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Research Article

Comparative Effect of Different Detoxified Rubber Seed Meal on Haematological and Serum Biochemical Indices of Broilers

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Abstract | The rubber seed meal (RSM) that obtained from rubber seed tree is a rich source of protein. However, it also contains high levels of hydrogen cyanide that cause hindrances in the utilization of RSM as animal feed. The present study was conducted to explore the potential of detoxified RSM in broilers by replacing it with conventional protein feed stuffs. A 42-d experiment was carried out to investigate the effect of differently processed (detoxified) RSM on the haematological and serum biochemical indices of broiler chicken. Five diets were formulated using differently detoxified RSM consisting of soaked, boiled, toasted and fermented RSM as well as the corn-soybean based control diet. Three hundred, 1- day old *Arbor acre* broilers were randomly distributed into five dietary treatments with six replicates of 10 birds each in a completely randomized design. After 42 days, three birds per replicate were randomly selected for haematological and serum biochemical evaluation. Results showed that boiling and fermentation were very efficient in lowering the level of cyanide in the seed followed by toasting and lowest in soaking method. Results of haematological evaluation showed a significantly higher ($P<0.05$) haemoglobin level, mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) in boiled and fermented RSM fed groups than other RSM fed groups. While serum biochemistry revealed that birds fed control, boiled and fermented RSM diets have higher ($P<0.05$) concentration in total protein and albumin but with reduced ($P<0.05$) concentration of creatinine, uric acid and cholesterol than those fed soaked and toasted RSM diets. In conclusion, results showed that incorporation of boiled and/or fermented RSM have better effects on the blood biochemical indices and haematology of the broilers.

Keywords | Broilers, Rubber seed meal, Processing, Cyanide, Haematology, Serum metabolites

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INTRODUCTION

In most developing countries, intensified competition for conventional concentrates such as maize, soybean and groundnut has resulted to unavailability and rising prices of these ingredients in poultry production (Mohammed and Agwunobi, 2009; Gadzirayi et al., 2012). The prevailing scarcity and high cost of these conventional feed resources have led to the recent high cost of poultry products (Aderemi et al., 2006). Increased cost of feeding livestock has necessitated the need to search for alternative feed resource for livestock, especially poultry. The replacement of expensive and imported conventional protein feed stuffs that are cheap, non-consumable and locally available present a suitable strategy for decreasing the total feed cost of poultry production (Iyayi and Fayoyin, 2005; Annongu et al., 2006; Tuleun and Igba, 2008). One of such potential non-conventional tropical feed resources is rubber seed meal, which are obtained from rubber seed tree (*Hevea brasiliensis*). They are very abundant in West Africa particularly in Nigeria produces rubber mainly for domestic and export purposes; however, the seeds are usually discarded. The rubber seed meal is utilized as feed material for animals and its nutritional value has been considered to be a good source of protein for poultry and pigs (Nwokolo, 1987). The Nigerian rubber seed is rich in essential amino acids such as lysine, methionine and tryptophan, and also high in oil and phosphorus (Oluyemi et al., 1975; Mmereole, 2008; Eka et al., 2010). Despite the potentials of this seed, the high levels of hydrogen cyanide (HCN) has been reported as the main hindrance in the utilization of rubber seeds as animal feed (Giok et al., 1967; Ukpebor et al., 2007; Ahaotu et al., 2010; Syahruddin et al., 2014). The high affinity of dietary cyanogenic glycoside towards the heme component of the erythrocyte (Isom and Way, 1974) lowers the animal performance by inhibiting cellular respiration (Sharma et al., 2014). Heat treatments, soaking, storage and fermentation aid to overcome the detrimental effect of HCN, hence improving the utilization of the rubber seed meal (Offiong and Olomu, 1990; Igene and Iboh, 2004; Ugwuene and Kong, 2004; Ukpebor et al., 2007). However, no systemic attempt has been made to evaluate the differently detoxified rubber seed meal in broiler diets to ascertain the effect on their haematological and serological status. Therefore, the present study was conducted to evaluate the comparative effect of different rubber seed meals that detoxified by various methods in broiler diets on haematological and serum biochemical indices in broilers.

MATERIALS AND METHOD

Experimental Site

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Production Technology, Federal College of Wildlife Management, New-bussa, Nigeria.

Collection And Processing Of Rubber Seed Meal

The rubber seeds procured for this study were gotten from rubber plantation at Ovia South-West Local Government Area of Edo state, Nigeria. All the raw seeds were collected fresh and divided equally into 4 batches and processed differently. First batch were soaked in cold water inside a closed metal drum for 72 hours followed by draining of the water and sun-drying for 5 days; second batch were boiled in water at temperature of 100°C for 45 minutes, drained of the water and sun-dried for 5 days. Third batch were toasted using a metallic frying pan for 45 minutes and the fourth batch were subjected to anaerobic fermentation for 72 hours. All the processed rubber seeds were separately hammer-milled prior to experimental diet formulation to produce the respective meals as soaked RSM (SRSM), boiled RSM (BSRM), toasted RSM (TRSM) and fermented RSM (FRSM).

