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Full Length Research Paper

Nutritive value and biochemical changes in broiler chickens fed detoxified castor kernel cake based diets

Akande, T. O.* and Odunsi, A. A.

[1]Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology, P.M.B. 4000, Ogbomoso, Oyo State, Nigeria.

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Castor bean (*Ricinus communis Linn.*) is an important oilseed rich in protein but rarely used as livestock feed due to antinutritional factors. Castor seed was detoxified using combined processing techniques of moist heating and fermentation (5 and 7- day) or lye treatment and fed to150 day-old Anak 2000 broiler chicks at varying levels (0, 10, 15 and 20%) in a 49-day experiment. There were 10 dietary treatments: a control diet, void of castor bean cake (CBC), 3 diets (at 10, 15 and 20%) each containing either heat cum lye treated CBC, heat cum 5-day fermentation or heat cum 7-day fermentation in a completely randomized design. The chemical constituent of detoxified castor kernel, performance, haematology and serum metabolites of the broilers served was evaluated. About 71% of haemaglutinin in the cake which constitutes the major impediment was removed via thermal cum lye treatment while thermal cum fermentation removed about 60%. Feed intake of lye treated CBC was not different (P>0.05) from control up to 20% inclusion although, the weight gained were not the same (P<0.05) with the bird on control. Both feed intake and weight gain in 5 and 7-day fermentation were similar (P>0.05) and significantly lower (P<0.05) than the control and lye treatment. Packed cell volume (PCV) value was highest in control and followed closely by lye treatment at 10% inclusion. A significant difference (P<0.05) was observed at 15% and 20% inclusion particularly on birds placed on fermented based diet. The white blood cell (WBC) increased significantly (P<0.05) with increased level of inclusion of CBC. There was downward trend in serum protein while an upward trend was observed for urea and creatinine with increasing levels of detoxified CBC. It was concluded that heat cum lye treatment can be used to detoxify CBC and such treated product maybe safely used at 15% inclusion rate.

Key words: Castor bean cake, detoxification, broilers, performance, blood component.

INTRODUCTION

Sustainable agricultural productivity, driven by research is an important component and essential to long-run economic development of any nation. In Africa where estimated 200 million people are now classed as under-nourished, almost 20% more than in the early 1990s, requires a timely intervention to rescue the populace. Due to high demands, there is exacerbating rise in the cost of feed ingredients and commercial feed millers have compromised quality of feed in terms of nutrient composition and quantity. Kudu et al. (2008) observed that branded commercial feeds do not truly reflect the nutrient contents indicated on branded commercial feed bags. In attempt to address these challenges, nutritionists have intensified efforts in seeking and developing novel feed ingredients in order to reduce the high cost of feeding livestock and competition for the conventional ingredients.

Castor (*Ricinus communis Linn.)* seed has potential as animal feed because of its high crude protein and energy comparable to the conventional ones but limited because of potent antinutritional factors such as ricin and allergen (Audi et al., 2005; EFSA, 2008). Castor toxicity has been managed by various physical and chemical treatments

*Corresponding author. E-mail: yakandetaiwo@yahoo.com

Abbreviations: TCA, Trichloroacetic acid; **EDTA,** ethylene diamine tetraacetic acid; **RBC,** red blood cell; **WBC,** white blood cell; **Hb,** haemoglobin; **MCV,** mean corpuscular volume; **MCH,** mean corpuscular haemoglobin; **MCHC,** mean corpuscular haemoglobin concentration; **ANOVA,** analysis of variance; **PCV,** packed cell volume; **CBC,** castor bean cake.

designed to denature the toxic protein constituent (ricin) however, with some limitation. Such treatments include autoclaving for 15 min at 125°C, fermentation, boiling, lye treatment and application of sodium hydroxide (Ani and Okorie, 2005; Apata et al., 1999; Akande et al., 2011; Anadan et al., 2005). The uncertainty of quantification and the imperfectly understood biological effects of antinutritional factors impede the development of methods to alleviate their effects in animal feed. Although, various processing techniques have been proposed to combat the challenges posed by feed toxins, varying degree of success have been realised.

