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Full Length Research Paper

Carcass yield and histopathological changes in meat type chickens fed raw and processed castor bean (*Ricinus communis Linn.*) cake

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Carcass and histopathological changes in meat type chickens fed raw and processed castor bean cake (CBC) was investigated. CBC was subjected to either lye treatment, boiling for 20 minutes or anaerobic fermentation for 3 days. 150 one day old chicks Anak strain were randomly allotted to the five dietary treatments in triplicate lots of 10 chicks each in a completely randomised design. Diet 1 contained groundnut cake (GNC) as a protein sources while diets 2, 3, 4 and 5 contained differently treated CBC (raw, lye treated, fermented and boiled) replacing GNC at 10% rate of inclusion. There were no notable changes in proximate composition of raw and differently processed CBC except for the caloric values that decreased in processed CBC. Lye treatment removed about 60% of active toxin in castor, lectin while about 45% were removed via boiling and fermentation. Feed intake, body weight gained, feed conversion and carcass cut parts declined (P<0.05) from control, lye, boiled to fermented group. Birds on the untreated CBC have their liver and kidney significantly (P<0.05) enlarged while breast and thigh meat of birds on raw CBC declined sharply (P<0.01). Birds fed raw 100 g of CBC/kg diet also revealed loss of body mass and very prominent ill appearance with mortality. It is evident that the control groups and lye treated groups share some similarities in performance and carcass traits. In case of feed shortages, application of lye water on castor bean may be considered over boiling and fermentation in deactivating castor toxin.

Key words: castor bean cake, carcass yield, histology, organ, broilers

INTRODUCTION

The performance of poultry is largely determined by feed, through changes in intake, absorption of key nutrients and their metabolism for protein accretion (Yamauchi and Isshiki, 1994; Bartov and Plavnik, 1998). The use of conventional protein feed ingredients such as soyabean and pea nut appear to have reached their limit of effectiveness in meeting the demand of increasing human population and expanding livestock industry. In Nigeria for instance, 51% of the need of pea nut is satisfied while for soyabean, it is only 30% (Longe, 2006).

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At present, the astronomical rise in the prices of conventional protein ingredients (soya bean and ground nut cake) and stiff competition for the available grains have put enormous pressure on the poultry farmer to look for alternatives.

Castor seed *(Ricinus communis Linn.)* is regarded as a wonder plant because of its numerous attributes. It is cultivated mainly for the seeds which yield viscous, non-volatile and non-drying oil with many medicinal and industrial applications while the residual cake is limited in use. Castor bean cake contained about 32-48% crude protein depending on levels of decortications and deoiling (Vilhjalmosdottir and Fisher, 1971; Rama Rao, 2004) and the whole seed contained 6.24g/kg GE (Akande *et al*., 2011). Despite the limiting toxins identified as ricin, ricinine and castor allergen (Audi *et al* 2005; EFSA, 2008)

castor bean cake, when detoxified, they could make an important by-product that is potentially beneficial in animal feeding.

Solvent extracted castor seed pomace has been shown to have an acute oral toxicity for the rat and chick. This acute toxicity has been managed by various physical and chemical treatments designed to denature the toxic protein constituent, ricin. Such treatments include autoclaving for 15 minutes at 125℃, fermentation, boiling, application of sodium hydroxide (Apata *et al*., 1999; Ani and Okorie, 2005; Anandan *et al*., 2005). A great deal of information is also available on the nature of the toxic factors present in castor bean (Jenkins, 1963; Audi *et al*. 2005). It appears that little work has been done to prepare an acceptable product from castor bean cake for animal consumption.

The physiological effects of dietary influence on animals are best judged by chemical constituents of the feed, performance of the animal and more closely by the cellular changes in the organs. It is on these views that this study was set to determine the performance, carcass yield and histopathological changes in broilers fed untreated castor bean cake and those subjected to either of boiling, fermentation or lye treatment.

MATERIALS AND METHODS

Sample collection

Samples of dried large seeded castor seeds were collected in Oyo state, the western part of Nigeria. Nigeria has a tropical climate with sharp regional variances depending on rainfall averaging 1276 m-1350mm. The 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° to 28℃ (77 ° to 82℉). The study was carried out on March, 2011 at the Teaching and Research Farm of Ladoke Akintola University of Technology, Oyo state, Nigeria.

