Growth Performance, Haematological and Serum Lipid Profile of Broiler Chickens Fed Detoxified Castor Cake Based Poultry Feed as Soybean Meal Replacement

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Abstract:

The growth, haematological and lipid characteristics of Cobb broilers (n = 150) fed inclusions of detoxified NCRICAS1 castor cake poultry feed (DNCCPF) incorporated in a 56-day trial were determined. Completely randomized design was employed in assigning 10 one day-old chicks to each of five labeled groups (G1-G5) and replicated thrice with dietary treatment groups G1 with 100% soybean meal (control), G2 contained 25% DNCCPF and 75% soybean meal, G3 comprised 50% DNCCPF and 50% soybean; G4 was 75% DNCCPF and 25% soybean while G5 was 100% DNCCPF. Daily feed intake and weekly weights of the chicks were measure. While, haematological and lipid characteristics were determined at the end of the study. Results show that birds fed 100 % soybean meal (control) had significantly ($p < 0.05$) highest weight (3257.00 g) after 56 days of feeding. This was not significantly different from birds fed 100 % castor cake (3173.40g). At eight weeks, feed conversion ratio of birds in control group G1 (0.31) was not significantly different from birds fed 100 % (0.32) and 75 % (0.32) castor inclusions. Red blood cell count was highest ($p < 0.05$) in G4 (1.76×10^6) and G5 (1.67×10^6 /uL) and lowest in G2 (1.38×10^6 /uL). Haemoglobin concentration was highest ($p < 0.05$) in G4 (8.20 g dL^{-1}) and lowest in G2 (5.47 g dL^{-1}). Decreased in triglyceride and lipoproteins in birds fed castor based feed were not significantly ($p > 0.05$) different from 100% soybean meal (control). Serum cholesterol (213.50mmol/L) of birds in the control group G1 was significantly ($p < 0.05$) higher than that in the entire castor based feed. The result of feed conversion ratio of birds fed castor cake based poultry is an indication that castor cake inclusion did not reduce the feeding of the birds. The DNCCPF 100 % castor inclusion was able to maintain growth performance, haematological and serum lipid characteristics of test broilers when compared with 100 % soybean meal and therefore, may replace soybean meal in poultry feed.

Key words: *castor, haemoglobin, serum, broilers, lipoproteins*

Introduction

One of the major challenges facing commercial poultry production in Nigeria is high cost of feeds. And the price was ordinarily 65–75 % of overall production cost (Anosikeet al., 2012). Soybean meal contributes about 30 % of the cost of production of poultry feed, and it is a ubiquitous ingredient in poultry feed formulation as it constitutes the major protein source in the feed (WHO, 2020); this could be partially or completely substituted with less expensive nutrient-equivalent ingredients.

Soybean (Glycine max, L) is one of the most important source of high quality edible oil and protein for human beings and one of the major oil crop in the world(Anderson et al., 2019).
Soybeans must be strictly redirected for human consumption because to the expanding human population and their critical function in feeding it, while other less common crops or plant products can be turned into animal feed (Vasanthyet al., 2021).

One of the underappreciated crops with a high protein content is the castor plant (Ricinus communis L.). Native to Africa, this oil plant is becoming more popular in Nigeria, where the National Cereals Research Institute (NCRI), Badeggi, is tasked with conducting research on the crop's genetic enhancement and use (Salihuet al., 2014). Castor cake is the end product of the process of using castor plants to produce castor oil (Patel et al., 2016). The cake may be used as a feed item for cattle because it provides between 35 and 39.8% crude protein (Chakrabarty et al., 2021). In this study, the effects of substituting castor cake for soybean meal in poultry feed were assessed.

Materials and Methods

Experimental Site, Duration and Ethical Approval

The National Cereals Research Institute's Poultry Unit at Badeggi was the site of the experiment. Before the 56-day animal trial started, the Federal University of Technology, Minna's committee on ethics in the use of animals for biomedical research gave its approval.

Processing of castor cake

Toxins were removed from the castor seed cake by boiling it for 60 minutes at 85°C and then fermenting it for five days at 40°C. After processing, the castor cake was allowed to air dry at room temperature (Oliveira et al., 2017).

