Performance of broiler finishers fed graded levels of processed castor oil bean (*Ricinus communis* L) meal supplemented with DL-methionine

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Abstract

A feeding trial was conducted to determine the effect of graded levels of dehulled and cooked castor oil bean (*Ricinus communis* L) meal (CBM) and supplementary DL-methionine on growth performance and certain blood parameters of broiler finishers. One hundred and eighty 6-week old broiler birds (Anak strain) were randomly divided into 12 groups of 15 birds each. The groups were randomly assigned to 12 isocaloric (2.90 Mcal/kgME) and isonitrogenous (21.00% CP) diets in a 4 x 3 factorial arrangement involving a control (0%), three cooked castor oil bean meal levels (10, 15 and 20%) and three DL-methionine levels (0, 0.25 and 0.5%). Each treatment was replicated thrice with 5 birds each. Feed and water were supplied ad libitum from 42 to 70d of age. The results showed that above 15% CBM inclusion level, average daily feed intake (ADFI) and average daily weight gain (ADWG) were significantly ($P < 0.05$) decreased. There were also significant reductions ($P < 0.05$) in efficiencies of feed and protein utilization, and in apparent retention of dry matter (DM), nitrogen, ether extract (EE) and nitrogen-free extract (NFE). While packed cell volume was not significantly ($P > 0.05$) affected by CBM or DL-methionine, haemoglobin concentration (Hb) was significantly ($P < 0.05$) increased at 20% CBM level. Supplementation with DL-methionine improved ($P < 0.05$) weight gain at the 15 and 20% levels of CBM inclusion; improved Hb and efficiencies of feed and protein utilization at the 20% level of CBM inclusion; improved nitrogen retention at the 0% level of CBM inclusion; improved EE retention at the 0 and 20% levels of CBM inclusion, and improved NFE retention at the 15% level of CBM inclusion. The results of this study indicate that processed CBM can be included in broiler finisher diet at 15% level with DL-methionine supplementation to obtain normal growth in broiler birds.

Key words: Castor oil bean meal, DL-methionine, broiler finishers, cooking, performance

Introduction

Oil seeds contain a large proportion of vegetable oil which when extracted, leaves a cake that is very high in vegetable protein. The cakes are usually industrial by-products and some of them like groundnut cake, soybean meal, palm kernel

cake, etc., have assumed important feed status. The use of others like sunflower meal, safflower meal, African oil bean seed meal and castor oil bean meal among others have not been fully evaluated or exploited. While the search for cheap sources of feedstuffs especially vegetable

protein continues, the potentials of these plant materials need to be evaluated and fully exploited as ingredients in animal feed. The non-conventional feedstuff being considered in this study is castor oil bean meal, a by-product of castor oil extraction industry. Castor oil plant, *Ricinus communis* L. is an angiosperm that belongs to the spurge family *Euphorbiaceae* (Atsmon, 1989). Castor oil, the primary product of the castor oil plant possesses unique characteristics for industrial applications. The hydrogenated oil serves as a lubricant in jet fuels and aircraft hydraulics. The oil is also a standard lubricant in food processing plants. Many new products that contain castor oil or its derivatives have been developed. Among such products are weather resistant paints and cosmetics (Browning *et al.*, 1990). Cultivation of castor oil plant in Nigeria is prevalent in the southern states where seeds are processed and used as a condiment locally referred to as "ogiri" in Igbo. Feeding tests with animals have shown that castor oil bean meal (CBM) can be used as a protein supplement for ruminants, pigs and poultry (Martins *et al.*, 1982; Browning *et al.*, 1990; An and Okorie, 2005). However, castor oil bean meal is not fully utilized as a feed ingredient in commercial rations because of its toxicity. The toxicity is due to the presence of ricin, a toxic protein component, which belongs to the class of lectins (Liener, 1986; Olaiya *et al.*, 1991; Okorie *et al.*, 1985). Besides ricin, castor oil bean meal contains ricinolein, a relatively harmless oil and an extremely potent allergen that has been identified as CB-1A (Horton and