Birds and Management

A total of 150 day old broiler chicks Anak strain were obtained from a reputable farm at Ibadan, Nigeria and fed a commercial broiler starter mash (24%CP/2900 ME kcal/kg) for 1 week to stabilize the chicks. Subsequently, the birds were weighed and randomly allotted to the five dietary treatments in triplicate lots of 10 chicks each in a completely randomised design. Five diets were prepared (Table 1). Diet 1 contained GNC and SBM as main protein sources, diets 2, 3, 4 and 5 contained raw and treated CBC replacing GNC at 10% rate of inclusion. CBC was subjected to either lye treatment which was prepared from ash and water, boiling for 20 minutes or anaerobic fermentation for 3 days.

Castor bean Processing

The seeds were dehulled manually to remove the fibrous seed coat. Dehulled seeds were pressed with hydraulic machine to remove the oil. The residue is referred to as castor bean cake (CBC). Different batches of the castor bean cake were made to undergo different treatment such as lye, fermentation and boiling

Lye treatment

Lye water was prepared by passing water over gray ash in a barrel. The ash was collected from Gari 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 by pH meter rule. The concentration of lye was controlled by the quantity of water poured on the ash. Castor bean cake was then soaked in the lye (1 part of the cake to 2 parts of lye to completely submerge the cake) for 18 hours. It is removed rinsed with water once and then sun-dried. Sundried product was milled to produce lye treated castor bean cake, LCB.

Fermentation

Another batch of the cake was placed in a muslin bag and then completely submerged in clean water for 3 days under air-tight condition. The water was drained on the 3rd day and the fermented cake sun-dried. It was then milled to produce fermented castor bean cake, FCBC.

Boiling

Another portion of the castor bean cake in muslin bag was boiled in water at 100ºC for 20 minutes, after which it was drained and dried. This represented boiled castor bean cake (BCBC). The fourth portion, the untreated, serve as the raw castor bean cake RCBC.

Data collection

Chemical evaluation

Proximate analysis

Proximate composition of the castor bean meal and experimental diets were carried out according to the procedure of AOAC (1990). The crude protein was determined by the Kjeldahl method as described by AOAC (1990). Crude fiber determination was carried out using the trichloroacetic acid (TCA) method. The ash and crude fat contents were obtained by charring in furnace and extraction with ether respectively while carbohydrate was calculated by difference.

Energy values

Energy was determined using the bomb calorimeter. One gram of the feed sample was pelleted and oven-dried at 103^{o}C for 24 hours. The samples were then re-weighed and bombed. Values of deflections obtained were used to calculate the gross energy of the diets.

Ca and P Analysis

Calcium was determined by established atomic absorption/emmision spectrophotometer and Phosphorus by calorimetric means using the Vanadomolybdate Method (A.O.A.C, 1990).

The antinutritinal factors such as Lectin, oxalates, phytic acid, tannin etc were determined. 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). Determination of phytohemagglutinating activity Analysis of the lectin content was conducted by hemagglutination assay in

Table 1: Diet composition for Broilers fed differently treated CBC

Ingredient(%)	Ref. Diet	UCBC diet	LCBC diet	FCBC diet	BCBC diet
Maize	48	48	48	48	48
Soya bean meal	23.5	23.5	23.5	23.5	23.5
Groundnut cake	10	-	-	-	-
Untreated CBC	-	10	-	-	-
Lye CBC	-	-	10	-	-
Fermented CBC	-	-	-	10	-
Boiled CBC	-	-	-	-	10
*Concentrate	18.5	18.5	18.5	18.5	18.5
TOTAL	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
ME, kcal/kg	2822	2885	2863	2865	2870
Crude protein,%	23.47	23.01	23.05	23.02	23.05
Crude fibre, %	3.90	3.81	3.63	3.94	3.81
Ether extract, %					
Lysine	1.52	1.50	1.50	1.50	1.50
Calcium	1.15	1.24	1.23	1.22	1.21
Phosphorous	0.64	0.66	0.65	0.63	0.65

Concentrate: wheat offal=10, fish meal=4.0, Bone meal=2.5, Oyster=1.0, [1]Premix=0.25, Methionine=0.25, Lysine=0.25, Salt=0.25, CBC- castor bean cake
[1]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 mg; 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 ?g; I, 2.0 mg; Se, 0.1 mg

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 (Grant *et al.,* 1983). The reciprocals of the values obtained were used as suggested by Eroarome *et al*. (1998).

Performance characteristics

Initial body weights of the birds were taken on replicate basis at the commencement of the study and thereafter on weekly basis. Weekly feed intake was also taken. The average weight gain, total feed intake and feed to gain ratio were thus calculated from the data obtained at the end of the experiment.

