The Journal of Animal & Plant Sciences, 23(5): 2013, Page: 1228-1235
ISSN: 1018-7081

EFFECTS OF PROCESSED CASTOR OIL BEAN (*RICINUS COMMUNIS* L) MEAL AND SUPPLEMENTARY DL- METHIONINE ON NUTRIENT UTILIZATION BY BROILER CHICKS

A. O. Ani and A.U Okorie

Department of Animal Science, University of Nigeria, Nsukka, Nigeria
Corresponding author Email: austinani2011@yahoo.com

ABSTRACT

The effects of processed castor oil bean (*Ricinus communis* L) meal (CBM) and supplementary DL- methionine on nutrient retention, carcass and organ weights of broiler chicks were investigated for five weeks. Two hundred and sixteen 7-day old broiler chicks (Anak strain) were randomly divided into 12 treatment groups of 18 birds each in a 4 x 3 factorial arrangement involving four processed CBM levels (0,10,15 and 20%) and three DL – methionine levels (0, 0.25 and 0.5%). During week 5 of the experiment, the apparent retention of the proximate components and the organs weights of birds were evaluated. Results showed that chicks on treatments 10-12 had lower ($P<0.05$) retention of DM, nitrogen, EE and NFE and lower ($P<0.05$) body weight, liver, kidney, spleen, heart and empty gizzard weights than birds on other treatments. Result showed that 10% and15% processed CBM can be included in the diet of broiler chicks without and with DL-methionine supplementation, respectively to enhance nutrient retention and for normal organ development of broiler chicks.

Key words: castor oil bean meal, DL-methionine, effects, nutrient utilization, organ weights, broiler chicks.

INTRODUCTION

The level of consumption of animal protein in Nigeria is estimated at 8g per person per day, which is about 27g, less than the minimum requirement recommended by the National Research Council of the United States of America (FAO, 2006). There is, therefore the need to increase the production of such animals as pigs and poultry in order to close the protein gap in the diet of most average Nigerians. Poultry in particular has been found to reproduce quicker than other livestock since they are highly prolific and good feed converters (Smith, 2001). Besides, poultry production involves the least hazardous and arduous process when compared to other livestock enterprises (Oluyemi and Roberts, 2007). Consequently it offers the best logical solution to national meat scarcity. In poultry production, the realization of maximum performance and cost return benefits depend on the quantity and quality of feeds. The quantity of feed required for intensive livestock production accounts for more than 75% of the total cost of production. The high cost of the primary feed ingredients (cereals and pulses) has invariably increased the cost of compound feeds. Consequently many poultry farmers and feed millers have been forced out of production. Considering the aforementioned problems, it is pertinent to examine the utilization of industrial wastes and by – products that are not directly utilizable by man as food. The alternative feed ingredient being considered in the present study is castor oil bean (*Ricinus communis*) meal, a by – product of castor oil extraction industry. The castor oil plant (*Ricinus communis L.*) is a member of the Spurge family of plants (Euphorbiaceae). It is grown commercially for the oil contained in the seed, which is used primarily for industrial purposes and in the manufacture of cosmetics. Most of the world's castor oil is produced in India, China and Brazil, but commercial production also occurs on a smaller scale in many other tropical countries. World production of castor oil increased from 0.4 million tonnes in 1970 to 0.8 million tonnes in 2000 (Weiss, 2000).Castor oil bean meal with a crude protein content of 35 to 40% has potentials as an alternative source of vegetable protein in livestock feeds (Ani, 2012). Castor oil bean meal has been used in the feeding of poultry (Ani and Okorie, 2004; Oso *et al.*, 2011). Ani and Okorie (2004), Ani and Okorie (2005) and Ani (2012) showed that 10-15% of the meal could be satisfactorily used in poultry rations when properly detoxified. Detoxification becomes very necessary because of the presence of some toxic substances (ricin and ricinine) and castor allergens in the raw bean (Olsnes, 2004; Audi *et al.*, 2005; Ani and Okorie, 2006). The large-scale utilization of castor oil bean meal in livestock feeds has therefore been limited by these substances and by its high level of abrasive fibre. A number of physical and chemical methods for detoxifying castor seed meal have been investigated. Physical treatments included Soaking (3, 6 and 12 hours), steaming (30 and 60 min), boiling (30 and 60 min), autoclaving (15psi, 30 min; 15psi, 60 min) and heating (100°C 30 min; 120°C 25min), while the chemical methods consisted of treatment with ammonia (Anandan *et al.*, 2004; Benge, 2006; Martinez-Herrera *et al.,* 2006; Nsa and Ukachukwu, 2007; Ani, 2012). However dry heat treatment could lead to the destruction of some amino acids, particularly lysine, threonine, tyrosine, cystine and methionine, and the consequent reduction in the protein quality of the castor oil bean meal tends to limit the suitability of the method. Against this background and recognizing that castor oil bean meal can serve as an alternative source of vegetable protein in animal feed, the present study was undertaken to investigate the effects of graded levels of processed castor oil bean (*Ricinus communis* L) meal and supplementary DL- methionine on nutrient utilization, carcass and organ weights of broiler chicks.

