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Biochemical parameters, performance studies and lipid profile of broiler birds fed Bambara meal substituted diet

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Target Audience: *Researchers and farmers*

Abstract

This research investigated the performance and serum enzymes activities of broiler birds fed 40% replacement level of Soybean meal (SBM) for Bambara groundnut meal (BGM). A total of 140 newly hatched broiler chicks (Arbor Acre strain) allocated in a completely randomized design were used for the research. The experimental diets consisted of seven dietary treatments, four replicates of five birds per replicate. Treatment 1 (0% BGM) served as the control diet, T2-T7 contained equal concentration (40% substitution level) of differently processed BGM. The activities of the transaminases (ALT and AST), gamma glutamyl transferase, the concentrations of serum total protein, creatinine, uric acid, as well as the serum lipid profile were monitored. Findings revealed that there were no significant ($p>0.05$) differences amongst the serum ALT of birds on boiled, fermentation with and fermentation without decantation Bambara groundnut diets (0.922, 0.933 and 0.932 nmol min^{-1} mg^{-1}) respectively. Serum high density lipoprotein cholesterol were highest in roasted and raw Bambara groundnut (1.86 mmol/L) meal diets. The drum stick (146.412 g) and the thigh (192.455g) of birds placed on raw Bambara groundnut meal had higher significant ($p<0.05$) weight gain values compared with those of birds on other experimental diets in the study. The results thus indicated that replacing Bambara groundnut at 40% against soya bean meal had no detrimental effects on measured indices, hence save for poultry farmers and consumers of the meat.

Keywords*: Bambara groundnut, broiler chicks, performance study, alkaline phosphatase, creatinine.*

Description of Problem

Bambara groundnut is of West Africa origin, but now extensively found throughout sub-Saharan Africa -SSA (1). The seeds are highly nutritious and are used for human and animal consumption. Common names are Bambara groundnut or Bambara nut. Botanical name is *Vonandzeia subterranean (L.) thousars*, it belongs to the plateau of the family of Fabaceae, sub family of Faboidea (2). It has high carbohydrate content of 65%, and high amino acid content of 18% as well as 6.5% of fat, making the nut a perfect food (3). According to (2), the nut had better vital essential amino acids compared to peanuts. Seeds and leaves have been efficiently used in animal nutrition, being a rich source of ~~n~~itrogen and phosphorus (2).

Bambara groundnut can be used to replace soya beans meal in poultry feeds, and previous research by (4) has replaced Bambara groundnut at 20% as a protein replacement in the starter phase, which was effective with no leakages of enzyme into the serum from vital body organs. In the present study, Bambara groundnut was increased to 40% to see if the nuts could have detrimental effect on vital organs as the concentration increases, targeting majorly the performance characteristics (carcass measures, weight gain and feed conversion ratio) and enzyme activities (serum liver and kidney function tests) of the broiler chickens at the finishing stage.

Materials and Methods

Sample collection and preparation

The study was carried out in the Biochemistry and Nutrition Unit, Department of Chemical Sciences. Fountain University, Osogbo, State of Osun, Nigeria. The experimental nuts were purchased from Wukari main market, Taraba State. The seeds were processed at Fountain University, Osogbo according to the method described by (4) as briefly highlighted;

Boiling

One kilogram of the seed was poured into distilled water (8 litres) for 60 minutes at the boiling point.

Soaking

A kilogram of the seed was soaked for 12 hours in distilled water (8 litres).

Fermentation without decantation

One kilogram of the seed was soaked in distilled water (8 litres), using a well-sealed container for 60 hours continuously without decanting the distilled water.

Fermentation with decantation

A kilogram of the seeds was soaked in distilled water (8 litres) for 12 hours using a well-sealed container. The water was then drained after the 12 hours, and then replenished with another fresh distilled water for subsequent 48 hours (5).