Maurice, 1989). High fibre levels in undehulled castor oil bean meal also limit its utilization. Castor oil bean meal has high level (11.40 – 38.21%) of abrasive fibre (Okorie *et al.*, 1985; Browning *et al.*, 1990). Dietary fibre has been shown to contribute to reduce feed intake in chicks (Lee *et al.*, 1978; Abdelsamie *et al.*, 1983; Okorie *et al.*, 1988; Macdonald *et al.*, 1995). The crude fibre content can be reduced to increase the biological value by dehulling while dry heat treatment has been suggested as a possible detoxification method (Vilhjalmssdottir and Fisher, 1971; Okorie *et al.*, 1985; Browning *et al.*, 1990). Although, Okorie *et al.* (1985) showed that roasting at 140°C for 30 minutes was an effective detoxification method, Okorie and Anugwa (1987), Okoye *et al.* (1987) and Okorie *et al.* (1988) later reported cases of mortality of some chicks fed with diets containing such heat-treated CBM. Besides, dry heat treatment has been reported to destroy some amino acids, particularly lysine, threonine, tyrosine, cystine and methionine, and consequently reduces the protein quality of the castor oil bean meal also tends to limit the suitability of the method (Polit and Sgarbieri, 1976). According to Ani and Okorie (2005), there is the need to supplement CBM-containing diets with DL-methionine and L-lysine which are the limiting amino acids in castor oil bean protein. Considering the aforementioned problems, the present study was designed to investigate the effects of graded levels of cooked and dehulled CBM and supplementary DL-methionine on the growth performance of broiler finishers.

Materials and Methods

The study was conducted at the Poultry Unit of the Department of Animal Science Research and Teaching Farm, University of Nigeria, Nsukka. Castor oil bean seeds and other feed ingredients used for the study were purchased from local markets in Nsukka and Enugu, Enugu State, Nigeria.

Processing of castor oil bean seeds

Castor bean seeds used in this feeding trial were the large mottled variety that was purchased from

Orba market near Nsukka in Enugu State. The seeds were manually dehulled by carefully cracking them between two stones. Decorticated seeds were obtained by separating the hulls from the cotyledons. The dehulled seeds were cooked in two stages at 100°C for 50 min per cooking as described by Ani and Okorie (2006). This was to ensure proper detoxification of the castor oil bean seeds. The cooked samples were dried overnight in the oven at 100°C, ground in a hammer mill and defatted using a mechanical oil press. The processed castor oil bean meal was used to

Table 1: Percentage composition of broiler finisher diets containing cooked castor oil bean meal supplemented with DL-methionine.

Castor oil bean meal levels (%)	0			10			15			20		
DL-methionine levels (%)	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5
Ingredients (% Treatment)	1	2	3	4	5	6	7	8	9	10	11	12
Maize	58.47	58.51	58.56	58.22	55.43	54.41	52.33	52.32	52.31	50.21	50.21	50.21
Wheat offal	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25
Soya bean meal	23.08	22.74	22.44	17.28	16.82	16.59	14.17	13.93	13.69	11.29	11.04	10.79
Castor oil bean meal	0.00	0.00	0.00	10.00	10.00	10.00	15.00	15.00	15.00	20.00	20.00	20.00
Fish waste (33.5% CP)	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
DL-methionine	0.00	0.25	0.50	0.00	0.25	0.50	0.00	0.25	0.50	0.00	0.25	0.50
Bone meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Iodized salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vit./Min. Premix *	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100	100	100	100	100	100	100	100
Calculated Analysis												
Crude protein (%)	21.03	21.03	21.04	21.06	21.01	21.05	21.00	21.03	21.07	21.02	21.05	21.08
Energy (Mcal of ME/kg)	2.93	2.93	2.92	2.95	2.95	2.94	2.97	2.96	2.95	2.98	2.97	2.96