Experimental Diets

Five experimental diets both for starter (1-21 d) and grower (22-42 d) phases were formulated with the differently processed RSM. Diet 1 consisted purely of corn-soybean based (control) diet while the different processed RSM, that is, quantitatively replaced soybean in the control at 30% dietary level in both starter and grower phases. The ingredient compositions of the experimental diets at 1-21 d and 22-42 d are shown in Table 1 and 2 respectively.

Experimental Birds And Management

The broiler chickens used in this study were raised under standard husbandry conditions and all experimental protocols were in accordance with the guidelines of the Institutional Animal Care and Ethics Control Committee of the Federal College of Wildlife Management, New-bussa, Nigeria. Three hundred (300) 1-day old *Arbor acre* broiler chicks were procured for the study, weighed and randomly distributed to the five dietary treatments with six replicates of ten birds each using a completely randomized design. The experiment lasted for 42 days. Each experimental group was provided with the corresponding diet and clean water *ad-libitum*. The birds were raised in an open sided poultry facility where deep litter system was adopted using wood shavings as litter material.

Sample Collection And Preparation

At the 42 d of age, three birds were selected randomly on weight equalization basis per replicate and fasted overnight so that the serum was cleared of excess fat and protein that hinder the experimental results. Blood sample was collected from their jugular vein from each bird, deposited into a labeled EDTA tube for hematological indices evaluation and kept in an ice-moist jute material to prevent haemolysis. Another blood was collected from the same birds and deposited into tubes without anti–coagulant (EDTA), allowed to stand for 45 minutes at room temperature and centrifuged at 3,000 revolutions per minute (rpm) for 10 minutes for determination of serum biochemistry.

Evaluation Of Haematological Indices

Haemoglobin level was determined using cyanomethaemoglobin method, packed cell volume (PCV), red blood cell (RBC), and white blood cell (WBC) were analyzed quantitatively using improved Neubar's haemacytometer after dilution (Dacie and Lewis, 1991). The mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) standard ratios were computed adopting the procedure described by Jain (1986).

Evaluation Of Serum Biochemical Indices

The serum biochemical indices such as total protein, albumin, globulin, uric acid, cholesterol and glucose were determined using blood samples collected without anticoagulant

Table 1: Percentage composition of experimental diets for starters birds (1-21 d)

Feed ingredients	Control	SRSM	BRSM	TRSM	FRSM
Maize	58.50	57.50	57.50	57.50	57.50
Soya bean meal	33.00	23.05	23.05	23.05	23.05
Rubber seed meal	0.00	9.90	9.90	9.90	9.90
Fish meal	4.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.30	0.30	0.30	0.30	0.30
L-Lysine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Nutrient composition					
ME (Kcal/kg)	3071.60	3140.80	3163.70	3112.50	3180.60
Crude Protein (%)	23.75	22.86	22.36	22.45	23.36
Crude fat (%)	5.33	6.06	5.36	5.97	5.35
Crude fiber (%)	4.17	4.13	4.88	4.05	4.73

SRSM: Soaked rubber seed meal; **BRSM:** Boiled rubber seed meal; **TRSM:** Toasted rubber seed meal; **FRSM:** Fermented rubber seed meal; ***:** Vitamin/Mineral premix supplied per kg of the diet: **Vit A:** 10,000iu; **Vit D:** 28000iu; **Vit E:** 35,000iu; **Vit K:** 1900mg; **Vit B12:** 19mg; **Riboflavin:** 7000mg; **Pyridoxine:** 3800mg; **Thiamine:** 2200mg; **Pantothenic acid:** 11000mg; **Nicotinic acid:** 45,000mg; **Folic acid:** 1400mg; **Biotin:** 113mg; **Cu:** 8000mg; **Mn:** 64000mg; **Zn:** 40, 000mg; **Fe:** 32000mg; **Se:** 160mg; **Iodine:** 800mg; **Cobalt:** 400mg; **Choline:** 475000mg

Table 2: Percentage composition of experimental diets for grower birds (22-42 d)

Feed ingredients	Control	SRSM	BRSM	TRSM	FRSM
Maize	65.50	64.50	64.50	64.50	64.50
Soya bean meal	26.00	18.15	18.15	18.15	18.15
Rubber seed meal	0.00	7.80	7.80	7.80	7.80
Fish meal	4.00	5.00	5.00	5.00	5.00
Dicalcium phosphate	2.50	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Vitamin-Premix*	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.30	0.30	0.30	0.30	0.30
L-Lysine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Nutrient composition					
ME (Kcal/kg)	3278.76	3281.96	3288.76	3211.96	3240.80
Crude Protein (%)	20.38	19.71`	19.24	19.37`	20.15
Crude fat %	6.03	6.39	6.23	6.29	6.13
Crude fiber %	4.77	5.33	4.45	5.33	4.27