Roasting

A kilogram of the seed was roasted in a frying pan half-filled with fine sand. This was continuously stirred until brownish colour was obtained. While roasting, superfluous burning was guided against in order to avoid denaturing the essential amino acids (6).

Raw Bambara groundnut

This is left raw without any processing method.

Nutritional analysis of the various processed seeds were then ascertained.

Diet formulation

The analysed proximate analysis of the nuts using different processing methods served as a basis for the formulation of the different dietary treatments that were used in the course of the experiments

Experimental design, diets and birds' management

140 newly hatched broiler chicks (Arbor Acre strain) from a reputable hatchery were used for the research. The experimental diets consisted of seven dietary treatments, four replicates of five birds per replicate in a completely randomized design. Treatment 1 (0% Bambara groundnut) served as the control diet, T2-T7 contained equal concentration (40% substitution level) of differently processed Bambara groundnut meal (Roasted Bambara groundnut: RBG, Boiled Bambara groundnut: BBG, Soaked Bambara groundnut: SBG, Fermentation with decantation: FBGw, Fermentation without decantation: FBGwo and raw) respectively. The poultry house was cleaned and disinfected a few days before the accession of the birds. The experimental protocol followed the regulations of the Animal Care and Use Committee, Fountain University, Osogbo, Nigeria. The basic managerial procedure was strictly adhered to, feed and water were given without restrictions. The chicks were vaccinated using the Lasota vaccine on the eighth day when maternal antibody had subsided (7), it was then repeated on the 17th day. They were also vaccinated orally using gumboro vaccine on the 10th and 37th day. The birds were initially group-brooded for the first week of life. The study lasted for six weeks.

Blood collection and carcass measures

Chemicals and reagents

Assay kits for the various enzyme studies and lipid profiles were obtained from Randox

Laboratories, County Antrim, UK. Other reagents (analytical grade) were prepared using distilled water.

Weekly weight gain and feed intake were monitored to allow for the calculation of final weight gain and feed conversion ratio.

Feeds were withdrawn 12 hours prior to sacrifice, so as to empty the crop. Two birds per replicate, totalling 8 birds per treatment were then sacrificed and blood samples obtained via jugular vein, allowed to clot for 20 minutes and then centrifuged at 3000 revolutions for five minutes using a Gallenkomp Bench Centrifuge 90-1 made in England. The resulting clear serum was aspirated using 0-1000 micropipette into the Eppendorf tube and used within 10 hours for the various biochemical analyses to retain the integrity of the enzyme in the sample. The birds were thereafter de-feathered, weighed whole and cut parts (breast weight, drum stick, and thigh) were weighed to assess the effect of the experimental diets on the cut parts.

Measurement of enzyme activities

The concentration of the protein was analyzed for, by Biuret method as described by (8). The activities of the enzymes were carried out by procedures as described for aminotransferases (alanine and aspartate aminotransferases) by (9), gamma glutamyl transferase (GGT) by (10), creatinine, uric acid and lipid profile by (11).

Statistical analysis

Test for differences between means were determined using analysis of variance, Duncan's and Tukey-Kramer's tests were then used for significant differences ($P<0.05$) between the variables in the study.

Results

Table 1 showed the overall proximate composition (g/100 g DM) of the individual seeds that were subjected to different processing methods. The crude protein contents of the differently processed seeds ranged within 22.64 g/100g DM for boiled seeds to 28.59 g/100 g DM for roasted seeds. The ether extract ranged between 7.65 to 7.90 g/100 g DM for birds on the boiled and those on the raw seeds respectively.

Table 2 summarized the gross composition (Kg / 100 g of the experimental diets. The results gotten from the initial proximate analysis of the individual seeds in Table 1 served as the basis of this formulation.

Table 3 showed the proximate composition (g/100 g DM) of the formulated BGM. This become very necessary in order to ascertain that what was formulated in Table 2 was actually worked with, hence authenticating the results gotten from the research.