* To supply the following per kg of diet: vitamin A, 12,500 IU; vitamin D₃, 2500 IU; vitamin E, 50.00mg; vitamin K, 2.50mg; vitamin B₁, 3.00mg; vitamin B₂, 6.00mg; vitamin B₆, 6.00mg; niacin, 40mg; calcium pantothenate, 10mg; biotin, 0.08mg; vitamin B₁₂, 0.25mg; folic acid, 1.00mg; chlorine chloride, 300mg; manganese, 100mg; iron, 50mg; zinc, 45mg; copper, 2.00mg; iodine, 1.35mg; cobalt, 0.25mg; selenium, 0.10mg; growth promoter, 40.00; antioxidant, 200mg.

formulate the broiler finisher diets. The composition of the diets is shown in Table 1.

Animals and management

One hundred and eighty 6-week old broiler birds (Anak strain) were randomly divided into 12 groups of 15 birds each. The groups were randomly assigned to 12 isocaloric (2.90 Mcal/kgME) and isonitrogenous (21.00% CP) diets in a 4 × 3 factorial arrangement involving a control (0%), three cooked castor oil bean meal levels (10, 15 and 20%) and three DL-methionine levels (0, 0.25 and 0.5%). Each treatment was replicated 3 times with 5 birds per replicate placed in 2.6m x 3m deep litter pens of fresh wood shavings. Feed and water were supplied *ad libitum* from 42 to 70d of age. The birds were subjected to standard broiler management procedure. At the beginning of the experiment, birds in each replicate were weighed individually. Feed intake was determined daily by the weigh-back technique. Live weights were recorded weekly for each replicate. Feed conversion ratio was then calculated from these data as quantity (grams) of feed consumed per unit (grams) weight gained over the same period. All measurements were taken between 8.00am and 12.00 noon. Mortality record was kept on daily basis.

Apparent retention (% of intake) of nutrients by broiler finishers

During week 4 of the experiment, a seven-day excreta collection from three chicks per treatment (one per replicate) was carried out to determine the apparent retention of the proximate

components. During this period birds were housed individually in metabolism cages and weighed quantity of feed (90% of the daily feed intake) was offered to each bird daily. The birds were allowed two days to adjust to the cage environment before droppings were collected. Daily feed consumption was recorded as the difference between the quantity offered and the quantity left after 24 hours. Faecal droppings were collected from separate cages in detachable trays placed beneath the wire mesh floor of the cages, oven-dried and weighed over a seven day period. At the end of the collection period, all faecal samples from each bird were bulked and preserved for analysis.

Haematological determination

During week 4 of the experiment, three birds were randomly selected from each treatment group (one per replicate) and blood samples were collected from their jugular veins with sterile needles. The blood samples were collected into properly labeled sterilized bottles containing EDTA (Ethylene diamine tetracetic acid) for determination of haematological parameters. The packed cell volume (PCV) was determined using the micro haematocrit centrifuge (Mitruka and Rawnsky, 1977). Haemoglobin (Hb) was determined by the cyanomethaemoglobin method (Lamb, 1991).

Proximate and statistical analyses

Feed and excreta samples were assayed for proximate composition by the methods of AOAC (1990). Gross energy of feed and faecal samples

was determined in a Parr oxygen adiabatic bomb calorimeter. Data collected were subjected to analysis of variance (ANOVA) in completely randomized design as described by Steel and Torrie (1980). Significantly different means were separated using Duncan's New Multiple Range Test (Duncan, 1955).

Results

Performance, packed cell volume, haemoglobin concentration and mortality of birds

The proximate composition of the experimental diets are presented in Table 2, while Table 3 shows the growth performance, packed cell volume,

haemoglobin concentration and mortality of birds fed graded levels of cooked castor oil bean meal (CBM) and supplementary DL-methionine. There was no ($P>0.05$) interaction between levels of CBM and methionine on feed intake but significant ($P<0.05$) differences existed in feed intake among treatments. Maximum feed intake was obtained with Birds on treatments 2 and 3 (0% CBM with 0.25 and 0.5% methionine, respectively) and this did not differ significantly ($P>0.05$) from the feed intake of birds on treatments 1, 4, 5 and 6 but differed significantly ($P<0.05$) from the feed intake of birds on other treatments. Birds on treatments 1 (control diet with 0% methionine), 4, 5, 6, 8 and 9 had similar feed intake.

