels of the boiled and fermented castor seed meal (BFCSM) increased. However, the crude fibre (CF) contents of the diets increased as the replacement levels of the BFCSM increased in the diets. There was an observed difference between the calculated and analyzed composition of the diets.

TABLE 3: Analyzed Proximate Composition (%) of the experimental broilers starter diets

	Levels of replacement of boiled and fermented castor seed meal (%)				
Nutrients	0	5	10	15	20
Dry Matter (DM)	91.13	95.78	90.25	93.56	89.98
Crude protein (CF)	22.93	22.51	22.31	22.04	19.64
Crude fibre (CF)	5.38	5.59	6.16	7.15	7.88
Ether- Extract(EE)	8.05	8.07	9.46	8.56	10.28
Ash	6.57	8.92	8.02	7.64	8.93
Nitrogen- free Extract	48.26	48.20	44.28	46.14	44.22
ME (Kcal/kg)*	3213.69	3197.64	3163.66	3146.81	3129.17

*ME = Metabolizable Energy: Calculated according to the formula of Pauzenga (1985): ME (Kcal/Kg) = 37 x % CP +81 x % EE + 35.5 x % NFE

TABLE 4: Analyzed Proximate composition (%) of the experimental broiler finisher diets

	Levels of replacement of boiled and fermented castor seed meal (%)				
Nutrients	0	5	10	15	20
Dry matter (DM)	91.30	93.00	93.70	91.60	90.8
Crude protein (CP)	18.60	18.20	18.02	17.13	17.00
Crude fibre (CF)	5.0	5.30	5.60	5.90	6.50
Ether Extract (EE)	10.00	9.48	8.60	8.05	10.20
Ash	7.00	6.50	7.40	8.20	9.50
Nitrogen-Free Extract (NFE)	52.56	53.52	54.0	55.72	47.60
ME (Kcal/kg)*	3371.37	3341.24	3283.10	3263.92	3145.00

*ME = Metabolizable Energy: Calculated according to the formula of Pauzenga (1985): ME (Kcal/Kg) = 37x % CP +81 x % EE + 35.5 x % NFE

Productive performance

The results of the productive performance (live weight (LW), daily feed intake, daily live weight gain, feed conversion ratio and mortality) are presented in Table 5. The LW, daily feed intake, daily live weight gain, and FCR at the starter (0 – 4 weeks), finisher (5 -9 weeks) and overall (0 -9 weeks) phases were negatively affected as the replacement levels of the BFCSM increased in the diets from 0 – 20 % BFCSM. The feed conversion ratio (FCR) of the birds on 20 % BFCSM diet was significantly ($P < 0.05$) inferior to those on 0, 5 and 10 % BFCSM at the different phases of the experiment. Mortality recorded during the experiment also in Table 5 showed that the birds on 0, 5, 10, 15 and 20 % BFCSM were 8.88, 11.11, 12.33, 17.78 and 35.55 % respectively. The group on 20 % BFCSM recorded the highest mortality. The post mortem result revealed that the birds looked emaciated, and on opening, showed petechial haemorrhage in the minor cardium; the trachea mucosa was covered with blood, the lungs look congested and oedematous, the liver were slightly congested, loss of coronary fat and there were no lesions of infection.

TABLE 5: Productive performance of broilers fed boiled and fermented castor seed meal (0 – 9 weeks)