SRSM: Soaked rubber seed meal, **BRSM:** Boiled rubber seed meal; **TRSM:** Toasted rubber seed meal; **FRSM:** Fermented rubber seed meal; ***:** Vitamin/Mineral premix supplied per kg of the diet; **Vit A:** 10,000iu; **Vit D:** 28000iu; **Vit E:** 35,000iu; **Vit K:** 1900mg; **Vit B12:** 19mg; **Riboflavin:** 7000mg; **Pyridoxine:** 3800mg; **Thiamine:** 2200mg; **Pantothenic acid:** 11000mg; **Nicotinic acid:** 45,000mg; **Folic acid:** 1400mg; **Biotin:** 113mg; **Cu:** 8000mg; **Mn:** 64000mg; **Zn:** 40, 000mg; **Fe:** 32000mg; **Se:** 160mg; **Iodine:** 800mg; **Cobalt:** 400mg; **Choline:** 475000mg

Table 3: Proximate composition of raw and differently detoxified rubber seed meal (RSM)

Parameters	RAW	BRSM	SRSM	TRSM	FRSM
Moisture (%)	4.80	5.01	5.17	4.60	5.60
Crude protein (%)	33.25	32.68	32.17	32.65	34.48
Ether extract (%)	22.57	21.94	20.12	20.77	20.05
Crude fiber (%)	5.61	4.54	4.04	5.25	3.81
Ash (%)	5.34	4.51	5.08	5.17	5.12
NFE (%)	33.23	36.33	38.59	36.16	36.54

RAW: Fresh (raw) rubber seed meal; **SRSM:** Soaked rubber seed meal; **BRSM:** Boiled rubber seed meal; **TRSM:** Toasted rubber seed meal; **FRSM:** Fermented rubber seed meal; **NFE:** Nitrogen Free Extract

Table 4: Effect of processing techniques on reduction of hydrogen cyanide (HCN) level in rubber seed

Processing methods	mg/kg HCN	% Reduction level of HCN
Raw	315.89	-
Soaking	167.45	46.99
Boiling	45.21	85.69
Toasting	108.56	65.63
Fermentation	62.34	80.27

and their concentrations were determined by using standard commercial clinical kits (Gold Analisa Ltda, Belo Horizonte, Minas Gerais, Brazil) according to manufactures recommendations.

Chemical Analysis

The differently processed RSM and experimental diets were analyzed for proximate composition according the procedure of AOAC (2000). The cyanide contents of the raw and different processed RSM were determined using alkaline titration method as described by AOAC (2000).

Statistical Analysis

The means of the pens served as the experimental unit for all measurements. Data collected from the study were subjected to the analysis of variance (ANOVA) by the General Linear Models procedure of SAS (2006). Significant differences that occurred among the treatment means were separated using Duncan multiple range F-test. The 5% level of probability was used to established the statements of significance

RESULTS AND DISCUSSION

Proximate And HCN Composition Of Raw And Detoxified Rubber Seed Meal

Table 3 shows the result of proximate composition analysis of raw and differently detoxified rubber seed meal (RSM). The crude protein (CP) value of the fresh raw seed (33.25%) obtained in this present study was higher than the values reported by Madubuike et al. (2006), Oyewusi et al. (2007), Khatun et al. (2015) and as 21.90%, 26.07% and 32.98% respectively but lower than 34.1% reported by Mmereole (2008). The variations obtained in CP values could be attributed to differences in varieties and agronomical practices or plant mechanism for uptake of nitrogenous nutrients in nitrate or ammonium forms (Oyewusi et al., 2007). After processing the seeds, the protein content was improved by fermentation and increased to 34.48%, thus confirming the findings of Ukpebor et al. (2007) who reported that this increase in protein level after fermentation of rubber seed and was attributed to the utilization of lipid and carbohydrate components of the RSM as carbon sources. However, lower CP level observed in BRSM and SRSM may be probably due to the fact that cooking and soaking enhance degradation which was attributed to solubilization and leaching of some nitrogenous components into the processing water (Udedibie and Carlini, 2000, Onu and Okongwu, 2006). Nevertheless, the level of protein content obtained in the study is in accordance with the reports of earlier authors confirming its status as a potential protein feed material (Mmereole, 2008; Sharma et al., 2014). Table 4 shows the composition and percentage reduction level of hydrogen cyanide (HCN) in the different processed rubber seeds. The result showed that the HCN content of the raw rubber seed (315 mg/kg) was lower than the values reported by Okafor and Anyawu (2006) and Sharma et al. (2014) as 391.60 and 415.10 mg/kg respectively, but higher than the values recorded by Batel et al. (2008) and Eka et al. (2010) as 263 and 186 mg/kg respectively. This result supports the report that genetic and environmental factors, location, season and soil factors are reasons for the wide variations observed in the cyanogenic glycoside concentrations (Ermans et al., 1980; JECFA, 1993). Moreover, reduction in the level of HCN was effective with the adopted processing methods and this revealed that cyanide level in the raw seed decreased by 49.99%, 65.63%, 80.27% and 85.69% for soaked, toasted, fermented and boiled processing techniques respectively. The highest level of cyanide reduction was obtained in the boiled seeds followed by fermented seeds and this is in agreement with previous researchers (Ukpebor et al., 2007; Syahruddin and Rita, 2009; Sharma et al., 2014) who stated that heat treatments and fermentation tends to reduce the concentration of HCN in RSM and makes them nutritionally