Considering the nutritional potential of castor seed as animal feed, a concerted effort is required in getting rid of the impediments. Breese Jones (1947) discovered that castor contains both heat labile and relatively heat stable factors. He considered that heating castor meal in water inactivated the ricin component which would be safe for feeding purpose but the allergenic activities were not destroyed. According to Uko and Kamalu (2008) combined heat treatment and water washing rendered the neem kernel as good protein supplement compared to groundnut. Alonso et al. (2000) have also reported an increase in protein content and decrease in phytic acid level, condensed tannin and trypsin inhibitor after germination and roasting. It then become imperative to combine such improvement techniques perhaps the synergetic effect will produce substantial outcome in subjugating effect of antinutritional factors in animal feeds. It is on this view that castor bean seed was subjected to moist heat treatment and fermentation for 5 or 7 days or lye treatment to determine its nutritive value and biochemical response of meat chickens fed such treated product.

MATERIALS AND METHODS

Site of experiment

The experiment was carried out at the teaching and research farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo state, Nigeria in October, 2010. Nigeria has a tropical climate with sharp regional variances depending on rainfall. Nigerian seasons are governed by the movement of the intertropical discontinuity, a zone where warm, moist air from the Atlantic converges with hot, dry, and often dust-laden air from the Sahara known locally as the harmattan. Temperatures are high throughout the year, averaging from 25-28°C (77-82°F). The location is between latitudes 8°07' and 8°12' N and longitudes 4°04E and 4°15'E. The mean annual rainfall is 1247 mm with relative humidity of between 60-85%

Birds and management

A total of 150 1-day old broiler chickens Anak strain were obtained from ZARTECH, Nigeria Ltd, Ibadan and fed a commercial broiler starter mash (24% CP/2900 kcal/kg ME) for 1 week. Subsequently, the birds were weighed and randomly allotted to the 10 dietary treatments in triplicate lots of 5 chicks each in a completely randomised design. There were 3 processing methods (heat cum lye treatment, heat cum 5-day fermentation and heat cum 7-day fermentation) and 3 inclusion levels (10, 15 and 20%) in 3X3 factorial arrangement with a reference diet without castor kernel cake.

Processing techniques

The seeds from large seeded type were dehulled manually to remove the fibrous seed coat. The dehulled seeds were firstly heated by boiling for 60 min. The water was allowed to boil before introducing the kernel. The boiled kernels were defatted before subjected to fermentation for 5 or 7 days or treated with lye: Different portion of the boiled and defatted castor seeds were made to undergo one of the 3 processing methods.

Lye treatment

Lye water was prepared by passing water over gray ash in a barrel. The ash was collected from Garri processing plant. The ash is first sieved to remove pieces of charcoal and other impurities. The sieved ash is then placed (without compaction) in a plastic container with holes plugged with sieve cloth at the base of the plastic. Hot water was poured on the ash and a brown liquid dripped at base of the container. This brown liquid represents the lye water used in this study. The pH of the lye water was determined using pH meter rule as 9.5. The use of lye water was to simulate sodium hydroxide reported by Anadan et al. (2005). Castor bean cake (CBC) was then soaked in the lye (1 part of the cake to 2 parts of lye to completely submerge the cake) for 12 h. It is removed and rinsed with water and then sun-dried. Sundried product is then milled to produce boiled cum lye treated CBC, BLC.

Fermentation

Another batch of the cake was placed in a muslin bag and then completely submerged in clean water for 5 days under air-tight condition. The water is drained on the 5^{th} day and the fermented cake sun-dried. It was then milled to produce boiled cum fermented CBC, BF^5C. Another batch was fermented in the same manner for 7 days and the dried product obtained was fermented CBC BF^7C.

Diet formulation

Ten diets were formulated comprising 9 diets containing varying levels (10, 15, and 20%) of differently processed CBC and a control diet that is void of CBC (Table 1)

Data collection

Proximate analysis

Proximate composition of the castor bean meal was carried out according to the procedure of AOAC (1990). The crude protein was determined by the Kjeldahl method as described by AOAC (1990). The crude protein value was estimated as 6.25 multiple of the nitrogen value. Crude fibre determination was carried out using the trichloroacetic acid (TCA) method. 1 g of the feed sample was digested and refluxed with 100 ml TCA solution followed by filtration. The recovered residue was then charred and ashed at 600°C for 30 min. The difference in weights between residue and ash multiplied by 100 gave the percentage crude fibre of the sample. The ash and crude fat contents were obtained accordingly

Table 1. Diet composition of broilers fed graded levels of treated CBC percent.