Experimental Diets, Birds and Design

Day-old Cobb chicks (n = 150) weighing around 45 g were used in the investigation. They were divided into five treatment groups (with tags; G1-G5) using a completely randomized experimental design. There were ten chicks in each replication for each tagged treatment group. The NRC (2012) standard for grill chickens was followed in the formulation of the experimental diets. G1 consisted of 100% soybean meal (control), G2 consisted of 75% soybean meal + 25% detoxified castor cake, G3 consisted of 50% soybean meal + 50% detoxified castor cake, G4 consisted of 25% soybean meal + 75% detoxified castor cake, and G5 consisted of 100% detoxified castor cake (table 1).

Table 1. Percentage composition of starter and finisher feeds

Ingredients (%)	100% Soymeal (Control)		25% Castor meal		50% Castor meal		75% Castor meal		100% Castor meal	
	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
Maize	63.20	70.60	63.20	70.60	63.20	70.60	63.10	70.60	63.20	70.60
Soymeal	30.80	21.80	23.10	16.35	15.40	10.90	7.70	5.45	-	-
Castor cake	-	-	7.70	5.45	15.40	10.90	23.10	16.35	30.80	21.80
Soybean oil	2.40	4.60	2.40	4.60	2.40	4.60	2.40	4.60	2.40	4.60
Dicalcium phosphate	1.24	0.82	1.24	0.82	1.24	0.82	1.24	0.82	1.24	0.82
Limestone	0.28	0.10	0.28	0.10	0.28	0.10	0.28	0.10	0.28	0.10
$NaHCO_3$	0.14	0.10	0.14	0.10	0.14	0.10	0.14	0.10	0.14	0.10
Salt	0.26	0.30	0.26	0.30	0.26	0.30	0.26	0.30	0.26	0.30
DL-Methionine 99	0.66	0.60	0.66	0.60	0.66	0.60	0.66	0.60	0.66	0.60
L- Lysine 99	0.52	0.58	0.52	0.58	0.52	0.58	0.52	0.58	0.52	0.58
Vitamin-mineral premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

Management of Experimental Birds

Prior to the birds' arrival, the 1.5 m × 2.0 m experimental enclosures were cleaned and disinfected using soap and disinfectants. Coarse wood shavings

were then put out as bedding. To provide a suitable brooding environment, the pens were pre-heated with bulbs and lanterns one day before to the chicks' arrival. The experimental pens had low walls that separated the various replications for proper ventilation in the production building. The chicks received an intraocular lasota vaccine when they arrived.

Also, glucose and vitamin supplements (Vitalyte®) were included in the chicks' drinking water at the manufacturer's prescription as anti-stress to ameliorate the negative effect of transportation on the birds. The chicks were fed a blanket of professional commercial feed for three days to acclimate before the introduction of the formulated feeds. However, the birds had Lasota and Gumboro intraocular vaccinations on the 7th and 14th days of the study. Broilers were fed a measured quantity (in grams) of feed twice daily (morning and evening) following routine inspection to assess chicks' health status. Feeding and drinking troughs were amply provided and properly cleaned daily before feeding.

Data Collection

Broilers were weighed at the start of the experiment and at weekly intervals using an Avery® weighing balance till the end of the study. The average daily weight gain (ADWG) was calculated as the difference in the birds' weekly body weights per day. The average daily feed intake (ADFI) was deduced as the difference in the quantity of feed supplied to a replicate bird in a day and the remnant (in grams) the next morning. Feed conversion ratio (FCR) was calculated as the ratio of daily feed intake to corresponding weight gain per bird.

Collection of blood samples

Using sterile syringes, 5 ml of blood was drawn from the wing vein and placed into ethylenediamine tetra-acetic acid bottles for hematological analysis and plain tubes for serum analysis, respectively. Ice packs in an enclosed chest were utilized to cold the tested bottles until analysis within an hour of collection and separate syringes were used for each collection to prevent sample contamination.Centrifuging at 3000 rpm for 15 mi nutes, as per Chesbrough's (2000) approach, allowed for the easy harvesting of plasma.