Table 1: Proximate composition (g/100gDM) of the different processed Bambara groundnut seed meal

Analysis (%)	BBG	SBG	FBG (wo)	FBG(w)	RBG	Raw
Crude protein	22.64	22.73	22.72	22.73	28.59	22.58
Dry matter	90.74	92.52	93.20	92.45	91.59	93.45
Crude fibre	8.71	10.17	9.84	9 .61	8.79	8.13
Ash	2.44	2.18	2.46	2.19	2.40	2.24
Ether extract	7.65	7.82	7.79	7.85	7.59	7.90
NFE	49.3	49.62	50.39	50.07	44.22	52.60

BBG= Boiled Bambara groundnut, SBG= Soaked Bambara groundnut, FBG (wo) = Fermentation without decantation, FBG (w) = Fermentation with decantation, RBG= Roasted Bambara Groundnut, NFE= Nitrogen Free Extract.

Table 2: Gross composition (kg/100gDM) of experimental diets

Ingredients	Control	Boiled	FBG(w)	FBG(wo)	RBG	SBG	Raw
Maize	67	62	62	62	62	62	62
Bambara	0	7.2	7.2	7.2	7.2	7.2	7.2
SBM	18	10.8	10.8	10.8	10.8	10.8	10.8
Fish	1	1	1	1	1	1	1
GNC	6	10	10	10	10	10	10
Wheat offal	2	2.5	2.5	2.5	2.5	2.5	2.5
Oil	2	2.5	2.5	2.5	2.5	2.5	2.5
Limestone	1.74	1.74	1.74	1.74	1.74	1.74	1.74
Bone meal	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Methionine	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Lysine	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Salt	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100

*SBM=Soya Bean Meal, GNC=Groundnut Cake, BBG= Boiled Bambara Groundnut, SBG=Soaked Bambara Groundnut, FBG (wo) =Fermentation without decantation, FBG (w) =Fermentation with decantation, RBG=Roasted Bambara Groundnut. *Premix supplied the following information Kg of diet: Vitamin A (12,500,000 I.U), Vit D3 (2,5000,000 I.U), Vit E (40,000mg) Vitamin K3 (2,000mg), Vitamin B (3,000mg), Vit B2 (5,500mg), Niacin (55,000mg), Calcium Panthothenate (11,500mg) Vit B6 (5000mg), Vit B12 (25mg) choline chloride (500,000mg), folic acid (1,000mg), Biotin (80mg), Mn (120,000mg).*

Table 3: Proximate composition (g/100gDM) of the formulated Bambara groundnut seed meal-based diets

Analysis (%)	Control	RBG	BGB	SBG	FBG_W	FBG_{WO}	RAW
D/M	92.54	92.52	92.31	92.00	92.38	92.52	91.84
C/P	18.28	18.09	18.04	18.03	18.08	18.02	18.28
C/F	3.32	3.56	3.56	3.65	3.61	3.62	3.67
Ash	2.67	2.72	2.61	2.15	2.34	2.45	2.79
E/E	5.60	5.55	5.55	5.83	5.85	5.79	5.90
NFE	62.67	62.60	62.55	62.44	62.52	62.64	61.20

D/M - Dry matter, C/P – Crude Protein, C/F – Crude Fibre, E/E, NFE - Nitrogen Free Extract, RBG: Roasted Bambara groundnut, BBG: Boiled Bambara groundnut, SBG: Soaked Bambara groundnut, FBGw: Fermentation with decantation, FBGwo: Fermentation without decantation.

Serum liver function tests

Table 4 showed that there were no prominent statistical significant differences ($p>0.05$) in the serum alanine aminotransferases (ALT) of birds on the raw Bambara groundnut meal diet and the control, there were also no noticeable differences amongst the serum ALT of birds on boiled, fermentation with and fermentation without decantation Bambara groundnut diets (BBG, FBG_W, and FBG_{WO} respectively). Serum ALT was highest for soaked Bambara groundnut meal.