Parameters	Levels of replacement of boiled and fermented castor seed meal (%)					
	0	5	10	15	20	SEM
Live weight.						
(a) Initial wt (g/bird)	41.90	41.37	42.22	41.33	40.64	3.08^{NS}
(b) Wt at 4 wks (g/bird)	732.15^{a}	588.60^{b}	426.34^{c}	380.14^{c}	276.80^{d}	31.28^{*}
(c) Final weight (g/bird)	2464.05^{a}	1966.63^{b}	1493.24^{c}	1335.39^{c}	1083.02^{d}	81.45^{*}
Daily Intake(g/bird)						
(a) Starter phase (0 – 4 wks)	48.42^{a}	40.40^{b}	31.88^{c}	27.50^{d}	22.33^{e}	2.65^{*}
(b) Finisher phase (5 – 9wks)	120.95^{a}	93.12^{b}	82.90^{c}	80.16^{c}	69.39^{d}	4.43^{*}
(c) Overall (0 – 9 wks)	88.72^{a}	69.64^{b}	60.23^{c}	56.75^{d}	46.62^{e}	2.89^{*}
Daily weight Gain (g/bird)						
(a) Starter phase (0 – 4 wks)	26.44^{a}	25.37^{a}	14.93^{b}	12.10^{bc}	8.44^{c}	2.65^{*}
(b) Finisher phase (5 – 9wks)	47.49^{a}	39.36^{b}	31.89^{c}	27.31^{cd}	23.05^{d}	2.02^{*}
(c) Overall (0 – 9 wks)	38.13^{a}	33.23^{b}	24.35^{c}	20.55^{d}	16.55^{e}	1.15^{*}
Feed Conversion Ratio (FCR).						
(a) Starter phase (0 – 4wks)	2.06^{c}	2.28^{bc}	2.44^{bc}	2.54^{ab}	2.93^{a}	0.19^{*}
(b) Finisher phase (5 – 9wks)	2.60^{b}	2.47^{b}	2.77^{ab}	3.06^{a}	3.08^{a}	0.16^{*}
(c) Overall (0 -9wks)	2.36^{c}	2.38^{c}	2.62^{bc}	2.83^{ab}	3.01^{a}	0.12^{*}
Mortality (%)	8.88	11.11	12.33	17.78	35.55	-

a, b, c, d and e = Means within the same row bearing different superscripts differ significantly($P < 0.05$).
* = Significant ($P < 0.05$); NS = Not significant ($P > 0.05$); SEM = Standard Error of Mean

TABLE 6: Apparent nutrient digestibility (%) of broilers fed graded levels of boiled and fermented castor seed meal

Nutrients	Replacement levels of boiled and fermented castor seed meal (%)					
	0	5	10	15	20	SEM
Dry Matter (DM)	76.16^{a}	75.24^{a}	70.00^{ab}	66.28^{b}	61.41^{b}	3.81^{*}
Crude Protein(CP)	75.34^{a}	72.46^{a}	$73,13^{a}$	62.15^{b}	61.41^{b}	3.76^{*}
Crude Fibre(CF)	70.63^{a}	68.25^{b}	65.05^{c}	61.59^{d}	55.01^{e}	0.02^{*}
Ether Extract(EE)	71.81^{a}	67.50^{b}	64.67^{bc}	62.47^{cd}	60.05^{d}	1.31^{*}
Nitrogen Free Extract(NFE)	72.00^{a}	70.78^{a}	68.81^{a}	58.00^{b}	56.30^{b}	2.76^{*}
Ash	68.11^{a}	67.26^{ab}	66.00^{ab}	65.80^{ab}	65.25^{b}	1.17^{*}

a, b, c, d, e = Means within the same row bearing different superscripts differ significantly($P < 0.05$) ;* = Significant ($P < 0.05$); NS = Not significant ($P > 0.05$); SEM = Standard Error of Mean.

Nutrients digestibility

The apparent nutrients digestibility for broilers fed graded levels of boiled and fermented castor seed meal (BFCSM) are presented in Table 6. The results indicate that the control diet (0 % BFSCM) consistently recorded the highest digestibility values, while the lowest digestibility value were recorded in 20 % BFCSM diet. The nutrients that recorded the lowest digestibility especially in the birds fed on 20 % BFCSM were NFE, EE and CF.

Carcass characteristics expressed as percentage of slaughter weights

The results of carcass characteristics expressed as percentage of slaughter weights are presented in Table 7. The slaughter, bled, plucked and dressed weight of the birds on the control (0 %) BFCSM diet were significantly ($P < 0.05$) higher than those on the BFCSM-based diets. The dressed weight significantly ($P < 0.05$) decreased with increase in the replacement levels of the BFCSM from 0 to 20 %. Similarly, cut-up parts of economic importance (back, thigh, breast and the drumstick) showed decreased in weight by increasing the replacement levels of BFCSM in the diets. However, internal organs such as the liver, kidney, gizzard, spleen and proventriculus increased in weight by the replacement of BFCSM in the diets. For example, the weight of liver, kidney and proventriculus of the birds on 20 % BFCSM diets were significantly ($P < 0.05$) higher than those on control (0 %) and 5 % BFCSM diets. The dressing percentage and cut- up parts which include the head, the back, shanks and wings as well as internal organs such as the heart and lungs were not affected by the replacement levels of the BFCSM.