Hematological parameters and serum lipid profile

Analysis for LDL, TRIG, HDL, CHL was carry out at the Federal Medical Centre, Bida using automated serum lipid analyser test machine MSL BASE-50 while hematological parameters (RBC, WBC, Platelet count, PCV and Hb) was carried out using an automated hematological analyser MLS AB-39T, Konsung.

Data Analysis

Statistical analysis was carried out on the triplicate value of the data obtained using Statistical Tool for Agricultural Research (STAR) version 2.0. Analysis of variance (ANOVA) was used to test for significance level and significantly different means will be separated using Duncan Multiple Range Test (DMRT) at $p < 0.05$.

Results and Discursion

Growth performance of broilers fed detoxified castor cake incorporated feeds

The growth performance of broilers fed detoxified castor cake based diets is presented in Table 2. The weight gained by the birds on weekly basis was significantly different at $p<0.05$ among treatment groups. At the end of the experiment (56 days), treatment group I with 100% soybean meal(control) had the highest live weight (3257.00 g) but not significantly different from treatment group V with 100 % castor cake (3173.40g). The lowest live weight (2966.73g) was obtained in treatment group III with 50% castor cake inclusion. The growth performance of broilers from the 100% castor cake diet matches broilers on 100% soybean meal diets because detoxified castor cake fulfills all necessary nutritional needs to support growth in poultry feed. The consumption of castor cake at 50% levels resulted in decreased final body weights of broiler chickens indicating limited nutritional value when substituting crude proteins.

Table 2. Average weekly weight gain (g) of broilers fed detoxified castor cake based feeds

Treatments	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
G1	10.71±1.91^{b}	66.20±4.70^{ab}	263.87±14.65^{a}	150.00±11.80^{b}	393.53±8.70^{a}	286.00±17.02^{bc}	406.07±20.93^{a}	802.60±29.58^{a}
G2	11.81±0.39^{b}	48.93±0.44^{c}	171.53±15.79^{bc}	229.67±19.29^{a}	267.60±44.43^{b}	237.20±39.28^{c}	431.67±15.52^{a}	623.13±14.59^{d}
G3	11.75±0.52^{b}	60.53±0.93^{b}	181.53±6.336^{b}	171.27±4.05^{b}	187.20±1.91^{c}	379.07±11.95^{a}	295.60±40.04^{b}	671.00±34.48^{cd}
G4	13.40±0.56^{b}	50.07±2.36^{cb}	144.73±10.84^{c}	145.53±7.84^{b}	299.07±11.47^{b}	325.93±14.19^{ab}	382.53±27.71^{a}	716.07±21.10^{bc}
G5	16.72±0.78^{a}	69.47±1.76^{a}	204.13±3.23^{b}	151.80±6.13^{b}	421.40±20.90^{a}	280.73±19.67^{bc}	387.27±18.15^{a}	780.53±24.45^{ab}

Values are represented as mean ± SEM of triplicate determinations. Value with different alphabets along a column is significantly ($p< 0.05$).). G1=100% soybean meal, G2=75% soybean meal +25% detoxified castor cake, G3=50% soybean meal +50% detoxified castor cake, G4=25% soybean meal+75% detoxified castor cake and G5= 100% detoxified castor cake.

The weight increase measurements of broilers in the different treatment groups produced distinctive results regarding weight development for every week except in the seventh week. Broilers consuming the diet containing 100% castor cake developed heavier weight during the initial weeks 1, 2 and 5 per results reported by Mondor & Hernández - Álvarez (2022) on how detoxified castor meal facilitates early phase growth. The weight gain results for broilers receiving soybean meal diets outperformed those getting 100% castor meal except in week 7; the remaining weight gain measures in weeks 3, 6 and 8 were statistically similar between both diet treatments. The research done by Saleh

et al. (2021) showed that castor cake sustains development at the start yet soybean meal proves more efficient later in a broiler's growth period.
While the residual anti-nutritional factors present in 50% castor cake diets may explain why performance metrics remained below the standard. The research published by Marchalet al. (2024) showed that when castor cake detoxification is not complete it results in reduced feed utilization along with a decrease in poultry growth rate. The improved feeding outcomes on completely processed castor cake diets show that appropriate methods for reduction of toxicity preserve feed nutritional content.