Carcass and organ evaluation:

At the expiration of the feeding period two birds from each replicate (tagged) were taken at random from each treatment for carcass analysis. The birds were starved overnight with ample supply of drinking water. Each bird was weighed separately the following morning and slaughtered using the procedure described by Contreras (2001) and Gonzalez *et al.* (2007). The birds were slaughter by cutting through the jungular vein and carotid artery to allow for quick bleeding before scalding (Gonzalez *et al*., 2007). The birds were defeathered completely using warm water then decapitated, eviscerated and weighed to obtain the eviscerated weights. The plucked carcass were dissected and eviscerated by removing the internal organs, the head and the shank. The head, shank and the internal organs (proventiculus, gizzard, kidney, liver, heart and lung are separately weighted on a sensitive top loading weighing balance and likewise the eviscerated carcass. The eviscerated carcass was carefully cut into parts (i.e. thighs, drumsticks, breast, neck and back) and weighed separately. The respective weights of different parts of the chicken were recorded and expressed as a percentage of body live weight

$$\text{Dressing \%} = \frac{\text{Carcass weight} \times 100}{\text{Live weight}}$$

(Warriss, 2000)

Histopathological measurement

The birds were monitored for disease conditions. Birds posture, exudates, faecal changes, morbidity, mortality and post mortem examination were carried out as appropriate. At the expiration of feeding trial, sample of liver were taken from slaughtered birds and preserve in 10% formalin solution. The samples were immediately taken to laboratory for the micrographs.

Statistical Analysis

Data were analyzed by one way analysis of variance in a completely randomized design using SAS (1990) software package and the mean separated by Duncan's Multiple Range Test option of

Table 2: Chemical constituents of processed castor bean cake

Parameter	Untreated CBC	LCBC	FCBC	BCBC
Proximate composition, %				
Moisture	9.34	9.59	9.56	9.17
Crude protein	38.58	39.43	38.87	39.32
Crude fibre	3.46	2.53	3.92	3.45
Ether extract	11.15	9.79	10.53	10.88
Ash	5.87	6.11	5.92	5.36
NFE	32.60	31.74	32.56	31.54
Gross energy kcal/g	5.624	5.493	5.480	5.585
Mineral content, %				
Ca	0.62	0.54	0.55	0.47
P	0.34	0.45	0.37	0.41
Antinutritive factor, %				
Lectin HU, mg/ml	4.00	1.78	2.22	2.33
Tannin	0.25	0.19	0.20	0.15
Phytic acid	0.94	0.62	0.79	0.68
Oxalate	0.46	0.23	0.20	0.15

CBC- castor bean cake, L-Lye, F-Fermented, B-Boiled, NFE- Nitrgen Free extract, Ca-calcium, P- phosphorous

the same computer software package.

RESULTS AND DISCUSSION

Effect of treatment on chemical composition of differently treated castor bean cake

The processing techniques significantly affected the chemical profile of castor bean cake (Table 2). There was a short fall in energy values of treated bean compared to untreated bean. Since all treatments are in a form washed with fluid, there are tendencies that parts of the nutrients were lost to the fluid particularly the soluble carbohydrate as reflected in decreased nitrogen free extract values of treated CBC particularly fermented product which also had the least gross energy. The crude protein of the defatted seed was reasonably high (about 39%) compare to many other oilseeds and compared closely with the conventional sources, soya bean meal and groundnut cake. Fermentation decreased the fibre content of the product and this may influence positively the bioavailability of other nutrients (Khetarpaul and Chauhan, 1989). Decorticated and treated castor seed cake contains high values of phosphorus and calcium than the untreated full-fat seed and this revealed that the nonconventional feedstuffs contain sufficient of these nutrients to meet the nutritional requirements of farm animals. The determined proximate composition of experimental diets (Table 3) shows lower value in crude protein compared to calculated analysis but sufficient to meet the requirement of the birds. pH of lye water was 10 revealing its alkalinity strength.

All the treatment employed in this study brought down the level of anti nutritional factors in castor seed cake with varying degree of detoxification. Lye treatment removed about 60% of lectin (ricin) in CBC while about 45% were removed via boiling and fermentation. Over 65% of oxalate was removed via boiling and 50% or less detoxification was achieved through fermentation and lye treatment respectively. Tannin and phytate followed similar pattern as least detoxification was recorded in fermented CBC. Tannin and oxalate appeared not to have been significantly affected by the treatments applied whereas over 50% of phytate were removed by all the treatments. The caustic property of lye water was likely responsible for effective deactivation of castor toxin. Similar result was reported by Anadan, (2005) who used NaOH and reported 100% removal of ricin in castor seed, although the product were not fed to animals.