Cost effectiveness

The result of the cost effectiveness in Table 8 showed the best and most economical cost per unit weight gain was obtained in the starter phase at 0 % BFCSM replacement, while at the finisher and overall phases these were at 5 % levels of replacement. The costs were N112.81, N137.45 and N134.78 for the starter, finisher and overall phases of the experiment.

DISCUSSIONS

Experimental Diets

Although, there was steadily decrease in the ME and the CP contents of the diets with increasing levels of the BFCSM, the nutrients were adequate for normal growth of broilers.

TABLE 7: Carcass characteristics expressed as percentage of slaughter weights of broiler fed graded levels of boiled and fermented castor seed meal

Parameters	Replacement levels of boiled and fermented castor seed meal (%)					
	0	5	10	15	20	SEM
Slaughter Weight(g)	2304.00^a	1942.30^b	1487.70^c	1264.30^c	930.00^d	115.69^*
Bled Weight(g)	2185.30^a	1766.00^b	1353.30^c	1171.71^c	848.30d	124.75^*
Plucked Weight(g)	2051.30^a	1630.00^b	1256.00^c	1120.00^c	828.30^d	121.87^*
Dressed Weight(g)	1640.50^a	1359.60^b	1019.10^c	863.80^d	639.36^e	32.46^*
Dressing Percentage	71.61	70.00	68.53	68.34	68.75	12.63^{NS}
Cut- up Parts as Percentage of Slaughter Weights						
Head Weight	1.98	4.48	2.73	2.82	3.09	1.43^{NS}
Neck Weight	5.01	5.44	5.57	4.03	4.93	1.21^{NS}
Shanks Weight	4.14	4.31	4.94	5.03	4.06	0.54^{NS}
Back Weight	17.65^a	16.56^{ab}	15.15^{bc}	13.07^c	13.64^c	0.91^*
Wings Weight	8.62	8.43	8.50	8.30	8.04	0.45^{NS}
Thigh Weight	12.40^{ab}	14.70^a	10.50^b	11.74^b	9.89^b	1.20^*
Breast Weight	18.74^a	18.16^{ab}	16.32^{abc}	15.49^{bc}	14.49^c	1.18^*
Drumstick Weight	10.05^b	11.95^a	9.97^b	9.47^b	9.65^b	0.68^*
Internal Organs as Percentage of Slaughter Weight						
Intestine Weight	3.53^c	4.20^c	6.04^b	6.16^b	7.25^a	0.37*
Heart Weight	0.40	0.42	0.49	0.42	0.51	0.07^{NS}
Liver Weight	1.41^c	1.75^b	1.97^a	1.97^a	2.07^a	0.09^*
Kidney Weight	0.53^b	0.62^b	0.71^{ab}	0.73^{ab}	0.98^a	0.13^*
Gizzard Weight	3.2^b	3.56a^b	4.50^a	4.27^{ab}	3.24^b	0.53^*
Spleen Weight	0.05^b	0.08^{ab}	0.14^a	0.08^{ab}	0.11^{ab}	0.03^*
Lungs Weight	0.56	0.55	0.70	0.68	0.76	0.11^{NS}
Proventiculus Weight	0.63^b	0.78^b	0.72^b	0.60^b	1.22^a	0.16^*

a, b, c = Means within the same row with different superscripts differ significantly ($P < 0.05$); *= Significant ($P < 0.05$); NS = Not Significant ($P > 0.05$); SEM = Standard Error of Means.

The ME (kcal/kg) of 3213.69 to 3129.17 obtained for broiler starter in this study was similar or comparable to 3200 Kcal/kg recommended by NRC(1994), but slightly higher than 3000 Kcal/kg recommended by Olomu (2011). For the broiler finisher, the ME (Kcal/kg) of 3371 to 3145 obtained was slightly higher than the 3000 Kcal/kg recommended by Olomu (2011), but similar or comparable to 3200 Kcal/kg recommended by NRC (1994). The analyzed CP values of 19.64 to 22.93 % obtained for the broiler starter was slightly lower than the 24 % CP recommended by Olomu (2011), but similar or comparable to the 23.00% recommended by NRC (1994). For the broiler finisher the CP values of 17.00 to 18.60 % obtained in this study is slightly lower than 20.00 % CP recommended by Olomu (2011), but similar or comparable to 18.00 % CP recommended by NRC (1994).