Serum aspartate aminotransferase (AST) also revealed a non-significant differences between birds on the control diet and those on the raw BGM diet. Birds on the soaked and fermentation with decantation had the highest AST levels. No significant ($p>0.05$) difference amongst the serum AST of birds on boiled and

fermentation without decantation Bambara groundnut meal diets.

Serum gamma glutamyl transferase (GGT) revealed that birds on soaked, fermentation with decantation and raw Bambara groundnut meal diets had significant ($p<0.05$) values when compared with the birds placed on the diet without Bambara groundnut meal, with birds placed on roasted meal diet having the highest GGT value.

Table 4: Biochemical assays of broiler birds fed different processed Bambara groundnut seed meal-based diets

			Serum liver function tests (nmol min^{-1} mg^{-1})				
Treatments	Control	RBG	BBG	SBG	FBG_W	FBG_{WO}	RAW
ALT	0.835 ± 0.04^{c}	0.893 ± 0.09^{bc}	0.922 ± 0.07^{b}	1.042 ± 0.04^{a}	0.933 ± 0.10^{b}	0.932 ± 0.06^{b}	0.820 ± 0.04^{c}
AST	0.608 ± 0.04^{c}	0.710 ± 0.06^{ab}	0.685 ± 0.08^{b}	0.747 ± 0.02^{a}	0.767 ± 0.02^{a}	0.683 ± 0.05^{b}	0.660 ± 0.04^{bc}
GGT	0.450 ± 0.03^{c}	0.555 ± 0.02^{a}	0.393 ± 0.04^{d}	0.450 ± 0.03^{c}	0.453 ± 0.03^{c}	0.683 ± 0.05^{b}	0.442 ± 0.05^{c}
			Serum Kidney function tests				
Treatments	Control	RBG	BBG	SBG	FBG_W	FBG_{WO}	RAW
Creatinine *(umol/L)*	29.00 ± 0.16^{b}	33.50 ± 2.56^{a}	21.83 ± 1.47^{c}	26.17 ± 2.85^{bc}	31.17 ± 1.16^{ab}	34.00 ± 1.41^{a}	32.67 ± 1.97^{ab}
Uric acid *(mmol/L)*	4.53±0.16	4.65±0.15	4.53±0.22	4.68±0.16	4.58±0.19	4.47±0.31	4.57±0.25
			***Serum total protein** (g/L)*				
Treatments	Control	RBG	BBG	SBG	FBG_W	FBG_{WO}	RAW
Total Protein	28.67 ± 1.63^{b}	27.67 ± 1.37^{b}	29.50 ± 2.17^{b}	34.17 ± 2.23^{a}	34.17 ± 0.98^{a}	29.67 ± 1.63^{b}	27.50 ± 1.63^{b}

The results are mean ± SEM of 4 determinations. RBG: Roasted Bambara groundnut, BBG: Boiled Bambara groundnut, SBG: Soaked Bambara groundnut, FBGw: Fermentation with decantation, FBGwo: Fermentation without decantation.

[a,b] Means within the column with different superscripts are significantly different ($p<0.05$).

Table 5. Performance studies (g) of broiler birds fed different processed Bambara groundnut seed meal-based diets