Table 2: Proximate composition of broiler finisher diets containing cooked castor oil bean meal supplemented with DL-methionine.

Castor oil bean meal levels (%)	0			10			15			20		
DL-methionine levels (%)	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5
Constituents (%)	1	2	3	4	5	6	7	8	9	10	11	12
Crude protein	21.03	21.05	21.08	21.00	21.02	21.04	21.00	21.01	21.02	20.99	21.00	21.01
Ether extract	4.75	4.55	4.50	6.75	6.70	6.65	8.55	8.50	8.45	13.55	13.15	13.05
Crude fibre	7.16	7.38	7.22	7.75	7.69	7.62	7.81	7.78	7.76	7.83	7.82	7.81
Ash	10.47	10.20	10.11	10.09	9.97	9.61	10.12	10.13	10.08	10.56	7.52	7.21
Moisture	8.49	8.53	7.89	9.04	9.12	9.00	8.67	8.51	8.32	9.18	8.87	8.42
Nitrogen-free extract	48.1	48.29	49.20	45.37	45.50	46.08	43.85	44.07	4.37	37.89	38.64	39.50
Dry matter	91.51	91.47	92.11	90.96	90.88	91.00	91.33	91.49	91.68	90.82	91.13	91.58
Gross energy (Kcal /kg)	4574	4573	4574	4585	4587	4586	4598	4596	4594	4603	4601	4601

Table 3: Effect of processed castor oil bean meal on performance, packed cell volume and haemoglobin concentration of broiler finishers

Castor oil bean meal	0			10			15			20			
levels (%)													
DL-methionine levels	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	
(%)													
Parameters	1	2	3	4	5	6	7	8	9	10	11	12	SEM
Av. daily feed intake (g)	176.37 ^a	176.88 ^a	176.99 ^a	175.48 ^a	176.01 ^a	176.18 ^a	173.92 ^a	174.97 ^a	175.00 ^a	144.62 ^b	145.06 ^b	145.45 ^b	0.47
Av. daily weight gain (g)	64.40 ^a	64.72 ^a	64.92 ^a	63.85 ^a	63.95 ^a	64.23 ^a	62.75 ^a	63.45 ^a	63.74 ^a	45.09 ^b	45.73 ^b	46.30 ^b	0.22
Feed conversion ratio	2.74 ^a	2.73 ^a	2.74 ^a	2.75 ^a	2.73 ^a	2.73 ^a	2.77 ^a	2.76 ^a	2.74 ^a	3.21 ^b	3.17 ^b	3.14 ^b	0.02
Protein efficiency ratio	1.74 ^a	1.74 ^a	1.74 ^a	1.73 ^a	1.73 ^a	1.74 ^a	1.72 ^a	1.73 ^a	1.73 ^a	1.48 ^b	1.50 ^b	1.51 ^b	0.01
Packed cell volume (%)	30.89	30.92	30.43	30.30	29.97	30.87	30.92	30.67	30.39	31.69	31.35	30.97	0.63
Hemoglobin conc.													
(mg/100ml)	9.83 ^a	9.82 ^a	9.38 ^a	9.31 ^a	9.08 ^a	9.81 ^a	9.37 ^a	9.54 ^a	9.79 ^a	9.92 ^a	10.46 ^b	11.14 ^b	0.31
Mortality %	-	-	-	-	-	-	-	-	-	-	-	-	-

a, b, c, d= means on the same row with different superscripts are significantly ($P < 0.05$) different.
SEM = Standard error of the mean.