TABLE 8: Cost effectiveness of broilers fed graded levels of boiled and fermented castor meal at starter (0-4wks), finisher (5-9wks) and overall (0-9wks) weeks

Starter phase (0-4wks) Parameters	Replacement levels of boiled and fermented castor seed meal (%)				
	0	5	10	15	20
Feed cost (₦/kg)*	61.40	60.12	58.71	57.20	56.20
Reduction in Feed cost (%)	0.00	2.08	4.38	6.84	8.53
Daily feed intake (g/bird)	48.42	40.40	31.88	27.50	22.37
Total feed intake (kg/bird)	1.36	1.13	0.89	0.77	0.63
Total feed cost (₦/bird)	83.50	67.93	52.25	44.04	35.41
Overall weight gain (g)	690.25	547.23	384.12	338.81	236.16
Feed cost/kg gain (₦)	112.81	124.14	136.03	130.00	149.92
Finisher phase (5-9wks)					
Feed cost (₦/kg)*	59.50	58.10	56.60	55.50	54.49
Reduction in Feed cost (%)	0.00	2.35	4.87	6.72	8.42
Daily feed intake (g/bird)	120.95	93.12	82.90	80.16	69.39
Total feed intake (kg/bird)	4.23	3.26	2.90	2.81	2.43
Total feed cost (₦/bird)	251.66	189.41	164.14	155.96	132.41
Overall weight gain (g)	1731.90	1378.03	1066.90	955.25	806.22
Feed cost/kg gain (₦)	149.64	137.45	153.84	163.26	164.24
Overall phase (0-9wks)					
Feed cost (₦/kg)*	60.45	59.11	57.66	56.35	55.35
Reduction in Feed cost (%)	0.00	2.22	4.62	6.78	8.44
Daily feed intake (g/bird)	88.72	69.64	60.23	56.75	46.62
Total feed intake (kg/bird)	5.59	4.39	3.79	3.58	2.94
Total feed cost (₦/bird)	337.92	259.49	218.53	201.73	162.73
Overall weight gain (g)	2422.15	1925.26	1451.02	1294.06	1042.38
Feed cost/kg gain (₦)	139.51	134.78	150.60	155.89	156.11

Calculated on the basis of the prevailing market prices of ingredients at the time of the study

The decrease in ME and CP as well as the increase in the CF contents of the diets with increasing levels of the BFCSM was because the BFCSM has lower gross energy and CP contents and higher CF content than the full fat soya bean meal and groundnut cake which were replaced. The increase in CF and the reduced ME in the diets may likely cause the birds to eat more of the diets in order to satisfy their energy needs. At higher replacement levels (15 and 20 % BFCSM), the fibre levels of the diets were elevated beyond 5% which was recommended by Smith (2001) for broilers. High fibre diets generate a lot of heat during digestion; this exerts pressure on the digestive system especially in high temperature environment and consequently feed intake is depressed. This finding was corroborated by Kwari and Igwebuike (2002), who reported a decrease in feed intake with increase in dietary levels of Parkia pulp in broilers diets. The observed difference between the calculated and analyzed feed composition was likely because of the difference of the feed composition table used for the calculation and the actual composition of feed ingredients.

Productive Performance

The decrease in the LW of the birds could be due to the decrease in ME and CP contents of the BFCSM-based diets. Also the increase in the BFCSM levels in the diets especially at 15 and 20 % levels increased the fibre contents of the diets above the maximum 5 % crude fibre tolerant level in broiler diets may reduce the feed intake and subsequently LW of the birds. The feed intake and daily weight gain decreased because of the increased in CF contents of the diets especially at 15 and 20 % replacement levels of BFCSM. The residual effect of anti-nutritional factors such as tannin and ricin in castor seed meal are also likely to be responsible for the decrease in feed intake. The detrimental effect of tannin on feed intake, nutrients utilization and chicks growth have been reported by Jansman *et al.* (1995) and the presences of appetite depressing factors in castor seed meal might also have contributed to the depressed feed intake (Teguia and Beynen 2005; Ani and Okorie, 2004).