MATERIALS AND METHODS

Processing of castor oil bean seeds: Castor bean seeds used in the present study were of the large and mottled variety, and were purchased from Enugu State, Nigeria. The seeds were dehulled manually 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 100^0C for 50 min per cooking to ensure proper detoxification as described by Ani and Okorie (2006) and Ani (2012). The cooked samples were dried overnight in the oven at 100^0C, ground in a hammer mill and defatted using a mechanical oil press. The processed castor oil bean meal was used to formulate the broiler starter diets. The percentage composition of the diets is presented in Table 1.

Animals and management: Two hundred and sixteen 7-day old commercial broiler chicks (Anak strain) were randomly divided into 12 groups of 18 birds each. The groups were randomly assigned to 12 isocaloric (2.80 Mcal of ME/kg) and isonitrogenous (24.00%CP) diets in a 4 x 3 factorial arrangement involving a control (0%), three levels (10,15 and 20%) of processed 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 6 birds per replicate placed in 2.6 m x 3m deep litter pens of fresh wood shavings. The experiment lasted for 5 weeks during which feed and water were provided *ad libitum*. The birds were subjected to routine broiler management procedure.

Apparent nutrient retention study: In the last week of the experiment, three birds per group (one bird per replicate) were housed in metabolism cages and weighed quantity of feed (90% of feed intake) was offered to each bird daily. A seven-day excreta collection from these birds was carried out to determine the apparent retention of the proximate components. The birds were allowed two days to adjust to cage environment before droppings were collected. Faecal droppings were collected from separate cages, oven-dried at 60^oC and weighed over a 7-day period. At the end of the collection period, all faecal samples from each bird were bulked and preserved for further analysis. Daily feed intake was recorded as the difference between the quantity offered and the quantity left after 24 hours. The weighed and analyzed faecal samples, together with the daily feed intakes were used to calculate apparent digestibility coefficients and apparent nutrient retention. Apparent nutrient retention(C) can be defined as follows: Quantity of nutrient in the feed consumed (A) – quantity of nutrient in the faeces voided (B) divided by the quantity of nutrient in the feed consumed (A) multiplied by 100. i.e. ($C = A\text{-}B \div A \times 100$).

Carcass and organ evaluation: At the 6th week of the experiment, 3 birds per treatment (one per replicate) were randomly selected and weighed for organ evaluation. The birds were starved overnight and slaughtered by severing the jugular veins, scalded in warm water for about a minute, and the feathers were plucked manually. The birds were eviscerated and weighed to obtain their dressed carcass weights. The kidney, liver, gizzard, heart, spleen and abdominal fat were removed and weighed using a sensitive electronic scale and grossly examined for any pathological changes. The organ weights were expressed as percentages of the live weight.

Proximate analyses of feed and faecal samples: Feed and faecal samples were assayed for proximate components by standard methods (AOAC, 2006). Gross energy of feed was determined in a Parr oxygen adiabatic bomb calorimeter.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) as described by Akindele (2004) using a Statistical Analysis System (SAS, 2006). Significantly different means were separated using Duncan’s New Multiple Range Test as outlined by Obi (2002). Simple regression and correlation analyses were also done to quantify the relationships between dietary castor oil bean meal (CBM) level and the response parameters.