Birds on treatments 10 to 12 (20% CBM with and without methionine supplementation) had the least feed intake. There was a significant ($P < 0.05$) interaction between CBM and methionine levels on weight gain. Methionine supplementation enhanced ($P < 0.05$) weight gain at the 15 and 20% levels of CBM inclusion. Birds on treatment 3 (0% CBM with 0.5% methionine) had significantly ($P < 0.05$) higher weight gain than those on treatments 4 to 12. Birds on treatments 1, 2 and 6 (10% CBM with 0.5% methionine) had comparable weight gain. Birds on treatments 1, 4, 5, 6 and 9 also had similar weight gain. Birds on treatments 10 to 12 had the least weight gain.

There were significant ($P < 0.05$) interactions between CBM and methionine levels on feed conversion ratio (FCR) and protein efficiency ratio (PER). Methionine supplementation improved the efficiencies of feed and protein utilization only at the 20% level of CBM inclusion. There were significant ($P < 0.05$) differences among treatments in FCR and in PER. Birds on treatments 1 to 9 (0, 10 and 15% CBM with and without methionine supplementation) had significantly ($P < 0.05$) lower FCR and higher PER than birds on treatments 10 to 12 (20% CBM with and without methionine).

There were no significant ($P > 0.05$) differences among treatments in packed cell volume. There were, however, significant ($P < 0.05$) differences in haemoglobin concentration (Hb) among treatments. Birds on treatment 12 (20% CBM with 0.5% methionine) had significantly ($P < 0.05$) higher Hb than birds on other treatments with the exception of treatment 11. Birds on treatment 11 had significantly ($P < 0.05$) higher Hb than birds on treatments 3, 4, 5 and 7. Birds on treatments 1 to 9 and 10 had similar Hb. There was a significant ($P < 0.05$) interaction between levels of CBM and methionine on Hb. Methionine supplementation ($P < 0.05$) increased Hb concentration at the 20% level of CBM inclusion. There was no incidence of death of birds in all the treatments.

Apparent retention (% of intake) of nutrients by broiler finishers

Data on the apparent retention (% of intake) of nutrients by the broiler finishers are presented in Table 4. There were significant ($P < 0.05$) differences among treatments in dry matter (DM), nitrogen, ether extract (EE) and nitrogen-free extract (NFE) retention. Birds on treatments 2 and 3 had significantly ($P < 0.05$) higher DM and NFE retention than those on treatments 3-12. Birds on treatments 1, 4, 5, 6 and 9 had similar DM retention, while birds on treatments 1 and 6 had similar NFE retention. Birds on treatments 2 and 3 had significantly ($P < 0.05$) higher nitrogen retention than those on other treatments, while

Table 4: Effect of processed castor oil bean meal on apparent retention (% of intake) of nutrients by broiler finishers

Castor oil bean meal levels (%)	0			10			15			20			
DL-methionine levels (%)	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	0	0.25	0.5	
Parameters	1	2	3	4	5	6	7	8	9	10	11	12	SEM
Dry matter	82.89 ^a	82.64 ^a	82.63 ^a	81.55 ^b	81.67 ^b	81.77 ^b	80.71 ^c	80.95 ^c	81.45 ^c	79.74 ^d	79.87 ^d	71.23 ^e	0.25
Nitrogen	79.61 ^a	80.24 ^a	80.37 ^a	79.03 ^b	79.37 ^b	79.43 ^b	78.17 ^c	78.30 ^c	78.70 ^c	66.67 ^d	66.83 ^d	67.15 ^d	0.14
Ether extract	91.42 ^a	91.83 ^a	92.28 ^a	91.06 ^b	91.08 ^b	91.38 ^b	90.51 ^c	90.65 ^c	90.97 ^c	78.82 ^d	79.22 ^d	80.89 ^d	0.21
Nitrogen-free extract	81.04 ^a	81.48 ^a	81.53 ^a	80.23 ^b	80.26 ^b	80.59 ^b	79.03 ^c	79.36 ^c	80.17 ^c	68.33 ^d	68.45 ^d	68.78 ^d	0.21

a, b, ..., f means on the same row with different superscripts are significantly ($P < 0.05$) different. SEM = Standard error of the mean.