Table 5: Haematological indices of broiler chickens fed diets containing differently detoxified rubber seed meal (0-42 d)

Parameters*	Control	SRSM	BRSM	TRSM	FRSM	SEM
PCV (%)	30.55	26.07	29.31	27.82	28.74	2.31
Haemoglobin (g/dl)	11.04^a	8.18^c	11.10^a	9.36^b	10.97^a	0.42
WBC x 10^3/mm^3	23.56	21.36	22.08	21.84	22.98	1.26
MCV (FL)	86.96^a	79.24^b	85.45^a	84.67^a	87.09^a	1.23
MCHC (%)	38.14	36.01	37.58	36.24	36.97	1.12
MCH (pg)	33.23^a	27.90^c	33.02^a	32.27^b	33.15^{ab}	0.53
RBC x 10^6/mm^3	3.55	3.22	3.43	3.30	3.27	0.18

a, b, c: Means in the same row bearing different superscripts differ significantly (P< 0.05); **SEM:** Standard error of mean; **SRSM:** Soaked rubber seed meal; **BRSM:** Boiled rubber seed meal; **TRSM:** Toasted rubber seed meal; **FRSM:** Fermented rubber seed meal; ***PCV:** Packed cell volume; **WBC:** White blood cell; **MCV:** Mean corpuscular volume; **MCHC:** Mean corpuscular haemoglobin concentration; **MCH:** Mean corpuscular haemoglobin; **RBC:** Red blood cell

less active. Moreover, according to Ravindran and Ravindran (1988), cooking of fresh kernels eliminated 93% of the initial cyanide content, thus suggesting that cyanide would not cause any detrimental effects should properly detoxified seed kernels be incorporated into animal feeds.

Haematological Response

The result of hematological indices of broilers fed different processed rubber seed meal based diets are shown in Table 5. No significant (P>0.05) difference in the packed cell volume (PCV) and red blood cells (RBC) values were observed among the treatment groups. The values were in the range of 27.07 to 30.55% and 3.09 x10^6 to 3.57 x10^6mm^3 for PCV and RBC respectively. All the PCV and RBC values were within the normal range of 25 to 45% and 2.88 to 4.12 x10^6mm^3 respectively reported by (Mitruka and Rawnsley, 1977). Haemoglobin concentration (Hb) values ranged from 8.18 to 11.10g/dl and were within the accepted range of 7.0 – 13.0 (g/dl) for broiler chickens (Mitruka and Rawnsley, 1977; Swenson, 1999). The birds fed control, BRSM and FRSM diets have higher (P<0.05) concentration of Hb than the other treatment groups, indicating higher tendency of the birds to overcome respiratory stress. High Hb implies high oxygen carrying capacity while below normal indicates low oxygen carrying capacity thus animals succumb easily to respiratory stress (Olugbemi et al., 2010; Aderemi and Alabi, 2013). According to Isom and Way (1974), free cyanide being a product of degradation from cyanogenic glycoside, as respiratory poison, has high acute toxicity due to its primary toxic effect of inhibiting cytochrome oxidase, the terminal enzyme of the mitochondrial electron transport chain by binding heme iron. Ultimately, this might have an effect on the erythropoiesis process; thus leading to low synthesis of the RBC from the lymphoid organ (Sharma et al., 2014). The mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH) of the birds were significantly (P<0.05) affected by the different methods of detoxification of the rubber seeds. The result of MCH and MCV of birds fed BRSM and FRSM diets compared (P>0.05) with those on the control diets while birds fed SRSM diets gave the lowest (P<0.05) concentration of these two variables. The lower (P<0.05) mean values of MCV and MCH recorded in birds fed SRSM diet might have resulted from the incomplete deactivation of residual hydrogen cyanide (Koprucu et al., 2006) due to soaking as compared to other processing methods. The WBC and MCHC showed there were no difference (P>0.05) among the different dietary treatment groups and their values ranged from 21.36 to 23.56 x10^6/mm^3 and 35.21 to 38.18% for WBC and WCHC respectively and were in harmony with the normal range of data reported for broiler chicken (Mitruka and Rawnsley, 1977). This indicted that all the treatment groups exhibit adequate immune response status and none of the detoxification methods predisposes broiler chickens to infection, as higher count than normal may mean that the bird's immune system may be combating some kind of infection (Adeyemo and Longe, 2007).