Table 1. Percentage composition of broiler starter 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	52.75	52.85	52.90	48.59	48.65	48.72	46.55	46.50	46.65	44.40	44.55	44.55
Wheat offal	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soya bean meal	30.00	29.65	29.35	24.16	23.85	23.53	21.20	20.90	20.60	18.35	17.95	17.70
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)	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.50
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	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis: Crude protein (%)	24.00	24.00	24.00	24.01	24.02	24.03	24.00	24.02	24.03	24.04	24.01	24.04
Energy (Mcal of ME/kg)	2.83	2.83	2.83	2.82	2.86	2.85	2.87	2.86	2.86	2.88	2.88	2.8
Determined composition (%)												
Crude protein	24.03	24.05	24.09	24.01	24.04	24.07	24.00	24.02	24.04	24.00	24.02	24.04
Ether extract	5.05	4.75	4.73	7.04	7.03	7.01	10.06	10.04	10.00	15.02	14.45	14.00
Crude fibre	6.58	6.73	6.54	6.96	7.00	6.88	6.51	7.04	7.01	7.26	7.18	7.12
Ash	11.04	11.00	10.59	10.66	10.42	10.60	10.61	10.02	10.00	10.95	10.71	10.68
Nitrogen-free extract	45.20	46.39	47.10	44.31	44.42	44.43	41.67	41.85	41.98	35.67	36.56	37.05
Dry matter	91.90	92.92	93.05	92.98	92.91	92.99	92.85	92.97	93.03	92.90	92.92	92.89
Gross energy (Kcal /g)	4340	4341	4341	4344	4341	4344	4341	4341	4340	4347	4347	4346

*To supply the following per kg of diet: vitamin A, 12,500 IU; vitamin D_3, 2500 IU; vitamin E, 50.00mg; vitamin K_3 2.50mg; vitamin B_1, 3.00mg; vitamin B_2, 6.00mg; vitamin B_6, 6.00mg; niacin, 40mg; calcium pantothenate, 10mg; biotine, 0.08mg; vitamin B_{12}, 0.25mg; folic acid, 1.00mg; chlorine chloride, 300mg; manganese, 100mg; iron, 50mg; zinc, 45mg; copper, 2.00mg; iodine, 1.55mg; cobalt, 0.25mg; selenium, 0.10mg; growth promoter, 40.00;antioxidant, 200mg

RESULTS AND DISCUSSION

Apparent retention of nutrients by broiler chicks: The apparent retention (% of intake) of nutrients by the experimental birds is presented in Table 2. There were significant differences ($P<0.05$) among treatments in apparent retention of dry matter (DM), nitrogen, ether extract, (EE) and nitrogen-free extract (NFE) by the broiler chicks.

Birds on treatment 3 (0% CBM diet with 0.5% methionine) had comparable ($P>0.05$) DM retention with those on treatments 1, 2 and 6, and this was higher ($P<0.05$) than that of birds on treatments 7 to 12. Birds on treatment 1 (0% CBM diet without methionine) had similar DM retention with birds on treatments 2, 4, 5 and

6 while birds on treatments 4 to 6 (0% CBM with or without methionine) had similar DM retention with birds on treatment 9.

Table 2: Apparent retention of nutrients by broiler chicks

Castor oil bean meal levels (%)	0			10			15			20			
DL-ethionine 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	77.76 ^{abc}	77.94 ^{ab}	78.25 ^{a}	77.25 ^{cd}	77.38 ^{bcd}	77.64 ^{abcd}	75.06 ^{f}	76.24 ^{e}	77.12 ^{d}	69.16 ^{i}	69.75 ^{h}	70.43 ^{g}	0.19
Nitrogen	74.29 ^{ab}	74.29 ^{ab}	74.72 ^{a}	73.41 ^{c}	73.78 ^{bc}	73.86^{bc}	71.08 ^{e}	72.24 ^{d}	73.37 ^{c}	63.84 ^{g}	64.74 ^{f}	65.20 ^{f}	0.23
Ether extract	82.39	82.61	82.84	81.86	81.99 ^{c}	82.34 ^{bc}	80.11	80.80	81.70	75.21 ^{f}	75.81^{f}	76.76	0.24
Nitro gen-free extract	77.41 ^{bc}	77.81 ^{ab}	78.27 ^{a}	77.08 ^{cd}	77.29 ^{bcd}	77.36 ^{bc}	75.25 ^{f}	75.87 ^{e}	76.66 ^{d}	67.28 ^{h}	67.59 ^{gh}	68.13 ^{g}	0.21

a, b, h: 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 diets with or without methionine) had the lowest retention of DM. Birds on treatment 3 had comparable ($P<0.05$) nitrogen retention with those on treatments 1 and 2, and this differed significantly ($P<0.05$) from that of birds on treatments 4 to 12. Birds on treatments 1 (0% CBM without methionine), 2 and 5 (10% CBM with 0.25% methionine), and 6 (10% CBM with 0.5% methionine) had similar ($P>0.05$) NFE retention. Birds on treatments 4 (10% CBM without methionine), 5 and 9 (15% CBM with 0.5% methionine) also had similar ($P>0.05$) NFE retention. The lowest NFE retention was observed in treatments 10- 12 (20% CBM with and without methionine supplementation. There were significant ($P<0.05$) CBM x methionine interactions on apparent retention of DM, nitrogen, EE and NFE. Methionine supplementation improved DM, nitrogen and EE retention at the 15 and 20% CBM levels and NFE at the 0, 15 and 20% CBM levels.