Feed conversion ratio of broiler birds fed detoxified castor cake based feeds

The feed conversion ratios (FCR) of broilers fed detoxified castor cake based feeds are presented in Table 3. There were significant difference at $p<0.05$ among treatment groups on weekly basis throughout the study. Feed conversion ratio decreased with increase in ages of broilers birds across all the treatment groups. Higher feed conversion ratios were obtained for castor cakes based diets especially 75 % castor cake inclusion except for week one as compared to the control diet. The highest (1.27) conversion ratio was observed in week one for the group fed twenty five percent (25%) detoxified castor cake inclusion while, the lowest (0.31) was observed in week eight for the group fed hundred percent soybean meal inclusion (control (Table 3). The experimental birds needed additional feed per weight gain when they received feed containing castor meal instead of the control diet. Marchalet al. (2024) previously discovered in their study that less efficient feed utilization occurred in young birds that possess immature digestive systems and metabolic processes compared to mature birds.

Table 3. Feed conversion ratio of broilers fed processed castor based poultry feeds

Treatment groups	wk 1	wk 2	wk 3	wk 4	wk 5	wk 6	wk 7	wk 8
G1	1.25±0.04^{ab}	0.85±0.01^{d}	0.73±0.00^{d}	0.52±0.00^{c}	0.49±0.01^{b}	0.51±0.01^{c}	0.36±0.01^{c}	0.31±0.00^{c}
G2	1.27±0.04^{a}	1.01±0.02^{b}	0.78±0.01^{c}	0.63±0.04^{b}	0.59±0.01^{a}	0.57±0.00^{b}	0.44±0.01^{b}	0.33±0.00^{ab}
G3	1.10±0.01^{d}	0.93±0.02^{c}	0.85±0.01^{b}	0.74±0.00^{a}	0.58±0.01^{a}	0.63±0.02^{a}	0.48±0.02^{a}	0.34±0.01^{a}
G4	1.19±0.01^{bc}	1.31±0.01^{a}	1.01±0.02^{a}	0.70±0.02^{a}	0.59±0.01^{a}	0.59±0.02^{b}	0.45±0.02^{ab}	0.32±0.00^{bc}
G5	1.11±0.01^{cd}	0.86±0.01^{d}	0.83±0.01^{d}	0.53±0.01^{c}	0.50±0.00^{b}	0.53±0.01^{c}	0.40±0.01^{c}	0.32±0.00^{bc}

Values are represented as mean ± SEM of triplicate determinations. Value with different alphabets along a column is significant ($p < 0.05$).). G1=100% soybean meal, G2=75% soybean meal +25% detoxified castor cake, G3=50% soybean meal +50% detoxified castor cake, G4=25% soybean meal+75% detoxified castor cake and G5= 100% detoxified castor cake

The FCR reached its peak value among the castor meal-fed groups at the 75% inclusion level in the early weeks since this diet offered the lowest feed efficiency at this period. The FCR outcomes of birds receiving 100% detoxified castor cake diet showed enhance feed utilization patterns throughout the late period of the experiment. The research by Pekelet al. (2022) demonstrated that proper detoxification methods for castor meal could enhance nutrition and feed absorption within poultry.

Birds with an inclusion of 25% castor cake in their diet achieved maximal FCR during week one followed by least efficient FCR in week eight when fed with 100% soybean meal. The results from Rocha et al. (2022) match those showing that despite being alternative to soybean meal as a protein source castor cake reveals lower efficiency in feed conversion. Feed efficiency reached its lowest level because anti-nutritional factors remained detectable in detoxified castor cake dietary supplements.