Ingredient	Control	Boiled and lye treatment			Boiled and 5-day fermentation			Boiled and 7-day fermentation		
		10%	15%	20%	10%	15%	20%	10%	15%	20%
Maize	56	56	56	56	56	56	56	56	56	56
GNC.	27.5	18	13.25	8.5	18	13.25	8.5	18	13.25	8.5
CBC	-	10	15	20	10	15	20	10	15	20
Wheat offal	10	9.5	9.25	9.0	9.5	9.25	9.0	9.5	9.25	9.0
Fish meal	2	2	2	2	2	2	2	2	2	2
Bone meal	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Oyster shell	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
[1]Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
TOTAL	100	100	100	100	100	100	100	100	100	100
Calculated analysis										
ME, kcal/kg	2904	2915	2915	2915	2915	2915	2915	2915	2915	2915
CP, %	20.45	20.40	20.40	20.40	20.40	20.40	20.40	20.40	20.40	20.40
Crude ibre	3.90	3.80	3.75	3.70	3.80	3.75	3.70	3.80	3.75	3.70
Oil	3.60	3.70	3.75	3.80	3.70	3.75	3.80	3.70	3.75	3.80

Vitamin and mineral premix contain the following per kg diet. Vitamins A, 10,000 IU; D3, 3,000 IU; E, 8.0 IU; K, 2.0 mg; B6, 1.2 mg; B12, 0.12 µg; Niacin, 1.0 mg; Pantothenic acid, 7.0 mg; Folic acid, 0.6 mg; Choline chloride, 500 mg; Minerals: Fe, 60 mg; Mn, 80 Mg; Mg, 100 mg; Cu, 8.0 mg; Zn, 50 mg; Co, 0.45 µg; I, 2.0 mg; Se, 0.1 mg; CBC, castor bean cake; GNC, groundnut cake; d- day, fermentation.

while soluble carbohydrate was calculated by difference.

Energy values

Energy was determined using a bomb calorimeter.

Mineral analysis

Calcium (Ca) and phosphorus (P) were analysed usin the procedure of AOAC (1990).

The antinutritional

The phytate content was determined by the method of Wheeler and Ferrel (1971). The tannin content was determined using the method of Makkar and Goodchild (1996). Analysis of the lectin content was conducted by hemagglutination assay in round-bottomed wells of microtitre plates using 1% (v/v) trypsinised cattle blood erythrocytes suspension in saline phosphate buffer, pH 7.0 (Makkar et al., 1997). The hemagglutination activity was defined as the minimum amount of the kernel material (in mg per ml of the assay medium), which produced agglutination. One hemagglutinating unit (HU) was defined as the least amount of material per ml in the last dilution giving positive agglutination (Grant et al., 1983).

Performance characteristics

Initial body weights of the birds were taken on replicate basis at the start of the study and thereafter on weekly basis. Weekly feed intake was also recorded. The average weight gain, total feed intake and feed to gain ratio were thus calculated from the data obtained during the overall experimental period. The birds were keenly observed for discharges, dispositions and appearance for any pathological condition

Haematological and serum biochemical studies

5 ml of blood were collected into vacutainer tubes containing ethylene diamine tetraacetic acid (EDTA) anticoagulant from each bird. The following haematological parameters were determined as described by Jain (1985): red blood cell (RBC) and white blood cell (WBC) counts, haemoglobin (Hb) concentration. The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular Haemoglobin concentration (MCHC) were calculated (Campbell, 1995) respectively. The serum biochemical constituents determined were total protein, globulin, creatinine, urea as described by Kohn and Allen (1995).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using statistical package of SAS, 1990 software and the mean separated by Duncan's multiple range test option of the same computer software package.

RESULTS AND DISCUSSION

Chemical constituents of detoxified CBC

There was a decline in crude protein content of the

Table 2. Chemical composition of raw and treated CBC.