Table 3 gives the simple regression and correlation coefficients relating response parameters to dietary CBM levels. There were significant ($P<0.01$) correlations between CBM levels and DM (r = - 0.87), nitrogen (r = - 0.87), EE (r = - 0.88) and NFE (r = - 0.86).

Table 3. Simple regression equations and correlation coefficients relating each response parameter (Y) to % dietary castor oil bean meal (X) of broiler starters.

Predictand (Y)	**Prediction equation**	**r**	**R^2**	**Probability of Significant**	
				Syx	**Correlation**
Dry matter retained (%)	$Y = 81.81 – 2.59X$	-0.87	0.76	0.69	Dry matter retained (%)
Nitrogen retained (%)	$Y =78.98 – 3.10X$	-0.87	0.76	0.82	Nitrogen retained (%)
Ether extract retained (%)	$Y = 85.78 – 2.19X$	-0.88	0.78	0.55	Ether extract retained (%)
Nitrogen – free extract retained	$Y =82.66 – 3.18X$	-0.86	0.74	0.88	Nitrogen – free extract retained

The apparent retentions of dry matter (DM), nitrogen, ether extract (EE) and nitrogen-free extract (NFE) declined as the level of castor oil bean meal in the diets increased beyond 15 percent. The decrease in DM retention could be due to a drop in digestive efficiency of the bird's digestive system occasioned by the presence of residual antinutritional factors (hydrocyanic acid and lectins), present in the processed castor bean(Ani and Okorie, 2004; Ani, 2012). Earlier reports (Carew *et al.*, 2002; Emenalom *et al*., 2004; Ani and Okorie, 2008) had shown that anti-nutritional factors could interfere with nutrient digestion, absorption and utilization. These are known to lower protein quality, interfere with pancreatic digestion, absorption and retention of nutrients. The resultant effects are reduced feed conversion efficiency and reduced growth (Carew *et al*., 2003). Lectins are known to exert their deleterious antinutritional effects via reduced nutrient absorption following extensive structural and functional disruption of the intestinal villi. It was likely that these ANFs caused a shedding of the outer membrane of GIT and decreased villus length, with consequent reduction in the surface area for absorption in the small intestine. However DL- methionine supplementation significantly improved the retention of DM at the 15 and 20% CBM inclusion levels. The DM retention values (69.16- 78.25%) obtained in the present study are higher than the values (60- 61.60%) reported by Okorie *et al*. (1988) for 5 weeks old broiler chicks fed diets containing graded levels of roasted and undehulled castor bean meal. The improvement observed in the present study may be attributed to the use of dehulled CBM. Macdonald *et al*. (2002) reported that a percentage increase in dietary fibre causes 0.7 to 1.0% reduction in digestibility as well as in retention of organic nutrients for ruminants and twice that value for non- ruminants; and vice versa. The observed reduction in dry matter and nitrogen retention may be attributed to depressed feed intake, which resulted in inadequate supply of dry matter and crude protein for digestive and retention purposes. Dietary protein in particular plays a significant role in nitrogen retention. High intake of protein or increased level of protein leads to an increase in nitrogen retention, whereas a decreased level of protein leads to a decrease in nitrogen retention. According to Maynard and Loosli (2000), inadequate supply of dietary protein results in reduced nutrient (nitrogen) retention. The reduction observed in nitrogen retention may also be attributed to poor protein absorption in the gastrointestinal wall of the birds due to the effect of residual ricin. Dublec (2011) had reported that antinutritional factors like lectins interfere with the utilization of dietary nutrients in a variety of ways, including reducing protein digestibility, binding to various nutrients or damaging the gut wall and thereby reducing digestive efficiency. Although castor oil bean meal significantly reduced nitrogen retention, the inclusion of methionine in some diets improved nitrogen retention at the 15 and 20% CBM inclusion levels. Methionine might have improved the quality of the CBM protein since castor oil bean seeds are known to be deficient in sulphur amino acids. The values (63.84 – 80.24%) of nitrogen retention obtained in this study are similar to the values (64.59-74.43%) reported by Ani and Okorie(2005). The reduction in EE and NFE retention as in other nutrients may also be attributed to residual ricin. The addition of DL- methionine to some of the diets had significant improvement on EE retention at the 15 and 20% CBM levels. The retention of NFE was also improved by methionine inclusion at the 0, 10, 15 and 20% CBM levels. The EE values (75.21 – 82. 84%) and the NFE values (67.28-78.27%) reported in this work are similar to the EE values (75.73-82.61%) and NFE values (67.67-77.83%) reported by Ani and Okorie (2005). The observed improvement may be attributed to the method of processing used in the present study. Generally the observed reduction in apparent retention of nutrients might have contributed to the depressed performance of birds that consumed the 20% CBM diets.