Serum Biochemistry

The results of serum biochemistry of broilers fed processed RSM based diets revealed that all the serum metabolites were significantly (P<0.05) affected by the processing methods (Table 6). Birds fed diets containing SRSM and TRSM have lower (P<0.05) serum protein than those on BRSM and FRSM diets having similar (P>0.05) mean values to those on the control diet. It appears that birds fed diet containing BRSM and FRSM have better protein utilization followed by TRSM than diet containing SRSM. This indicates efficient protein utilization by the broilers fed diets containing BRSM and FRSM, which are necessary for the formation of immunoglobulin as well as development of antibodies (Mmereole, 2008). Higher values show that there is enzymatic catabolism of dietary proteins and explained that the blood pool serves as a major source of amino acids needed for proteins synthesis (Scott, 1970; Njidda et al., 2006). This observation is an indication that the crude protein level in the BRSM and FRSM diets was sufficient to sustain the normal serum protein levels. Serum albumin values showed difference (P<0.05) among

Table 6: Serum biochemical indices of broiler chickens fed diets containing differently detoxified rubber seed meal (0-42d)

Parameters	Control	SRSM	BRSM	TRSM	FRSM	SEM
Total Protein (g/dL)	5.95^{a}	3.16^{c}	5.33^{a}	4.07^{b}	5.45^{a}	0.40
Albumin (g/dL)	3.22^{a}	2.32^{c}	3.14.^{a}	2.58^{b}	3.17^{a}	0.09
Uric acid (nmol/L)	0.58^{b}	1.83^{c}	0.62^{b}	1.27^{b}	0.71^{b}	0.07
Creatinine (mg/dL)	2.12^{a}	1.12^{c}	2.08^{a}	1.91^{b}	2.03^{ab}	0.06
Cholesterol (mg/dL)	139.73^{b}	162.77^{a}	144.84^{b}	157.76^{a}	146.88^{b}	3.60

a, b, c: Means in the same row bearing different superscripts differ significantly (P< 0.05); **SEM:** Standard error of mean; **SRSM:** Soaked rubber seed meal; **BRSM:** Boiled rubber seed meal; **TRSM:** Toasted rubber seed meal; **FRSM:** Fermented rubber seed meal.

the processing methods where birds fed FRSM and BRSM diets have the highest mean values than birds fed on diet containing TRSM and SRSM, but similar (P>0.05) to those on the control diet. This result agreed with the reports of Anon (1980) and Allison (1955) who reported changes in protein reserve in animal as shown by serum total protein to be associated with variations in the albumin component. In the present study, broiler birds fed SRSM diet have higher (P<0.05) uric acid concentration followed by those on TRSM diet than those fed control, BRSM and FRSM diets. This is an indication of reduced efficient protein utilization and could be due to the presence of residue cyanide that were not completely eliminated to a safe non-toxic level by soaking and toasting processing techniques, as reflected by the low serum total protein observed by birds in these groups (Akinola and Abiola, 1990). The diet and deamination of tissue proteins account for the origin of serum uric acid and also signifies the good quality of dietary protein (Awosanya et al., 1999; Ewuola and Egbunike, 2008). Lower (P<0.05) creatinine level observed in birds fed diet containing SRSM could be attributed to the presence of higher residual anti-nutritional factor, thus, leading to improper nutrient utilization since serum creatinine depend on the protein quality and quantity in the diet (Polat et al., 2011). The lower (P<0.05) concentrations of serum creatinine recorded among the birds fed control, BRSM, and FRSM diets is as a result of improved protein utilization for muscle growth in the tissues of birds (Lemme et al., 2007). Creatinine is the final product of the degradation of creatine and phosphocreatine in the skeletal muscle where it diffuses into the bloodstream (Nelson and Cox, 2000) and also an indicator of muscle mass catabolism (Ladokun et al., 2008). The lower creatinine values derived in birds fed BRSM and FRSM revealed no muscular wastage, possibly due to inadequacy of protein utilization in the birds as well as exhibiting an impairment of renal function (Ologhobo et al., 1993) Mean values of cholesterol of the birds showed significant (P<0.05) differences among the treatments and birds fed BRSM and FRSM diets compared favorably with the control diet and their mean values were lower (P<0.05) than those on TSRM and SRSM. The lower serum cholesterol observed in birds fed BRSM and FRSM could be attributed to low level of hydrocyanic acid (HCN) in the test RSM which must have caused no interference of glycosides on intestinal absorption of dietary cholesterol and lipid (Olugbemi et al., 2010; Aderemi and Alabi, 2013). The observed similarity in blood cholesterol among the control group and those on BRSM and FRSM diets was expected because of the comparable crude fat levels contained in diets which may invariably lead to comparable dietary fat intake (Duwa et al., 2012). The variations observed in most of the serological parameters are indication of reduced effect of toxic factors in the diet formulated with boiled and fermented RSM (Price et al., 1979).