birds on treatment 3 had significantly ($P < 0.05$) higher EE retention than those on other treatments with the exception of treatment 2. DM Birds on treatments 10 – 12 had the lowest retention of DM, nitrogen, EE and NFE. Although there was no significant ($P > 0.05$) interaction between CBM and methionine levels on DM retention, significant ($P < 0.05$) interactions existed between CBM and methionine levels on nitrogen, EE and NFE. Methionine supplementation improved nitrogen retention at the 0% level; EE retention at the 0, and 20% levels, and NFE retention at the 15% level of CBM inclusion.

Table 5 shows that there were significant ($P < 0.01$) correlations between levels of CBM and

feed intake ($r = -0.81$), weight gain ($r = -0.81$), FCR ($r = 0.79$), PER ($r = -0.79$), and Hb ($r = 0.41$). For every percentage increase in castor oil bean meal, there were about 9.61g, 5.77g and 0.07 unit decreases in feed intake, weight gain and PER, respectively. There were also about 0.26mg/100ml and 0.13 unit increase in Hb and FCR, respectively. Although there was no significant ($P > 0.05$) correlation between levels of CBM and PCV, there were significant ($P < 0.01$) but negative correlations between levels of CBM and DM retention ($r = -0.84$), nitrogen retention ($r = -0.84$), EE retention ($r = -0.82$) and NFE retention ($r = -0.85$). For every percentage increase in CBM, there were about 3.52, 4.04, 3.74 and 3.94% decreases in the retention of DM, nitrogen, EE and NFE, respectively.

Table 5: Simple regression equations and correlation coefficients relating each response parameter (Y) of broiler finishers to % dietary castor oil bean meal (X)

Predictand (Y)	Prediction equation	r	R ²	S _{yx}	Probability of significant correlation
Average daily feed intake (g)	$Y = 192.10 - 9.61X$	-0.81	0.65	3.31	$P < 0.01$
Average daily weight gain (g)	$Y = 73.34 - 5.77X$	-0.81	0.66	1.96	$P < 0.01$
Feed conversion ratio	$Y = 2.52 + 0.13X$	0.97	0.63	0.05	$P < 0.01$
Protein efficiency ratio	$Y = 1.85 - 0.07X$	-0.79	0.63	0.03	$P < 0.01$
Packed cell volume (%)	$Y = 30.27 + 0.17X$	-0.19	0.04	0.42	$P < 0.05$
Hemoglobin concentration (mg/100ml)	$Y = 9.12 + 0.26X$	-0.41	0.17	0.27	$P < 0.01$
Dry matter retained (%)	$Y = 87.84 - 3.52X$	-0.84	0.70	1.09	$P < 0.01$
Nitrogen retained (%)	$Y = 86.24 - 4.02X$	-0.84	0.70	1.24	$P < 0.01$
EE retained (%)	$Y = 47.66 - 3.74X$	0.82	0.67	1.24	$P < 0.01$
Nitrogen-free extract retained (%)	$Y = 87.29 - 3.94X$	-0.85	0.71	1.17	$P < 0.01$

Discussion

Performance, packed cell volume, haemoglobin concentration and mortality of birds