Carcass and organ weights: Table 4 shows the effects of graded levels of CBM and supplementary DL-methionine on body weight at 6weeks, organ weights and relative organ weights of broiler chicks. There were significant differences ($P<0.05$) among treatments in body weight, liver weight, relative liver weight, kidney weight, relative kidney weight, spleen weight, heart weight, empty gizzard weight and relative empty gizzard weight. Birds on treatments 1, 2, 3 and 6 had similar and significantly ($P<0.05$) heavier live weights than birds on all other treatments. Birds on treatments 1 – 3 (0% CBM with or without methionine supplementation) had significantly ($P<0.05$) bigger liver weight and smaller relative liver weight than that of birds on treatments7-12. Birds on treatments 10-12 (20% CBM with or without methionine supplementation) had the lowest body weight, liver weight, kidney weight, relative kidney weight and the biggest relative liver weight. Birds on treatment 3 had significantly ($P<0.05$) bigger kidney weight than those on treatments 4-12. Birds on treatments 2 and 3 had similar spleen weight with those on treatments 1, 4, 5, 6 and 9 and this was heavier ($P<0.05$) than that of birds on treatments 10 – 12 (20% CBM with 0-0.5% methionine). Birds on treatments 1, 2, 3, 5, 6 and 9 had bigger ($P<0.05$) heart weight than those on treatments 7, and10 – 12. Birds on treatments 2 and 3 (0% CBM with 0.25 and 0.5% methionine supplementation) had comparable empty gizzard weight with those on treatments 1, 5 and 6,and this differed significantly ($P<0.05$) from that of birds on other treatments. Birds on treatment 7 and those on treatments 8, 10, 11 and 12 had comparable relative empty gizzard weight, while birds on treatments 1, 2, 3 and 6, and those on treatments 4, 5 and 9 had comparable relative empty gizzard weight.

While there were no CBM x DL-methionine interactions on liver weight, kidney weight, relative kidney weight, spleen weight, relative spleen weight, relative heart weight and empty gizzard weight, significant ($P<0.05$) interactions existed between CBM and methionine levels on body weight, relative liver weight, heart weight and relative empty gizzard weight. Methionine supplementation significantly ($P<0.05$) improved body weight of the chicks at the 10 and 15% levels of CBM inclusion; decreased relative liver and empty gizzard weights at the 15% level of CBM inclusion, and increased heart weight at the 15% level of CBM inclusion. The table of regression (Table 5) shows that there were significant ($P<0.01$) correlations between CBM levels and body weight ($r = -0.91$), liver weight ($r = -0.86$), relative liver weight ($r = 0.78$), kidney weight ($r = -0.88$), relative kidney weight($r = -0.47$), spleen weight ($r = -0.86$), heart weight ($r = -0.75$), relative heart weight ($r = 0.52$), empty gizzard weight ($r = -0.86$) and relative empty gizzard weight ($r = 0.63$). For every percentage increase in castor oil bean meal, there were corresponding decreases of about 194.50g in body weight, 2.95g in liver weight, 1.34g in kidney weight, 0.03% in relative kidney weight, 0.41g in spleen weight, 0.89g in heart weight, 4.01g in empty gizzard weight and corresponding increases of about 0.22% in relative liver

Table 4: Effects of cooked castor oil bean meal supplemented with DL-methionine on body and organ weights of broiler starters.