CONCLUSION

Boiling and fermentation as a detoxification methods proved to be a more efficient for HCN reduction in rubber seed than toasting and soaking in water, hence making the protein in the diet more available for proper utilization. Therefore, the result revealed that inclusion of cooked and fermented RSM have positive effect on hematological and serum biochemical status of the broilers that was found almost similar to the control group.

CONFLICT OF INTEREST

Authors declared no conflict of interest.

AUTHORS CONTRIBUTION

Aguihe PC and Kehinde AS were responsible for the design and conduct of the experiment including laboratory analysis. Ospina-Rojas IC and Murakami AE were responsible for the statistical analysis of data. Aguihe PC and Ospina-Rojas wrote the manuscript. Murakami AE took responsibility of the proof reading and correction of manuscripts.

REFERENCES

• Aderemi F, Alabi O (2013). Effect of grade levels of cassava

peels fortified with moringa as a replacement to wheat bran on performance, digestibility and blood profile of broilers. J. Agri. Sci. Technol. 3(23): 210-215.
- Aderemi FA, Lawal TE, Iyayi EA (2006). Nutritional value of cassava root sieviate and its utilization by layers. J. Food Technol. Afr. 4 (3): 216-220.
- Adeyemo GO, Longe OG (2007). Effects of graded levels of cottonseed cake on performance, haematological and carcass characteristics of broilers fed from day old to 8 weeks of age. Afr. J. Biotechnol. 6 (8): 1064–1071.
- Ahaotu EO, Ekenyem BU, Agiang EA, Balakrishnan A, Madubuike FN (2010). Effects of dietary substitution of rubber seed cake for groundnut cake on the body conformations of finisher broilers. Anim. Prod. Res. Adv. 6: 44-47.
- Akinola SO, Abiola SS (1990). Blood chemistry and Carcass Yield of Cockerels Fed melon Based Diet. Trop. J. Anim. ScI. 3: 39-44.
- Akpodiete OJ, Ologhobo, AD (1998). The nutritive value of maggot meal in broiler chicks. II – Nutrient retention, haematology and serum chemistry. In: The Nigerian Livestock Industry in the 21st Century. Proceedings of the 3rd Annual Conference of the Animal Science Association of Nigeria (A. D. Ologhobo and E. A. Iyayi, eds.), Lagos Airport Hotel, Ikeja, Lagos. September 22nd – 24th, Pp 41-42.
- Allison JB (1955). Biological evaluation of proteins. Physio. Rev. 35: 664-669.
- Annongu AA, Ogundun NJ, Joseph KJ, Awopetu V (2006). Changes in chemical composition and bioassay assessment of nutritional potentials of almond fruit waste as an alternative feedstuff for livestock. Biokemistri. 18(1):25-30
- Anon (1980). Guide to the Care and Use of Experimental Animals Vol. 1. Ottawa, Ontario, Canada, Canadian Council on Animals Care. pp: 85-90.
- Association of Official Analytical Chemists (AOAC) (2006). Official Methods of Analysis of the Association of Official Analytical Chemists, Horwitz, W. (Editor), 18th edition, Washington DC, USA, 24-59.
- Awosanya B, Joseph JK, Apata DF, Ayoola MA (1999). Performance, blood chemistry and carcass quality attributies of rabbits. Int. Trop. J. Anim. Sci. 2: 89-96.
- Batel E, Geraf M, Meyer GT, Moller R, Schoedder G, Cher L (2008). Chemical composition and fatty acid profile of the lipid fractions of selected Nigerian indigenous oilseeds. Int. J. Food Prop. 11:273-281. https://doi.org/10.1080/10942910701302598
- Dacie JV, Lewis SM (2001). Practical Haematology, 9th ed. Churchill Livingstone, London.
- Duwa H, Oyawoye EO, Njidda AA (2012). Haematological Resoponses and Serum Biochemical Indices of Broilers Fed Differently Processed Sorrel Seed (Hibiscus Sabdariffa) Meal in Semi-Arid Region of Nigeria. Br. J. Poult. Sci. 1(1): 05-10.