Hematological parameters of broilers fed detoxified castor cake

Table 4, shows the hematological parameters of broilers fed detoxified castor cake based feeds. There were significant differences among the treatment groups fed with different percentages of detoxified castor cake inclusions at $p<0.05$. The red blood cell (RBC) increases with increase in detoxified castor cake inclusion. All the treatment groups except for group II have higher count than the control group (group I). This trend was also observed for other haematological parameters measured. The physiological health condition of poultry gets measured through hematological parameters. Laboratory results showed a meaningful difference ($p<0.05$) in the red blood cell (RBC) count and white blood cell (WBC) count and hemoglobin levels and packed cell volume (PCV) and platelet count of broilers based on castor cake inclusion levels. Higher levels of castor cake consumption in bird diets led to increased RBC and WBC values because birds adapted their physiological systems to the aliment.

Table 4. Hematological parameters of broilers fed castor based poultry feed

Treatments	Red Blood Cell (10^6/uL)	WBC (10^6/uL)	HGB (g/dL)	PCV (%)	PLT (10^4/uL)
G1	1.44±0.05^{bc}	1.19±0.03^{ab}	7.43±0.15^{a}	24.67±0.82^{a}	3.43±0.15^{a}
G2	1.38±0.05^{c}	1.15±0.01^{b}	5.47±0.54^{b}	19.10±0.56^{b}	1.50±0.29^{b}
G3	1.56±0.02^{abc}	1.22±0.01^{a}	7.43±0.75^{a}	22.60±2.14^{a}	2.80±0.31^{a}
G4	1.76±0.05^{a}	1.23±0.02^{a}	8.20 ±0.06^{a}	24.97±0.28^{a}	3.47±0.03^{a}
G5	1.67±0.04^{ab}	1.22±0.04^{a}	7.50±0.06^{a}	24.73±.12^{a}	3.43±0.20^{a}

Values are represented as mean ± SEM of triplicate determinations. Value with different alphabets along a column is significantly ($p< 0.05$). G1=100% soybean meal, G2=75% soybean meal +25% detoxified castor cake, G3=50% soybean meal +50% detoxified castor cake, G4=25% soybean meal+75% detoxified castor cake and G5= 100% detoxified castor cake, SEM- standard error of mean, WBC- white blood cell, HGB- hemoglobin, PCV- packed cell volume, PLT- platelet.

Research by Surai, et al., 2019 shows that properly detoxified alternative protein sources such as castor cake can boost both red blood cell values and maintain or increase erythropoiesis in poultry. Studies (Iliya, Obaroh, Ukatu, &Bshar, 2023) have documented that castor cake shows immune-stimulatory activity leading to increased WBC observations in this study. Malenica, Kass and Bhat (2022) suggested that proper detoxification of castor cake phytochemicals leads to improved immune defense in poultry.

The inclusion of higher levels of castor cake in the study resulted in rising numbers of both packed cell volume and hemoglobin measurements. The study results show that effectively detoxified castor cake maintenance does not affect oxygen distribution abilities throughout the blood. The research by Ohanenyeet al. (2022) documented identical substitutions of plant-based processed alternatives for conventional protein sources.

The findings indicated that platelet counts exhibited inconsistent patterns between groups although they decreased significantly when test animals received 25% castor cake. Additionally, Thakur, et al., (2019) reported equivalent findings when studying anti-nutritional factors in detoxified food sources. The research indicates platelet counts stayed at equilibrium when

birds consumed diet formulas with 75% and 100% castor cake inclusion concentrations since they displayed adaptation to these food compositions throughout the study period.

Lipid profile of broilers fed detoxified castor cake based diets.

Results of biochemical parameters of broilers fed detoxified castor cake based feeds are in Table 5.Among all the parameters measured, serum proteins and cholesterol were significantly at $p<0.05$ different among treatment groups. Serum protein was highest in group fed 75% castor inclusion and lowest in the group fed 25% castor inclusion. Serum cholesterol concentration was highest (213.50 mmol/L) in treatment group fed the control diet(100% soybean meal) while, the lowest cholesterol level was in group fed 100% detoxified castor cake based feed. Whereas, there was no significant ($p>0.05$) difference among the treatment groups for high density lipoprotein (HDL), low density lipoproteins(LDL), triglycerides, creatinine and albumin.. HDL concentration was highest in 25% castor inclusion (0.81 mmol/L) while the lowest concentration was found in 50% castor inclusion (0.72 mmol/L), TG was found highest in concentration in the control 100% soybean meal (0.92 mmol/L) and lowest in 75% castor inclusion (0.66 mmol/L). Cholesterol concentration decreases with the inclusion castor cake in poultry feed from 213.50 mmol/L in the control treatment to 180.43 mmol/L in 100 % castor inclusions.. A total serum protein was highest with 75 % castor inclusion (37.67 g/L) and lowest at 25% castor inclusion (30.67 g/L). Broiler biochemical (lipids profile and protein) assessments serve as essential markers for detecting dietary intervention effects on metabolic and physiological processes. Neither HDL nor LDL nor TG nor creatinine nor albumin concentrations differed significantly among the treatment groups according to this study. The amount of total protein (TP) and cholesterol (CHL) within birds' bodies changed significantly because of adding castor cake.