The result on FCR the birds on 20 % BFCSM diet had poorer feed utilization than those on 0, 5 and 10 % BFCSM. The poor feed utilization of the birds fed on 20 % BFCSM diet could possibly be due to decrease in ME and CP content of the diet, high CF content of diets and the adverse effect of tannin and ricin.

On mortality, this result is in agreement with the findings of Jensen and Allen (1981) who revealed that in poultry the clinical signs of castor seed toxicity resemble those of botulism except for mucoid and blood-tinged excreta. EFSA (2008) also reported that upon autopsy haemorrhage and necrosis were found in the intestinal wall, the heart and lymph gland of chickens fed castor seed meal and these are signs of ricin toxicity.

Nutrient Digestibility

The result obtained on nutrient digestibility could be attributed to the residual effects of anti-nutritional substances in the 20 % BFCSM diet. Gualitieri and Rapaccinni (1990) reported that the anti-nutritional factor such as tannin lowers dry matter and protein digestibility in chickens. The nutrients that recorded the lowest digestibility especially in the birds fed on 20 % BFCSM were NFE, EE and CF which reflected reduction in major energy components of the diet. This is in line with the report of Duee *et al.* (1979) who stated that tannin lowers energy digestibility. There are limited literatures on the effect of ricin on the digestibility of various nutrients to make any assertion or comparison.

Carcass characteristics expressed as percentage of slaughter weights

On carcass characteristics, the observed decrease in dressed weight and cut-up parts of economic importance with increase in the replacement levels of the BFCSM from 0 to 20 % may be due to decrease in feed intake. The decrease in feed intake could be attributed to high fibre content, residual effect of tannin and appetite depressing factor of castor seed meal in the diets especially at higher levels of BFCSM replacement. Residual ricin in the feed has been shown to interfere with the digestion and absorption of nutrients in the gastro- intestinal tract and inhibit protein synthesis (Goldstein and Poretz ,1986; Lenier, 1986).

However, the increase in weight of internal organs such as the liver, kidney, gizzard, spleen and proventriculus could likely be because of increase in metabolic activities of these organs probably due to the presence of anti-nutritional factors or high fibre content in the diets. Ekwe *et al.* (2013) obtained a similar result after feeding *Mucuna sloanei*-based diet to broilers and attributed the increase in the weights of these internal organs to the increase in metabolic activities due to the anti- nutritional factors in the *Mucuna* based diet. Similarly, Carew *et al.* (2003) reported that the consumption of unprocessed raw velvet beans (*Mucuna pruriens*) by broiler chickens reduced body weight gain, but weights of the pancreas, gizzard, proventriculus and the heart as well as length of the small and large intestine and ceca increased.

Cost effectiveness

On the cost effectiveness, in a study by Yisa *et al.*(2012) on the feeding of graded levels of boiled and dried pigeon pea(*Cajanus cajan*) (20 to 29 % CP) to broiler starter (0 – 4 weeks) the feed cost /kg gain were ₦135.45 and ₦138.05 at 10.00 and 20.00 % replacement levels, respectively. However, the feed cost/ kg gain for feeding of boiled and fermented castor seed meal(19.60 % CP) at the same replacement levels of 10 and 20 % were ₦136.03 and ₦149.92 respectively. This means the feeding of pigeon pea was cheaper and more economical since it contains slightly higher CP than the BFCSM. In another study by Adamu *et al.* (2012) on the replacement value of Baobab (*Adansonia digitata*) leaf meal (10.6 % CP) for soyabean in the diet of broilers chicks, the cost per kg weight gain was ₦260.00 at 25.00 % replacement as against ₦156.11 at 20.00 % replacement level of boiled and fermented castor seed meal. This indicates that the feeding of BFCSM was more economical since BFCSM contain higher CP of 19.6 % than 10.6 % for Baobab leaf meal.

CONCLUSION

It was concluded that the replacement of BFCSM especially at higher levels (15 and 20 %) has negative effect on the productive performance, nutrient digestibility and carcass characteristics` (cut-up parts) of economic importance. The best and most economical cost per unit weight gain was obtained in the starter phase at 0 % BFCSM replacement, while at the finisher and overall phases these were at 5 % replacement levels. The costs were N112.81, N137.45 and N134.78 for the starter, finisher and overall phases of the experiment.

RECOMMENDATIONS

There is need for further for research on the detoxification process for castor seed meal so that more economic benefit could be drive from its utilization.

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