Performance of broiler chickens fed differently treated CBC

Growth response, feed intake and feed conversion efficiency are as indicated in Table 4. Inclusion of treated and untreated CBC depressed ($P<0.05$) feed intake. Birds on control diet had highest feed consumption while

Table 3: Proximate composition of experimental diets

Parameter	Control	Untreated CBC	LCBC	FCBC	BCBC
Moisture	8.50	9.54	7.90	8.30	8.10
Crude protein	21.78	21.05	20.75	19.80	20.11
Crude fibre	4.20	3.68	4.55	4.85	3.90
Ether extract	5.20	6.75	6.33	6.52	5.86
Ash	5.70	4.66	4.65	5.25	5.91
NFE	54.62	54.32	55.82	55.28	56.12

Table 4: Growth performance of broiler chickens fed differently treated CBC

Parameters	Control diet	Raw CBC	Lye treated CBC	Fermented CBC	Parboiled CBC	
	1	2	3	4	5	SEM
IBW	66.67	62.67	69.00	63.33	62.67	0.20
FBW	1672.67^{a}	663.67^{d}	1419.67^{b}	1201.00^{bc}	983.67^{c}	98.50
BWG	1606.00^{a}	601.00^{d}	1350.67^{b}	1137.67^{bc}	921.00^{c}	76.56
ADWG	38.24^{a}	14.31^{d}	32.16^{b}	27.08^{bc}	21.93^{c}	2.50
TFI	4134.45^{a}	1668.50^{d}	3065.15^{b}	2582.95^{C}	2410.43^{c}	350
ADFI	98.44^{a}	39.73^{d}	72.98b	61.50^{c}	57.39^{c}	10.38
FGR	2.58a	3.10b	2.27a	2.27a	2.64a	0.30

IBW- Initial body weight, F- Final body weight, TFI- Total feed intake, FGR- feed gain ratio
^{abc} means with different superscript are significantly different (P<0.05)

feed intake of birds on untreated CBC declined significantly (P<0.05) compared to those on treated CBC. The limiting factor was sensed by the animals which resulted to low acceptability of feed containing treated or untreated CBC. Lye treatment, followed by fermentation produced better results in terms of feed consumption. The results of final body weight followed similar trend with the outcome of feed intake. Highest feed intake was equally translated to highest final body weight. In fact, a positive correlation was established between body weight gain and total feed consumed over the entire period of study by the experimental animals. Continued consumption of the high CBC diets up to the finisher phase put an increased pressure on the birds of the need for amino acids for detoxification of the anti-nutrients thereby sparing only a little for growth. Sulphur-containing amino acids have been implicated in the detoxification of feed toxin (Delange *et al.,* 1994). Differences observed for feed gain ratio showed that birds on UCBC had poorer feed conversion, whereas those on treated CBC converted the feed better compared to those on control groups. This elicited a fact that well treated CBC can adequately support growth because of possible good amino profile as indicated by Annongu and Joseph (2008). It can also be said that CBC protein equally supported broilers growth as obtained for groundnut cake. In essence, if factor that limit acceptability of CBC could be adequately handled, better growth performance are likely. Similar result was reported by Okorie *et al.* (1985), Ani and Okorie (2005) and Akande and Odunsi (2012) that attributed poor growth to poor palatability of CBC based diets. Processing of CBC improved the nutritional responsibility of broilers to CBC. Mortality was recorded on untreated CBC meaning that untreated bean is lethargic at the 10% inclusion in broiler's diet.

Carcass and Organ changes of broilers fed differently treated castor bean cake

The results of primal cuts reflected the trend in body weights of the experimental birds (Table 5). The percentage carcass yield showed significant differences (P<0.05) between birds on treated CBC and those placed on raw CBC. The breast and thigh regions were mostly affected and actually dictated the changes in carcass weight. Control had similar values (P>0.05) with birds on lye treated CBC meaning that carcass yield were not significantly compromised with the use of 10% lye treated CBC in diets of broiler chickens .