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
Body weight (g)	1300.00^{ab}	1315.00^{a}	1350.00^{a}	1150.00^{cd}	1200.00^{bc}	1300.00^{ab}	1000.00^{e}	1060.00^{de}	1200.00^{bc}	700.00^{f}	700.00^{f}	750.00^{f}	32.27
Liver weight	31.10^{a}	31.18^{a}	31.20^{a}	29.53^{ab}	30.27^{ab}	30.75^{ab}	28.87^{b}	29.00^{b}	29.12^{b}	21.33^{c}	21.58^{c}	22.25^{c}	0.58
Liver wt. as % of body wt.	2.40^{d}	2.38^{d}	2.31^{d}	2.57^{bcd}	2.53^{d}	2.37^{d}	2.91^{ab}	2.74^{acd}	2.43^{d}	3.04^{a}	3.07^{a}	2.98^{a}	0.11
Kidney weight (g)	7.50^{ac}	8.00^{ab}	8.12^{a}	6.90^{cd}	7.00^{cd}	7.27^{bcd}	6.50^{d}	6.73^{cd}	6.82^{cd}	3.28^{e}	3.63^{e}	3.67^{e}	0.27
Kidney wt. as (%) of body wt.	0.58^{ab}	0.61^{ab}	0.60^{ab}	0.60^{ab}	0.58^{ab}	0.57^{ab}	0.65^{a}	0.63^{a}	0.57^{ab}	0.47^{d}	0.52^{cd}	0.49^{cd}	0.03
Spleen weight (g)	2.65^{abc}	2.77^{ab}	2.83^{a}	2.43^{abc}	2.53^{abc}	2.58^{abc}	2.23^{c}	2.30^{c}	2.35^{ac}	1.35^{d}	1.45^{d}	1.62^{d}	0.14
Spleen wt. As % of body wt.	0.21	0.21	0.21	0.21	0.21	0.20	0.23	0.22	0.20	0.19	0.21	0.21	0.01
Heart weight (g)	8.02^{a}	8.12^{a}	8.17^{a}	7.05^{abd}	8.05^{a}	8.07^{a}	6.00^{bcd}	7.00^{acd}	8.00^{a}	5.23^{d}	5.35^{d}	5.63^{d}	0.45
Heart wt. as % of body wt.	0.62	0.62	0.61	0.61	0.70	0.62	0.60	0.66	0.67	0.74	0.77	0.75	0.05
Empty gizzard weight	33.22^{ab}	34.00^{a}	34.73^{a}	32.00^{bc}	33.37^{ab}	33.22^{ab}	30.95^{c}	30.95^{c}	31.88^{bc}	20.67^{d}	20.92^{d}	21.92^{d}	0.58
Empty gizzard wt. as % of body wt.	2.57^{c}	2.59^{c}	2.58^{c}	2.78^{bc}	2.78^{bc}	2.56^{c}	3.12^{a}	2.66^{bc}	2.93^{ab}	2.96^{ab}	2.99^{ab}	2.93^{ab}	0.10

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

Table 5. Simple regression equations and correlation coefficients relating body and organ weights (Y) of broiler starters to % dietary castor oil bean meal (X)

Predictand (Y)	**Prediction equation**	**r**	**R^2**	**Syx**	**Probability of significant correlation**
Body weight (g)	Y = 1571.67 – 194.50X	-0.91	0.83	42.06	P<0.01
Liver weight (g)	Y = 35.39 – 2.95X	- 0.86	0.75	0.81	P<0.01
Liver weight as % of body weight	Y = 2.09 + 0.22X	0.87	0.60	0.08	P<0.01
Kidney weight (g)	Y = 9.64 - 1.34X	-0.88	0.76	0.34	P<0.01
Kidney weight as % of body weight	Y =0.64 - 0.03X	-0.47	0.22	0.02	P<0.01
Spleen weight (g)	Y =3.27 – 0.41X	-0.86	0.74	0.11	P<0.01
Spleen weight as % of body weight	Y =0.21 – 0.0008X	-0.5	0.002	0.01	P<0.05
Heart weight	Y =9.31 – 0.89X	-0.75	0.57	0.37	P<0.01
Heart weight as % of body weight	Y =0.56 + 0.04X	0.52	0.27	0.03	P<0.01
Empty gizzard weight (g)	Y =39.83 – 4.01X	0.86	0.75	1.10	P<0.01
Empty gizzard weight as % of body weight	Y =2.45 + 0.14X	0.63	0.40	0.08	P<0.01

weight, 0.04% in relative heart weight and 0.14% in relative empty gizzard weight. Gross pathological examination showed that there were no lesions in all the organs.