Dietary treatments	Initial weight	Final weight	Weight gain/bird/day	Feed intake	Feed conversion Ratio
Control	0.116 ± 0.01^{c}	1.600 ± 0.13^{b}	1.483 ± 0.12^{c}	2.699^{d}	1.82^{b}
RBG	0.117 ± 0.01^{c}	1.525 ± 0.09^{d}	1.408 ± 0.08^{d}	2.422^{d}	1.72^{a}
BBG	0.116 ± 0.01^{c}	1.542 ± 0.14^{c}	1.425 ± 0.13^{c}	2.480^{b}	1.74^{a}
SBG	0.1225 ± 0.01^{b}	1.633 ± 0.11^{ab}	1.510 ± 0.10^{b}	2.582^{c}	1.71^{a}
FBG_W	0.125 ± 0.00^{ab}	1.594 ± 0.12^{bc}	1.469 ± 0.12^{bc}	2.512^{c}	1.71^{a}
FBG_{WO}	0.128 ± 0.00^{a}	1.700 ± 0.17^{a}	1.573 ± 0.57^{a}	2.674^{d}	1.70^{a}
Raw	0.116 ± 0.01^{c}	1.525 ± 0.09^{d}	1.408 ± 0.08^{d}	2.394^{a}	1.70^{a}

The results are mean ± SEM of 4 determinations. RBG: Roasted Bambara groundnut, BBG: Boiled Bambara groundnut, SBG: Soaked Bambara groundnut, FBGw: Fermentation with decantation, FBGwo: Fermentation without decantation.

[a,b,c,d,] Means within the column with different superscripts are significantly different ($p<0.05$)

Serum kidney function tests and total protein

There were no clear statistical significant ($p>0.05$) differences between the serum creatinine contents of birds placed on raw and fermentation with decantation BGM based diets when compared with those of the birds placed on the control diet. There were no significant ($p>0.05$) differences in the serum creatinine mean values of birds placed on the roasted and fermentation without decantation Bambara groundnut meal based diets. The results amongst all dietary treatment groups compete favourably with the results of birds placed on the control diet. No significant

($p>0.05$) differences were noticed also in the serum uric acid contents across all treatments.

Birds placed on roasted, boiled, fermentation without decantation and raw BGM showed no significant differences in term of serum total protein when compared with the control. There were equally no significant ($p>0.05$) differences in the serum total protein value of birds placed on soaked and fermentation with decantation BGM diet.

Table 6: Lipid profile (mmol/L) of broiler birds fed with different processed Bambara groundnut seed meal-based diet.

Dietary Treatments	Total Cholesterol	HDL cholesterol	LDL cholesterol	Triglycerides
Control	2.67 ± 0.15^{a}	1.16 ± 0.02^{b}	2.05 ± 0.03^{a}	2.70 ± 0.03^{a}
RBG	2.17 ± 0.08^{c}	1.86 ± 0.02^{a}	0.34 ± 0.02^{c}	2.66 ± 0.02^{a}
BBG	2.47 ± 0.12^{b}	0.88 ± 0.02^{c}	0.33 ± 0.02^{c}	2.28 ± 0.02^{b}
SBG	1.93 ± 0.12^{d}	0.67 ± 0.02^{d}	0.25 ± 0.01^{d}	1.63 ± 0.03^{c}
FBG_W	2.23 ± 0.12^{bc}	0.89 ± 0.02^{c}	0.35 ± 0.02^{c}	1.49 ± 0.01^{d}
FBG_{WO}	2.17 ± 0.10^{c}	0.87 ± 0.02^{c}	0.53 ± 0.01^{b}	2.68 ± 0.02^{a}
Raw	2.17 ± 0.08^{c}	1.86 ± 0.02^{a}	0.34 ± 0.02^{c}	2.66 ± 0.02^{a}

The results are mean ± SEM of 4 determinations. RBG: Roasted Bambara groundnut, BBG: Boiled Bambara groundnut, SBG: Soaked Bambara groundnut, FBGw: Fermentation with decantation, FBGwo: Fermentation without decantation.

^{a,b,c,d} Means within the column with different superscripts are significantly different ($p<0.05$).

Performance characteristics

Table 5 showed that the final weight gain per bird per day (g) of birds on fermented Bambara groundnut without decantation (1.573g) was significantly different ($p<0.005$) from the final weight of birds on the control diet (1.483), and as well from the final weight gain of birds on the different processed Bambara meal diets . There were no significant differences between feed conversion ratios (FCR) of birds on the different processed BGM, which were significantly different from the FCR of birds on the experimental diets. Birds on the different processed BGM had better FCR when compared with that of the birds on the control diet.