- Eka HD, Tajul Aris Y, Wan Nadiah WA (2010). Potential use of Malaysian rubber (*Hevea brasiliensis*) seed as food, feed and biofuel. Int. Food Resour. J. 17: 527-534.
- Ermans AM, Mbulamoko NM, Delange F, Ahluwalia R (1980). Role of Cassava in the Etiology of Endemic Goitre and Cretinism. International Development Research Centre, Ottawa, Ontario, Canada.
- Ewuola EO, Egbunike GN (2008). Haematological and serum biochemical response of growing rabbit bucks fed dietary fumonisin B1. Afr. J. Biotechnol. 7: 4304-4309.
- Gadzirayi CT, Masamha B, Mupangwa JF, Washaya S (2012). Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal. Int. J. Poult. Sci. 11 (1): 5-10. https://doi.org/10.3923/ijps.2012.5.10
- Giok LT, Samsudin MD, Husaini BS, Tarwotjo IT (1967). Nutritional value of Rubber seed Protein. American Journal of Clinical Nutrition 20:1300- 1303.
- Igene FU, Oboh SO (2004). Growth performance and haematological responces of cockerels fed diets containing differents diets levels of rice offals as replacements for wheat offals. Proceedings of 9th Annual Conference Animal Science Association Nigeria. Ebonyi State University, Abakiliki. pp. 20-22.
- Isom GE, Way JL (1974). Effect of oxygen on cyanide intoxication VI. Reactivation of cyanide inhibited glucose catabolism. J. Pharmacol. Exp. Ther. 189: 235–243.
- Iyayi EA, Fayoyin FK (2005). Effect of feeding cassava fruit coat meal on the nutrient digestibility and performance of broilers. Livestock Res. Rural Develop. 17, Art. #9. Retrieved February 16, 2017, from http://www.lrrd.org/lrrd17/1/iyay17009.htm
- Jain NC (1986). Schalm Veteniary Haemotology. 4th edition Philadelphia, Lea and Ferbinger.
- Joint FAO/WHO Expert Committee Report on Food Additive (JECFA). (1993). Cyanogenic glycosides. In: Toxicological Evaluation of Certain Food Additives and Naturally Occurring Toxicants, 39th Meeting of the Joint FAO/WHO Expert Committee on Food Additives (WHO Food Additive Series 30). World Health Organization, Geneva. http://www.inchem.org/documents/jecfa/jecmono/v30je18.htm
- Khatun MJ, Karim MZ, Das GB, Khan MKI (2015). Effect of the replacement of soybean meal by rubber seed meal on growth, Economics and carcass characterisitics of broilers. Iran. J. Appl. Anim. Sci. 5(4): 919-925.
- Köprücü SS, Köprücü K, Ural MS¸ Ispir Ü, Pala M (2006). Acute toxicity of organophosphorous pesticide diazinon and its effects on behavior and some hematological parameters of fingerling European catfish (Silurus glanis L.). Pestic. Biochem. Physiol. 86: 99–105. https://doi.org/10.1016/j.pestbp.2006.02.001
- Ladokun AO, Yakubu A, Otite JR, Omeje JN, Sokunbi OA, Onyeji E (2008). Haematological and Serum biochemical indices of Naked and Nomally feathered Nigerian Indigeneous Chicken in the Sub–Humid Tropical Environment. Int. J. Poult. Sci. 7 (1):55 – 58. https://doi.org/10.3923/ijps.2008.55.58
- Lemme A, Ringel J, Sterk A, Young J F (2007). Supplemental guanidino acetic acid affects energy metabolism of broilers. Proc. 16th Eur. Symp. Poult. Nutr. Strasbourg, France. World's Poult. Sci. Assoc., Beekbergen, the Netherlands. Pp. 339–342.
- Lindsay DB (1977). The effect of feeding patterns and sampling on blood parameters. Occasional Public. No. 1 Br. Soc. Anim. Prod. Ed. By D. Lister, pp. 99-120.
- Madubuike, FN, Ekenyem BU, Tobih KO. (2006). Performance and cost evaluation of substituting rubber seed cake for groundnut cake in diets of growing pigs. Pak. J. Nut. 5(1):59-61. https://doi.org/10.3923/pjn.2006.59.61
- Mitruka BM, Rawnsley HM (1977). Clinical biochemical and hematological reference values in normal experimental animals. USA: Masson Publishing Inc. 1977.