Parameter	Untreated CBC	BLCBC	B5-d FCBC	B7-d FCBC
Proximate composition, %				
Moisture	6.56	5.59	6.32	6.17
Crude protein	39.58	38.43	37.65	37.22
Crude fibre	2.47	2.34	2.57	3.12
Ether extract	13.15	10.32	12.53	12.16
Ash	5.87	6.11	5.92	5.36
NFE	32.37	37.21	35.01	35.97
Gross energy, kcal/g	5.624	5.593	5.495	5.491
Mineral content, %				
Ca	0.62	0.60	0.52	0.45
P	0.34	0.34	0.35	0.37
Antinutritive factor				
Lectin HU mg/ml	2.5	8.75	6.50	6.45
Tannin, %	0.25	0.15	0.15	0.17
Phytic acid, %	0.94	0.52	0.59	0.68
Oxalate, %	0.46	0.21	0.24	0.17

Ca, Calcium; P, phosphorous; NFE, nitrogen free extract; d, day; F, fermentation; L, lye; CBC, castor bean cake.

treated CBC; the fermented products had the least values while the untreated CBC had higher protein (Table 2). This may be as a result of leaching and possible vapourisation of some nitrogenous substances during processing (Emiola and Ologhobo, 2006). However, the crude protein value was consistent with literature values reported for decorticated and defatted castor bean (Okoye et al., 1987; Annongu and Joseph, 2008). The energy component of the cake also declined across the treatments. There appear to be a positive correlation between energy loss and extent of exposure to the fluid. Fermentation considerably reduced the energy level in the cake compare to lye treatment and the untreated. It may be that part of the soluble portion of the nutrients had been lost to the fluid during soaking in lye water and fermentation. The gross energy obtained in this study is higher than those obtained by Nsa and Ukachukwu, (2007) and Okoye et al. (1987) but fall within range with those obtained by Annongu and Joseph (2008). The crude fiber was related to level of decortications while crude fat was associated with method of oil extraction. It is important to remove the abrasive seed coat to mitigate the effect of high fibre in nutrient absorption and of course deoiled the kernel to less than 7.5% to prevent the purgative influence which tends to interrupt with nutrient absorption (Akande et al., 2009).

The antinutritional factors of castor bean cake de-creased with processing techniques. About 71% of haemaglutinin in the cake which constitutes the major impediment was removed via thermal cum lye treatment while thermal cum fermentation removed about 60%. The values were higher than values 40% and 25% obtained for single effect of lye treatment and fermentation alone reported by Akande et al. (2011). The synergetic effect of heat with fermentation and lye treatment corroborates the fact that castor bean contain both the heat stable and heat labile toxins (Breese, 1947). The phytate component was significantly reduced by treatment effect as over 50% was removed. There is need however, for more concerted efforts in getting rid of castor impediment completely.

Performance of broiler fed graded levels of differently treated castor bean cake

Feed intake of lye treated CBC was not different from control up to 20% inclusion; although, the weight gained were not the same with the birds on control. Both feed intake and weight gain in 5 and 7-day fermentation were similar ($P>0.05$) and significantly lower ($P<0.05$) than the control and lye treatment (Table 3). Similar trend was observed for the feed conversion ratio. In Table 4, 15% and 20% fermentation at 5 or 7 days lowered feed consumption significantly ($P<0.05$). It then means that the toxic components of castor are not stable in alkali and that lye cum heat was potent enough to effectively remove the palatability depressing factor of castor bean. This corroborates the findings of Anadan et al. (2005) who reported 100% detoxification of castor toxin with lime Since control and lye treatment were similar in terms of feed consumption but different in ability to convert the same to meat, it may be that the growth promoting factors in castor is low particularly the essential amino

Table 3. Interaction effect of processing and inclusion levels on performance of broilers chickens fed differently with treated CBC.

Parameter	Control	Lye treated			5-day fermentation			7-d fermentation			SEM
	0%	10%	15%	20%	10%	15%	20%	10%	15%	20%	
IBW, g	97.7	99.7	100.0	102.5	103.3	100.0	97.7	98.0	103.5	99.0	2.44
FBW, g	1424.3^{a}	1417.7^{a}	1375.5^{ab}	1257.5^{c}	1335.7^{abc}	1090.5^{d}	858.7^{e}	1292.7^{bc}	1086.7^{d}	947.0^{e}	31.22
TFI, g	3720.3^{a}	3674.8^{a}	3602.4^{ab}	3577.3^{ab}	3630.5^{a}	3448.0^{b}	3124.9^{d}	3601.7^{ab}	3441.5^{b}	3120.6^{d}	60.56
BWG,g	1326.7^{a}	1281.7^{ab}	1275.5^{abc}	1155.0^{c}	1232.3^{abc}	990.5^{d}	761.0^{e}	1194.7^{bc}	983.0^{d}	848.0^{e}	42.11
FGR, g	2.8^{d}	2.8^{d}	2.9^{cd}	3.2^{c}	3.1^{cd}	3.5^{b}	4.0^{a}	3.1^{cd}	3.5^{b}	3.7^{b}	0.10
N/kg	80	75.67	73.70	71.40	75.67	73.70	71.40	76.00	74.1	71.80	3.50
FC/kg BWG	224^{cd}	211.87^{d}	213.73^{d}	228.48^{c}	234.58^{c}	257.95^{b}	285.60^{a}	235.00^{c}	259.35^{b}	265.66^{b}	5.50