Lipid profile

Table 6 showed that the birds placed on the soybean meal diet (control diet) recorded the highest total cholesterol level. High density lipoprotein cholesterol, termed good lipids are highest in roasted and raw Bambara groundnut meal diets. Low density lipo-protein (LDL) cholesterol termed bad lipid was highest in the control diet. Every processing method recorded a lower LDL level. No significant difference in the triglycerides values of birds on the control, roasted, fermentation without decantation, and raw Bambara groundnut meal diets (2.77, 2.66, 2.68, 2.66 mmol/L) respectively. Birds placed on soaked and fermentation with decantation BGM diets recorded lower mean values of triglycerides (1.63 and 1.49 mmol/L) respectively.

Table 7: Carcass characteristics and organ to body weight ratio (g) of broiler birds fed different processed Bambara groundnut seed meal-based diets

Carcass characteristics							
Treatments	Control	RBG	BBG	SBG	FBG_W	FBG_{WO}	RAW
Breast weight	174. 908±3.78^{c}	159.063±1.09^{d}	123.343±1.91^{f}	217.333±1.58^{a}	139.578±0.53^{e}	170.302±1.12^{C}	192.937±5.19^{b}
Drum stick	118.137 ±3.77^{c}	119.127±0.91^{c}	122.175±2.36^{b}	106.703±0.75^{d}	99.035±0.65^{e}	101.428±0.79^{e}	192.455±2.80^{a}
Thigh	153.012±1.88^{c}	159.155±1.60^{b}	156.200±2.63^{c}	149.368±1.30^{d}	134.588±2.08^{e}	128.537±1.10^{f}	192.455±2.80^{a}
Organ to body ratio							
Treatments	Control	RBG	BBG	SBG	FBG_W	FBG_{WO}	RAW
Kidney	5.477 ± 0.12^{C}	7.003 ± 0.31^{b}	9.395 ±0.70^{a}	6.065 ± 0.61^{c}	5.848 ±0.05^{c}	6.772 ±0.31^{b}	9.788± 1.12^{a}
Liver	23.11± 0.75^{b}	21.87 ± 1.27^{bc}	24.05 ± 0.93^{b}	23.57 ± 0.96^{b}	20.38 ±0.92^{c}	16.86 ±0.07^{d}	27.00 ± 1.99^{a}

The results are mean ± SEM of 4 determinations. RBG: Roasted Bambara groundnut, BBG: Boiled Bambara groundnut, SBG: Soaked Bambara groundnut, FBGw:
Fermentation with decantation, FBGwo: Fermentation without decantation.
^{a,b,c,d,e,f} Means within the column with different superscripts are significantly different ($p<0.05$)

Carcass characteristics and organ to body ratio

Table 7 showed the carcass characteristics of experimental birds fed different processed BGM. Birds fed with soaked Bambara groundnut (SBG) followed by those on the raw nuts had higher significant ($p<0.05$) breast weight when compared with other experimental diets. The drum stick and the thigh of birds placed on raw Bambara groundnut meal had higher weights ($p<0.05$) compared with birds on other experimental diets.

The organ to body ratio (kidney and liver) as a percentage of birds' dressed weight showed that the birds placed on raw and boiled BGM based diets had the highest ($p<0.05$) kidney to body weight ratio (%) when compared with the weight of the kidney of birds placed on the control diet, followed by those of the birds placed on RBG and FBG_{wo} diets. There were no noticeable significant difference in the kidney to body weight ratio of birds on the soaked and fermentation with decantation BGM based diet when compared with those of the birds placed on the control diet. In the same vein, the liver to body weight ratio of birds on raw BGM based diet also had a statistical significant ($p<0.05$) effect when compared with those on other experimental meal, this was followed by the liver weight of birds on boiled and soaked BGM based diet competing favourably with those of the birds placed on the control diet, showing no noticeable statistical significant differences ($p<0.05$).