The responses of the birds to dietary CBM and DL-methionine showed that inclusion of CBM above 15% decreased feed intake. This observation corroborates earlier reports (Ani and Okorie, 2002; Ani and Okorie, 2004a), and further confirms the reports of Lee *et al.* (1978) and Okorie *et al.* (1988). The depressed feed intake may be attributed to the possible presence of appetite depressant in the diets and poor palatability of the CBM based diets. Jenkins (1963) and Clemens (1963) cited by Ani and Okorie (2004a), had suggested that there could be an antinutritive factor in castor bean cake other than ricin since diets containing detoxified castor oil bean meal (CBM) were not readily accepted by rats and rabbits. Ani and Okorie (2005) had also attributed depression in feed intake to the presence of appetite depressing castor allergen in heated-treated CBM. Okorie *et al.* (1988) and Ani (2007) had also attributed depression in feed intake to poor palatability of the diets containing high level (20%) of CBM. High level of dietary CBM did not only depress feed intake, it also reduced efficiencies of feed and protein utilization as evidenced by reduced weight gain. This observation is in consonance with the views of Lee *et al.* (1978), Okorie *et al.* (1988), Ani and Okorie (2002), Ani and Okorie (2004a) and Ani (2007) that inclusion of heat-treated CBM at high levels resulted in reduced weight gain. Reduction

in body weight gain of broiler birds that consumed processed CBM has been blamed on reduced feed intake, coupled with poor efficiency of feed conversion which limits the availability of the nutrients required for normal growth. The presence of residual ricin in the processed CBM might also have contributed to the growth depression. Ani and Okorie (2006) reported the presence of residual ricin in two-stage cooked CBM. Ricin has been shown to interfere with the digestion and absorption of nutrients in the gastro-intestinal tract and to inhibit protein synthesis (Goldstein and Poretz, 1986; Liener, 1986). Although dietary CBM did not have any significant effect on PCV, it significantly increased Hb at the 20% CBM level. The observed increase in Hb may suggest the production of more blood cells in the birds as they tried to develop immunity to the toxic effect of the residual ricin. According to Radeleff (1970), cited by Ani and Okorie (2002), ricin as a protein is capable of inducing immunity in animals consuming it in small quantities over a long period. Jackson (1957) and Clark and Clark (1975) also reported the antigenic effects of castor bean seed poison.

Apparent retention (% of intake) of nutrients by broiler finishers

Increasingly CBM levels had adverse effects not only on feed intake and weight gain but also on nutrient absorption and utilization as evidenced by the significant depressions in the retention of DM, nitrogen, EE, and NFE. Similar

depressions in nutrient digestibility with increasing dietary CBM levels had been reported (Okorie *et al.*, 1988; Ani and Okorie, 2004b; Ani and Okorie, 2005). The adverse effect of residual ricin on nutrient absorption and utilization cannot be ruled out. Ricin has been classified as a lectin (Gold and Balding, 1975) and has been implicated in reduced digestive efficiency, as it causes serious impairment in the absorption of nutrients across the intestinal wall (Jaffe, 1980; Goldstein and Poretz, 1986; Liener, 1986). It is likely therefore, that the significantly lower weight gains of the birds fed on the 20% CBM diets relative to the control and to the 10 and 15% CBM diets may have resulted from the low nutrient intake, and poor nutrient absorption of the 20% CBM diets. DL-methionine was included in some of the diets since castor bean seeds are known to be deficient in sulphur amino acids (Satar *et al.*, 1979; Browning *et al.*, 1990). Although its inclusion did not have any significant effect on feed intake at the 0, 10, 15 and 20% CBM levels, it significantly improved weight gain at the 15 and 20% CBM levels, Hb and efficiencies of feed and protein utilization at the 20% CBM level, nitrogen retention at the 0% level, EE retention at the 0, and 20% levels, and NFE retention at the 15% level of CBM inclusion. DL-methionine may have enhanced the performance of the broiler birds by improving the quality of the castor oil bean protein. Polit and Sgarbieri (1976) had shown that supplementing castor oil bean meal diets with methionine improved net protein utilization in weanling rats. DL-methionine may also have

provided labile methyl groups, which might have been involved in further detoxification of the CBM (Rayudu *et al.*, 1970; Harper *et al.*, 1979 cited by Ani (2002)), particularly as both ricin and ricinene, the toxic components of castor oil bean are known to be pyrimidine based (Okorie *et al.*, 1988).

Conclusion

The results of the present study indicate that processed CBM can be included in broiler finisher diet at 15% level with DL-methionine supplementation to obtain normal growth in broiler birds.

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