IBW, Initial body weight; FBW, final body weight; TFI, total feed intake; BWG, body weight gained; FGR, feed gain ratio; FC, feed conversion; ^{abcd}, means with different superscripts are significantly different (P<0.05).

Table 4. Effect of processing methods on performance of broiler chickens fed differently with treated CBC.

Parameter	Control	B Lye treated	B 5-day Fermentation	B 7-d Fermentation	SEM
IBW, g	100.67	100.72	100.33	100.17	2.23
FBW, g	1424.33^{a}	1350.22^{b}	1094.94^{c}	1108.78^{c}	32.02
TFI, g	3720.30^{a}	3618.18^{a}	3401.14^{b}	3387.92^{b}	56.43
BWG, g	1323.67^{a}	1237.39^{b}	994.61^{c}	1008.56^{c}	43.50
FGR	2.82^{b}	2.96^{b}	3.53^{a}	3.42^{a}	0.12

IBW, Initial body weight; FBW, final body weight; TFI, total feed intake; BWG, body weight gain; FGR, feed gain ratio; B, boiled.

acids. (Vilhjalmsdottir and Fisher, 1971) had shown that castor bean is limiting in lysine, methionine. Similarly, Kodras et al. (1949) in his microbiological analysis of the total seed protein for the principal amino acids showed that the protein contained relatively large amounts of glutamic acid and was serisously deficient in tryptophan. It then mean that for effective utilization of CBC, amino acids and other growth promoting factors may be required to augment the nutrient profile of castor bean cake. Factors such as texture, taste, odour have been linked with level of feed consumption (Odunsi and Longe, 1995). This is evident in fermented products which generated a lot of foul odour during processing and imparted the same to the diet particularly at higher inclusion rate. It is evident that the higher the inclusion of CBC the lower the performance of bird on treated groups. The 10% inclusion compared favourably with control while the 15% in lye treated group also fair well with control. Up to 15% of the thermal cum lye treatment could therefore be used in feeding broiler chickens without deleterious effect while fermented product may be safely used at 10% rate of inclusion.

Blood profile of broilers fed graded levels of differently treated castor bean cake

Packed cell volume (PCV) value was highest in control and followed closely by lye treatment at 10% inclusion (Table 5). A significant difference (P<0.05) was observed at 15% and 20% inclusion particularly on birds placed on fermented CBC based diet. The WBC increased with increased level of inclusion of CBC. The immune system was triggered at 15 and 20% inclusion levels. It is well known that a reduced quantity and quality of erythrocytes and a decreased Hb level lead to a deteriorated oxygen supply and predispose the animal to anaemia. Graitcer (1981) had reported that a Hb concentration below that normally seen in healthy population best characterizes anaemia. The reduced Hb and PCV in birds on treated CBC (Table 6) in this study may be first and foremost an expression of adjustment because values were within normal range reported for birds in the tropics (Mitruka and Rawnsley, 1997). Although, numerical difference (P>0.05) were observed between treatments in blood differential count, it was regarded as expression of adjustment because they were within normal range, are capable of performing their phagocytic function. The quality of erythrocytes may be evaluated by both their morphologic characteristics and their Hb concentration. The two most commonly used indexes are MCV and MCH (Bothwell and Charlton, 1981). MCV is an important trait which determines the cell size of erythrocytes and is therefore an important factor in determining the ability of birds to withstand prolonged oxygen starvation (Mitruka and Rawnsley, 1997). Results indicate that all birds were not really affected with various inclusion of detoxified CBC.