As shown in Table 4, the body weight of birds fed the 0%CBM diet was (1300g) as compared to 1150g, 1000g and 700g body weights of birds fed 10, 15 and 20%CBM diets, respectively. The 1300g obtained from birds fed the 0%CBM diet compares well with the body weight (1383g) reported by Ali *et al*. (2012) for broiler chicks fed soybean meal based diet(control) , but differs from the body weight (1447.67g) reported by Ullah *et al*.(2012) for broiler chicks fed soybean meal based diet. It was observed that body weight and relative organ weights decreased as the level of CBM in the diets increased to 20%. The reduction observed in body weight and relative organ weights could be attributed to depressed feed intake and reduced efficiency of feed and protein utilization. Besides, the toxic residue (ricin) present in heat-treated CBM might have led to the observed reduction. This might have increased in concentration with increase in the level of CBM in the diets. Bisiriyu *et al*.(2005) and Ani and Okorie (2008) had attributed reduction in carcass and organ weights of broiler birds fed diets containing more than 10% heat-treated CBM to depressed feed intake and ricin. Earlier reports (Ani and Okorie, 2004; Ani, 2007) had shown that feeding broiler birds with diets containing 15% and 20% CBM resulted in depression of feed intake and low efficiency of feed and protein utilization. The intake of ricin probably led to partial digestibility of the protein and their component amino acids thereby rendering undigested portion useless and unavailable for tissue and organ development. The castor plant contains in its seeds a group of closely related toxicglycoproteins (the ricin group), ricinoleic acid (12-hydroxyoleic acid) and the alkaloid ricinine. Ricin is capable of interfering with digestion, absorption and retention of nutrients ((Onimisi *et al*., 2008). It was likely that the major cause of reduction in live body and organ weights of broilers which consumed the 15% unsupplemented CBM diets and the 20% supplemented and unsupplemented CBM diets was reduced feed intake coupled with low nutrient retention. However supplementation of some of the diets with DL-methionine resulted in improved body and organ weights of birds that consumed such diets.

Conclusion: It is evident from this study that processed CBM can be included in the diet of broiler chicks at 10% level without DL-methionine supplementation and at 15% level with DL-methionine supplementation without any adverse effects on nutrient utilization, carcass and organ development of broiler chicks.

REFERENCES

Akindele, S.O. (2004). Basic Experimental Designs in Agricultural Research. 1st Ed. Royal Bird Ventures; Mushin-Lagos (Nigeria). Pp. 19-81.

Ali, M., M. Sharif, J. I. Sultan, S. Rehman, K. Farooq and M. L. Khan (2012). Influence of varying levels of bergafat on performance of broiler chicks. J. Anim. Plant Sci. 22(4):853-856.

Anandan, S., G. Kumar, J. Ghosh, and K. Ramachandra (2004). Effect of different physical andchemical treatments on detoxification of ricin in castor cake**.** Anim. Feed Sci. & Technol. 120: 159-168.

Ani, A.O. and A.U. Okorie (2002). The nutritive value of dehulled and cooked castor oil bean (*Ricinus communis* L) meal to broiler finishers. Proc. Ann. Conf. of Nig. Soci. for Anim. Prod., 27:141-143.

Ani, A.O. and A.U. Okorie (2004). The effect of dietary castor oil bean (*Ricinus communis* L) meal and supplementary L-Lysine on the performance of broiler starter chicks. Discov. & Innov. 16 (1/2): 46-52.

Ani, A.O. and A.U. Okorie (2005). The effects of graded levels of dehulled and cooked castor oil bean (*Ricinus communis* L) meal on performance of broiler starters. Nig. J. Anim. Prod. 32(1): 54-60.

Ani, A.O. and A.U. Okorie (2006). The efficacy of two-stage cooking as method of detoxifying castor oil bean (*Ricinus communis*,L) meal for livestock feeding. J. Sustain. Agric. & Environ. 8 (1): 14-22.

Ani, A.O. (2007). Effects of graded levels of dehulled and cooked castor oil bean (*Ricinus communis* L) meal and supplementary L-lysine on the performance of broiler finishers. Agro-Sci. J. Tropic. Agric., Food, Environ. & Ext. 6(1):89-97.

Ani, A.O. and A.U. Okorie (2008). Carcass and organ characteristics of broiler finishers fed diets containing graded levels of processed castor oil bean (Ricinus communis L) meal and supplementary DL-methionine . Proc. Ann. Conf. of Nig. Soci. for Anim. Prod., 33:378-381.

Ani, A.O. and A.U. Okorie (2009). Performance of broiler finishers fed graded levels of processed castor oil bean (*Ricinus communis* L) meal supplemented with DL-methionine. Nig. J. Anim. Prod. 36: (1):52-60.

Ani, A.O. (2012). Nutritional Evaluation of Castor oil bean (Ricinus communis L) Meal. Lambert Academic Publishers, Saarbrucken, Deutschland(Germany). 172pp.

AOAC (2006). Association of Official Analytical Chemists. Official Methods of Analysis. 18th ed. Washington, DC.

Audi, J., M. BelsonM. , Patel, J. Schier and J. Osterloh (2005). Ricin poisoning – a comprehensive review. *JAMA*, 294: 2342-2351.