The weight of organs in broilers is known to indicate the response of birds to the feed intake in relation to their growth or the age of the birds. The weight of organs in

Table 5: Organs and primal cuts of broiler chickens fed differently treated CBC

Parameters	Control	Raw CBC	Lye treated CBC	Fermented CBC	Boiled CBC	SEM
Organs, %						
Lungs	0.68	0.60	0.76	0.56	0.62	0.50
Kidney	0.66^{b}	0.88^{a}	0.59^{b}	0.80^{a}	0.65^{b}	0.05
Liver	2.47^{c}	2.96^{a}	2.54^{bc}	2.61^{b}	2.67^{b}	0.20
Heart	0.45	0.58	0.45	0.45	0.52	0.05
Gizzard	4.48	4.02	3.97	4.57	4.68	0.30
Carcass cut, %						
Breast	17.22^{a}	12.58^{b}	16.66^{a}	15.90^{a}	16.06^{a}	0.55
Thigh	11.75^{a}	8.62^{b}	10.87^{a}	9.42^{ab}	10.38^{a}	0.15
Drum stick	9.03	8.95	9.94	10.09	9.49	0.28
Arm	7.65	9.16	8.63	8.57	8.43	0.44
Back	15.30	15.44	15.36	14.20	13.75	0.35
Neck	4.77	4.51	5.23	5.07	4.93	0.40

*Measure as percentage of live weight
^{abc} means with different superscripts are significantly different ($P<0.05$)

broilers also reflects the anatomical response of birds to the type of diets consumed, such as the use of whole grains in feed or large high fibre particles (Atteh, 2004). Since the percentage organ weight of the total life weight were statistically different $P<0.05$ particularly on the untreated group whose liver and kidney enlarge because of possible congestion, it could be said that, the anti-metabolic substances in CBC at 10% inclusion produced some damages to these vital organs. Despite some level of detoxification attained with processing methods, slight changes in organs is indicative of toxicity of residual anti nutritional factors in treated castor bean cake .

Pathological observation of birds fed differently treated castor bean cake based diets

Clinical examination of birds fed 100 g of castor bean cake, CBC/kg diet revealed general loss of body mass and a very prominent ill appearance in those placed on raw CBC. Ruffled appearance of fea thers, constriction of eye pupils and head retraction in birds fed raw castor bean cake was apparent particularly in sick birds. Autopsy showed marked pallor of the carcasses and emaciation on all birds except those fed lye treated CBC and control diets. Jejuna segment of the small intestine of birds was hemorrhagic in raw and fermented CBC diets. However, Blood - tinged excreta was not conspicuous as indicated by Jensen and Allen (1981) even in birds fed untreated CBC. The liver and kidneys of the test groups were enlarged and congested compared to those of the reference group.

Histological changes in birds fed differently treated castor bean cake based diets (Fig. 2, 3, 4, 5)

No histological or macroscopic alterations were observed in livers of the birds on control diets, there was normal arrangement of hepatocytes, with blood vessels neatly arranged (Fig. 1). The histological changes observed in the group exposed to CBC based diets were cellular infiltration and congestion. Gross cellular infiltration and widespread formation of nodules in the liver were notable in the untreated CBC (Fig. 2) indicating the extent of damages to internal organs of the birds to prolonged exposure to castor toxin. There was mild congestion in Lye treated group (Fig. 3) while fermented group (Fig.4) showed cellular infiltration and some heamorrhagic spots whereas exposure to boiled CBC (Fig.5) was marked with mild cellular infilteration. Animals with cellular infiltration, haemorrhagic spot and necrosis had their cells badly altered. It may be said that the severity of the histological observation was dependent on the level of residual antinutritional factors present in the untreated and treated CBC as indicated in Table 2. This was in consonance with observation of Okoye *et al.* (1987). The most consistent findings was a high incidence of cellular infiltration and degeneration. Jensen and Allen (1981) earlier reported lesions such as severe fatty change in the liver, widely distributed internal petechial hemorrhages or ecchymoses, and catarrhal enteritis. Despite the detoxification achieved with processing methods, the toxins residue particularly in fermented and boiled may pose serious health challenge to birds with prolong exposure.