The serum protein is an important factor in the development of immunoglobin in the formation of antibodies.

Table 5. Interaction effect of processing and inclusion levels on haematological and serum components of broiler chickens fed differently treated CBC.

Parameter	Control	Heat cum Lye treatment			Heat cum fermentation		5-day	Heat cum fermentation		7-d	SEM
	0%	10%	15%	20%	10%	15%	20%	10%	15%	20%	
Haematology											
PCV,%	34.33^{a}	34.00^{a}	31.33^{abcd}	27.33^{cd}	31.67^{abc}	30.67^{abcd}	27.00^{d}	32.00^{abc}	29.33^{bd}	27.33^{cd}	1.38
Hb, gm%	9.03^{a}	8.43^{ab}	7.70^{ab}	7.27^{ab}	8.73^{ab}	7.77^{ab}	7.17^{b}	7.37^{ab}	7.67^{ab}	7.07^{b}	0.54
WBC,x10^{6}	9.83^{b}	9.80^{b}	10.87^{ab}	10.83^{ab}	10.77^{ab}	12.13^{a}	12.13^{a}	11.93^{ab}	10.77^{ab}	12.80^{a}	0.73
RBC,x10^{9}	3.67^{a}	3.53^{a}	3.57^{a}	3.50^{ab}	3.39^{b}	3.47^{ab}	3.30^{b}	3.50^{ab}	3.43^{ab}	3.30^{b}	0.13
MCV, fl	93.67	96.48	87.87	78.22	93.50	89.02	81.59	91.64	85.64	83.41	4.78
MCH, pg/cell	24.61	23.91	21.60	20.81	25.82	22.55	21.68	21.07	22.70	21.55	1.82
MCHC,%	2.62	2.48	2.46	2.66	2.76	2.53	2.66	2.29	2.63	2.59	0.21
Neutrophil	18.33	19.67	19.00	20.33	18.33	21.33	20.33	19.00	21.33	17.33	1.16
Lymphocyte	73.00	72.67	77.00	71.33	68.67	70.67	71.67	72.33	73.33	77.00	1.53
Monocytes	1.33	2.00	2.33	2.00	2.33	2.00	2.00	2.33	2.00	2.33	0.24
Eosinophil	3.67	5.33	4.00	5.67	5.67	4.33	4.33	3.67	5.33	4.33	0.22
Serum composition											
TPr, g/dl	7.07	6.83	6.23	6.33	6.80	6.30	6.40	5.93	6.07	5.93	0.32
Albumin	3.57	3.27	3.07	3.10	3.67	3.40	2.97	2.87	3.20	3.20	0.25
Globulin	3.50	3.57	3.17	3.23	3.13	2.90	3.43	3.07	2.87	2.73	0.18
Urea, mg/dl	16.00^{b}	18.67^{b}	21.33$^{a\,b}$	23.00$^{a}_{b}$	26.67^{a}	23.00$^{a\,b}$	31.67^{a}	29.00^{a}	31.67^{a}	34.00^{a}	2.56
Creatinine mg/dl	0.40^{d}	0.50^{d}	0.40^{cd}	0.53^{bcd}	0.47^{abcd}	0.50^{bc}	0.67^{a}	0.50^{ab}	0.60^{a}	0.63^{a}	0.05

Table 6. Effect of processing techniques on blood profile of broilers fed differently treated CBC.

Parameter	Control	Heat cum Lye treatment	Heat cum 5-day fermentation	Heat cum 7-d fermentation	SEM
Haematology					
PCV %	34.33^{a}	30.89^{b}	29.78^{b}	29.56^{b}	1.35
Hb, %	9.03^{a}	7.80^{b}	7.89^{b}	7.37^{b}	0.52
Leucocytes, 10^{3} mm	9.83^{b}	10.50^{ab}	11.68^{a}	11.83^{a}	0.73
Erythrocytes, 10^{6} mm	3.67^{a}	3.53^{ab}	3.39^{b}	3.41^{ab}	0.13
MCV, pg	93.67	87.52	88.04	86.89	5.65
MCH., fl	24.61	22.11	23.35	21.77	1.82
MCH, conc.	2.62	2.53	2.65	2.50	0.21
Neutrophyll, %	18.33	19.67	20.00	19.22	1.16
Lymphocytes, %	73.00	73.67	70.33	74.22	1.53
Monocytes, %	1.33	2.11	2.11	2.22	0.24
Eosinophyll, %	3.67	5.00	4.78	4.44	0.20
Serum					
Total Protein, g/dl	7.07^{a}	6.47^{ab}	6.50^{ab}	5.98^{b}	0.31
Albumin, g/dl	3.57	3.14	3.34	3.09	0.23
Globulin, g/dl	3.50	3.32	3.16	2.89	0.19
Urea, g/dl	16.00^{b}	21.00^{a}	27.11^{a}	31.56^{a}	2.57
Creatinine, mg/dl	0.40	0.48	0.54	0.58	0.05