Benge, M. (2006). Assessment of the potential of Jatropha curcas, (biodiesel tree,) for energyproduction and other uses in developing countries. Posted on ECHO's website July 2006 and updated August 2006.

Bisiriyu, L., A.M. Bamgbose, S.O. Oboh, S.O. Omoikhoje, J.A. Imaseun, C.S.O. Otoikhian and A. A. Alade(2005). Performance and nutrient digestibility of cockerel starters fed castor oil seed meal based diets. Proc. Ann. Conf. Anim. Sci. Assoc. of Nig. 10: 143-145.

Carew, L. B., M.T. Valverde, E. I. Zakrzewska, F. A. Alster and A.G. Gernat (2002). Raw velvet beans (*Mucuna pruriens*) and L-dopa have differing effects on organ growth and blood chemistry when fed to chickens. Proc. Inter. workshop "Food and Feed from Mucuna: Current Uses and the Way Forward". Tegucigalpa, Honduras. Pp272 – 287.

Carew, L. B., D. Hardy, A.G. , Gernat, and E.I. Zakrzewska (2003). Heating raw velvet beans (*Mucuna pruriens*) reverses some antinutritional effects on organ growth, blood chemistry and organ histology in growing chickens. J. Tropic. & Subtropic. Agroecosystems, 1 (2-3): 267 – 275.

Dublecz, K. (2011). The significance of antinutritional factors. Lectins. In: Animal nutrition. *www.tankonyvtar. hu›.› Mezőgazdaság*

Emenalom, O., I.C. Okoli and A.B.I. Udedibie (2004). Observations on the pathophysiology of weaner pigs fed raw and pre-heated Nigerian *Mucuna pruriens*(Velvet bean) seed. Pakistan J. Nutri. 3(2):112-117.

FAO. (2006). Food and Agriculture Organization. Fisheries Statistics: Aquaculture Production, 88/2 FAO, Rome (Italy).P12.

McDonald, P., R.A. Edwards, J.F.D. Greenhalgh and C.A. Morgan (2002). Animal Nutrition. 5th Ed. Addison Wesley Longman Ltd., Edinburgh (U. K).606pp.

Martinez-Herera, J., P. Siddhuraju, G. Francis, G. Davila-Ortiz and K. Becker (2006) .Chemical composition, toxic/ antimetabolic constituents, and effects of different treatments ontheir levels, in four provenances of Jatropha curcas L. from Mexico. Food Chem. 96: 80-89.

Maynard, L. A. and J.K. Loosli (2000). Animal Nutrition. 11th Ed. McGraw Hill Book Co. New York. 542pp.

Nsa, E.E and S.N. Ukachukwu (2007). Determination of the true metabolizable energy of raw and thermal treated castor bean (*Ricinus communis*) using adult broiler birds Proc. Ann. Conf. of Nig. Soci. for Anim. Prod., 32: 287-289.

Obi, I. U. (2002). Statistical methods of detecting differences between treatment means and research methodology issues in laboratory and field experiments. 2nd Ed. Express Publ. Ltd. Enugu. Pp13-21.

Olsnes, S. (2004). The history of ricin, abrin and related toxins. Toxicon. 44: 361-370.

Oluyemi, J.A. and F.A. Roberts (2007). Poultry Production in the Warm Wet Climates. Spectrum Books Ltd, Ibadan. Pp 58-87.

Onimisi, P.A., J.J. Omage, N.S. Hussaini and L. Ademu (2008). Evaluation of steamed castor bean meal on performance of young rabbits: Effect on digestibility and histopathology. Proc. Ann. Conf. Anim. Sci. Assoc. of Nig. 13: 413-417.

Oso, A.O., W.A. Olayemi, A. M. Bamgbose and O.F. Fowoyo (2011). Utilization of fermented castor oil seed (*Ricinuscommunis*, L) meal in diets for cockerel chicks. Arch. Zootecnica. 60 (229): 75-82.

Smith, A.J. (2001). Poultry. 2nd Ed. Macmillan Publishers Ltd. London. Pp 1-11.

SAS Institute Inc. (2006). Statistical Analysis System Institute ,SAS® 9.1.3 Output delivery system: User's guide, 1 & 2. Cary, NC: Author.

Ullah, M. S., T. N. Pasha, Z. Ali, Saima, F. M. Khattak and Z. Hayat (2012). Effects of different pre-starter diets on broiler performance, gastro intestinal tract morphometry and carcass yield. J. Anim. Plant Sci. 22(3):550-575.

Weiss, E.A. (2000). Castor. In "Oilseed Crops, 2nd Edition", Blackwell Scientific Ltd., Oxford. Pp13-52.