- Mmereole FUC (2008). Effects of replacing groundnut cake with rubber seed meal on the haematological and serological indices of broilers. Int. J. Poult. Sci. 7: 622-62. https://doi.org/10.3923/ijps.2008.622.624
- Mohammed A, Agwunobi LN (2009). Taro Cocoyam (Colocasia esculenta) Meal as Feed Ingredient in Poultry. Pak. J. Nut. 8: 668-673. https://doi.org/10.3923/pjn.2009.668.673
- Nelson DL, Cox MM (2000). Amino acid oxidation and the production of urea. In: Nelson DL, Cox MM (Eds) Lehninger Principales of Biochemistry, 3rd edn, pp. 666–700 (New York, NY, Worth Publishers).
- Njidda AA, Igwebuike JU, Ngoshe AA, Tijjani AO (2006). Effect of substituting maize with graded levels of cane molasses on the performance of broiler finisher birds in the semi- arid region of Nigeria. J. Sustain. Agric. Environ. 8(1): 1-13.
- Nwokolo E (1987). A nutritional assessment of African yam bean (Sphenostylis stenocarpa (Horst ex A. Rich) Harms. and Bambara groundnut *Voandzeia subterranea* L. J. Sci. Food Agric. 41 (2): 123-129. https://doi.org/10.1002/jsfa.2740410205
- Offiong SA, Olumu JM (1990). Effect of feeding raw, toasted, cooked or autoclaved full fat soybean on the growth of broiler chicken. Trop. Agric. Trinidad. 3:297-302.
- Okafor PN, Anyanwu NO (2006). Enzymatic and oven-drying method of processing rubber seeds for animal feed and the evaluation of the toxicity of such feed in rats. J. Ani. Vet. Adv. 5(1): 45-48.
- Ologhobo AD, Apata DF, Oyejide A, Akinpelu RO (1993). Toxicity of raw lima beans (*Phaseolus lunatus*) and Lima bean fractions for growing chicks. Br. Poult. Sci. 34: 505-522. https://doi.org/10.1080/00071669308417606
- Ologhobo AI, Jimoh, OA, Orscar TJ, Mosenthin R (1999). Evaluation of detoxified Jackbean (*Canavalia ensiformis*) in broiler starter rations with amino acid supplements. Trop. J. Anim. Sci. 1: 117-126.
- Olugbemi TS, Mutayoba SK, Lekule FP (2010). Effect of Moringa (Moringaoleifera) inclusion in cassava based diets fed to broiler chickens. International Journal of Poultry Science, 9: 363 – 367.
- Oluyemi JA, Fetuga BL, Endely HN (1975). The metabolisable energy value of some feed ingredients in young chicks. Poult. Sci. J. 53: 611-618.
- Onu PN, Okongwu, S.N. (2006). Performance characteristics and nutrient utilization of starter broilers fed raw and processed pigeon pea (*Cajanu scajan*) seed meal. Int. J. Poult. Sci. 5: 693-697. https://doi.org/10.3923/ijps.2006.693.697
- Oyewusi PA, Akintayo E T, Olaofe O (2007). The proximate and amino acid composition of defatted rubber seed meal. Int. J. Food Agric. Environ. 5 (3-4): 115-118.
- Polat U, Yesilbag D, Eren M (2011). Serum Biochemical Profile of Broiler Chickens Fed Diets Containing Rosemary and Rosemary Volatile Oil. J. Biol. Environ. Sci. 5(13): 23-30.
- Price ML, Butler LG, Rogler JC, Featherston WR (1979). Overcoming the nutritionally harmful effects of tannin in sorghum grains by treatment with inexpensive chemicals. J. Agric. Food Chem. 27: 441-445. https://doi.org/10.1021/jf60222a052
- Ravindran V, Ravindran G (1988). Some nutritional and anti-nutritional characteristics of Para-rubber (Hevea brasiliensis) seeds. Food chem. 30(2): 93-102. https://doi.org/10.1016/0308-8146(88)90147-1
- Scott A (1970). Absorption of carbohydrate and protein metabolism. In: Duke's Physiology of Domestic Animals. 18 edn. (Swenson, M.J. edns). Cornell University Press Limited, London.
- Sharma BB, Saha RK, Sala H (2014). Effects of feeding detoxified rubber seed meal on growth performance and haematological indices of *Labeo rohita* (Hamilton) fingerlings. Anim. Feed Sci. Technol. 193: 84-92. https://doi.org/10.1016/j.anifeedsci.2014.03.008
- Statistical Analysis System (SAS) (2006). Statistical Analysis System, Users Guide. Statistical Analysis Institute Inc. Cary, North Carolina.
- Swenson MJ (1999). Duke's physiology of domestic animal. Constick Publishing Associates, a division of Cornell University Press, Thecae, London, Eleventh edition, Pp. 22 -48.
- Syahruddin E, Herawaty R, Ningrat RWS (2014). Effect of substitution of leaves and seeds of rubber (*Hevea Brasilliensis*) fermentation with soybean meal on the performance of broilers. Pak. J. Nut. 13(7): 422-426. https://doi.org/10.3923/pjn.2014.422.426
- Tuleun CD, Igba F (2008). Growth and carcass characteristics of broiler chickens fed water soaked and cooked velvet bean (*Mucuna utilis*) meal. Afr. J. Biotechnol. 7 (15): 2676-2681.
- Udedibe ABI, Carlini CR (2000). Relative effects of dry and most heat treatment on hemagglutinating and antitryptic activities of selected legumes grains. Niger. Poult. Sci. J. 1:81-87.
- Ugwuene MC, Kong SFA (2004). Performance of broiler chickens fed varying levels of full fat palm kernel meal. In: Proc. Ninth Ann. Conf. Anim. Sci. Assoc. Nig. Ebonyi State Univ., Abakiliki, pp. 73–75.
- Ukpebor JE, Akpaja EO, Ukpebor EE, Egharevba O, Efedue E (2007). Effect of the edible mushroom, *Pleurotus tuberregium* on the cyanide level and nutritional contents of rubber seed cake. Pak. J. Nut. 6: 534-537. https://doi.org/10.3923/pjn.2007.534.537