in birds fed with detoxified CBC. Prolong feeding of fermented castor particularly at 15 and 20% (Table 7) may predispose the birds to serious health hazards as their immunoglobins may be severely hampered. The blood concentration of excretory and electrolyte constituents is an important tool in assessing the functional

Table 7. Main effect of varying inclusion levels of detoxified CBC on blood profile of broiler chickens fed differently with treated CBC

Parameter	Control	Lye treated	5-d fermentation	7-d fermentation	SEM
Haematology					
PCV, %	34.33[a]	30.89[b]	29.78[b]	29.56[b]	1.35
Hb, %	9.03[a]	7.80[b]	7.89[b]	7.37[b]	0.52
Leucocytes, 10^3 mm	9.83[b]	10.50[ab]	11.68[a]	11.83[a]	0.73
Erythrocytes, 10^6 mm	3.67[a]	3.53[ab]	3.39[b]	3.41[ab]	0.13
MCV, pg	93.67	87.52	88.04	86.89	5.65
MCH, fl	24.61	22.11	23.35	21.77	1.82
MCH, conc.	2.62	2.53	2.65	2.50	0.21
Neutrophyll, %	18.33	19.67	20.00	19.22	1.16
Lymphocytes, %	73.00	73.67	70.33	74.22	1.53
Monocytes, %	1.33	2.11	2.11	2.22	0.24
Eosinophyll, %	3.67	5.00	4.78	4.44	0.20
Serum					
Total Protein, g/dl	7.07[a]	6.47[ab]	6.50[ab]	5.98[b]	0.31
Albumin, g/dl	3.57	3.14	3.34	3.09	0.23
Globulin, g/dl	3.50	3.32	3.16	2.89	0.19
Urea, g/dl	16.00[b]	21.00[a]	27.11[a]	31.56[a]	2.57
Creatinine, mg/dl	0.40	0.48	0.54	0.58	0.05

capacity of the kidney because it demonstrates the presence or absence of active lesions in the kidney and the functional capacity of the different parts of the nephron (Dyer et al., 2000). Urea and creatinine, waste products of protein metabolism that are excreted via the kidney, are the most sensitive biochemical markers employed in the diagnosis of renal damage. So, in cellular damage, there will be retention of urea and creatinine in the blood as noticed (Tables 6 and 7) and affirm an indication of functional damage to the kidney (Dyer et al., 2000). Therefore, the significant increases ($p<0.05$) in creatinine levels noticed in this study is a classical sign that the kidney was adversely affected by the exposure arising from intake of CBC based diets. Elevation in plasma levels of urea could also be attributed to increase in the activities of urea enzymes, ornithine carbomoyl transferase and arginase (not determined) mostly associated in liver damage in many animal species. This could most likely be responsible for the defective urea cycle and the inability of the liver to transform ammonia to urea leading to its build up in blood. Other factors may be responsible for the increment among which are excess breakdown of blood protein and increase in tissue protein catabolism. The results of blood changes is indicative of residual effect of bioactive component of detoxified CBC and as such care should be taken in feeding of the treated material in meat chickens particularly at levels beyond 10%.

Conclusion

Subjecting castor seed to combined processing methods improved its nutritional quality in this study. About 70% of the toxin (lectin) was removed via combined processing while birds tolerated such processed cake up to 15%. Heat combined with lye treatment best detoxified castor seed and such product could be used in feeding broilers up to 15% rate of inclusion without any deleterious effect in response parameters measured. This means that detoxified CBC could be safely used to replace about 50% of ground nut cake in diets of broiler birds. A more concerted effort is required in getting total rid of castor impediment.

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