Table 5. Serum concentrations of lipid profile of broilers fed detoxified castor cake based feeds

	(mmol/L)				
Treatments	**HDL**	**LDL**	**TG**	**CHL**	**CHL**
G1	0.77±0.03 [a]	1.47±0.05 [a]	0.92±0.10 [a]	213.50±2.39[a]	213.50±2.39[a]
G2	0.81±0.03 [a]	1.49±0.18 [a]	0.82±0.03 [a]	206.68±1.93[b]	206.68±1.93[b]
G3	0.72±0.04 [a]	1.44±0.06 [a]	0.90±0.11 [a]	194.18±2.64[c]	194.18±2.64[c]
G4	0.79±0.01 [a]	1.19±0.01 [a]	0.66±0.03 [a]	185.43±1.03[d]	185.43±1.03[d]
G5	0.74±0.04 [a]	1.42±0.06 [a]	0.85±0.06 [a]	180.43±0.68[d]	180.43±0.68[d]

Values are represented as mean±SEM of triplicate determinations. Value with different alphabets along a column is significantly ($p < 0.05$). G1=100% soybean meal, G2=75% soybean meal +25% detoxified castor cake, G3=50% soybean meal +50% detoxified castor cake, G4=25% soybean meal+75% detoxified castor cake and G5= 100% detoxified castor cake, HDL-high density lipoprotein, LDL-low density lipoprotein, TG- triglyceride, CHL- cholesterol, ALB – albumin, TP- total protein.

With no significant differences in lab results of HDL, LDL, TG and creatinine it can be concluded that poultry fed with castor-based diets experienced no negative effects on lipid metabolism or renal function. A research conducted by Hussain, et al., (2024) confirmed that using detoxified plant-based protein sources instead of soybean meal did not affect renal health or lipid profile measurements in broiler chickens. Research conducted by Lestingi, et al., (2024) established that proper detoxification and dietary balance of alternative protein sources maintain stability in poultry lipid metabolism.

Similar to Sarvaniet al. (2020), the presence of phytosterols combined with other bioactive compounds in castor cake results in decreased serum cholesterol levels in broilers. The results indicate castor cake has the potential to reduce cholesterol levels thus delivering health benefits to poultry.

The measurement of total protein levels indicates protein metabolism may be influenced by the level of castor cake included in the diets. The highest total protein measurements were noted at the 75% castor inclusion level according

to experimental data as reported by (Zhu et al., 2021). The research suggests that alternative protein ingredients have the potential to maintain ideal protein use in poultry diets when processed correctly for diet inclusion.
The findings of this study indicated that using castor-fed poultry feed does not produce adverse biochemical effects on broiler health. Another implication is that lowering cholesterol levels might provide health advantages for broilers alongside improved protein utilization at elevated levels of castor inclusions.

Conclusion

Detoxified castor cake showed encouraging results in broiler feeding trials, sho wing growth performance, haematological, and lipid profile parameters that wer e comparable to those of traditional soybeanbased diets.When compared to 100 % soybean meal, the 100% castor inclusion was able to preserve the test broile rs' growth performance, haematological, and serum lipid characteristics; as a r esult, it may be used in place of soybean meal in poultry feed.This promotes su stainable animal production systems, lessens dependency on traditional feed in gredients, and diversifies the sources of protein used in feed formulation.

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