CONCLUSION

There are acceptability depressing and toxic factors in castor bean cake. Inclusion of untreated CBC at 100g/kg

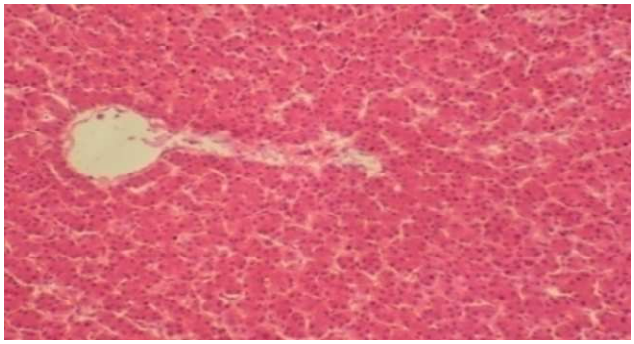

Fig 1: Micrograph of the Liver of a bird on control diet showing normalintegrityof the Hepatocyte and blood vessels.Mag. X 200.

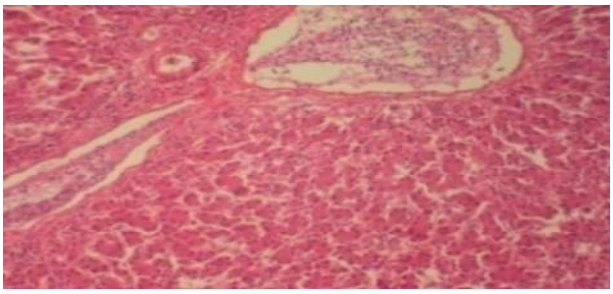

Fig 2: Micrograph of the Liver of a bird on untreated CBC showing cellular dilatationand infilteration. Mag. X 200

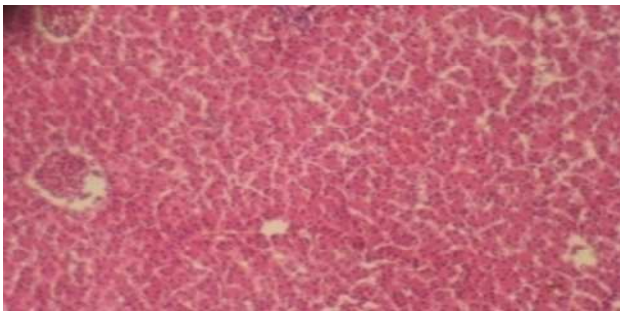

Fig 3: Micrograph of the Liver of a bird on Lye treated CBC showing mild congestion Mag. X 200

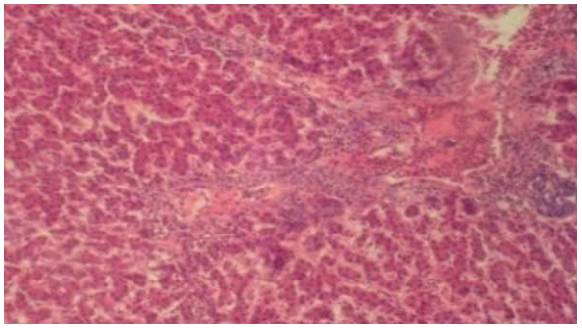

Fig 4: Liver of bird on fermented CBC showing cellular infiltration, with haemorrhagicspot. Mag. X 200

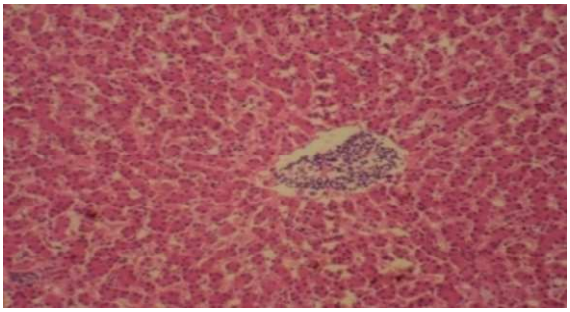

Fig 5: Micrograph of the Liver of a bird on boiled CBC showing cellular infilteration. Mag. X 200.Mag. X 200

diet is lethargic to broiler chickens. There was loss of body mass and very prominent ill appearance with mortality in birds fed 100 g of raw CBC/kg diet while those on treated CBC all survived and performed closely with control group. It may be said that the severity of the pathological effects was dependent on the level of antinutritional factors present in the untreated and residue in treated CBC. It appears that CBC contains both thermo-stable and thermo-labile toxic factors which could be managed by moist heating and lye treatment as indicated in this study. Caustic property of lye looks very promising in detoxification of castor toxins. Although, castor bean required some level of sophisticated processing, when properly treated could form a suitable alternative or additional protein source for farm animals. More concerted efforts should be directed towards improving the processing methods perhaps combination of various methods to remove all deterrents in CBC.

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