Discussion

The safety or dangers associated with the use of plant materials at the cellular level have always been monitored through enzyme activities (12). Cellular necrosis is usually monitored using ALT and AST, and high levels in serum may signal malfunctioning of the liver (13). Both enzymes occupy a central point in amino acid metabolism and are usually found in the liver, heart, kidney, skeletal muscle and other tissues (14). They are indicators of liver damage, majorly resulting from exposure to chemicals (15). Alanine aminotransferase is more liver specific (16). It was earlier reported that pigeon pea and Bambara nut are the only legumes that are comparable with soyabean as constituents in poultry diets formulation (17).

GGT is another liver enzyme found in the renal and hepatic tissue, but are having the highest level of its activity found in the renal

tissue (16, 18). Its' occurrence in the serum originates primarily from the hepatobiliary system (14). GGT activity is activated during all types of diseases of the liver, with the highest level found during cases of intrahepatic or post-hepatic biliary blockage. It is more a specific detector of jaundice, cholangitis, and cholecystitis than alkaline phosphatase and transaminases (18). Inclusion of up to 40% *Vigna subterranean* in broiler rations had no effect on broiler liver function indices (19). A non-significant difference in the organic matter (OM) and crude protein CP contents of birds placed on the Bambara groundnut diet and those on control at up to 57% inclusion level had earlier been reported by (20).

The indices of liver functionality researched into in this study (ALT, AST and GGT) had proven that the liver of birds on the different processed experimental diets were not jeopardized, since some of the results had similar enzyme activities as recorded in those of the birds placed on the control diet. BGM at 40% supplement has proven to be safe in broiler diets formulation. Inclusion of up to 40% *Vigna unguiculata/subterranean* in broiler rations did not result into any negative impact on feed intake and enzyme activities (18, 19). Raw Bambara groundnut diet seems to compete favourably with the control diet in all indices of measuring liver functionalities. This could imply that that the antinutrients, if any, which may be in the raw nuts is still within the lethal dose, hence, are not detrimental to broiler chicks' performance (17).

Creatinine, a by-product of creatine metabolism is an analyte, usually used as an indicator of kidney functionality (21). Results obtained for creatinine is in line with the work of (22) that reported non-statistical significant difference in finisher broiler chickens fed with Bambara groundnut meal at up to 30%. Non-significant ($p>0.05$) differences in the result proved that the Bambara groundnut meal had no negative effect on the kidney of the birds on different experimental dietary treatment. The result further depicted a good anatomical process in the experimental broiler chickens given the experimental diets, confirming the nutritional correctness of the various processing methods of the experimental diets (23, 24).

The internal production of uric acid is usually from the kidneys, liver, intestines, and the vascular endothelium (25). Uric acid synthesis and digestion are intricate mechanisms involving different factors that control hepatic synthesis, and consequently the renal and gut elimination of the compound (26). The obtained uric acid results negates the findings of (17, 27) that reported decreased levels of serum protein and albumin and an increase levels of serum urea and creatinine in rats fed kidney bean and some other legumes dominant in tropical West African for poultry. This implies that the serum uric acid contents were not influenced by any of the processing methods. A non-significant ($p>0.05$) difference in uric acid concentration when bitter vetch seeds were fed to 42-day old chicks had earlier been reported by (28).

Protein performs many functions in living organisms, ranging from providing structural supports, storage medium, to serving a transportational role, transporting important substances across biological membranes. It also serves as an expensive means of synthesising energy. The various processing methods posed no detrimental effect on the quality of serum total protein of the birds, raw diet inclusive. Cooking time as a form of processing method had earlier been reported by (5) to improve the quality of protein of Bambara groundnut seed.

The final weight gain (gram/bird/day) as obtained in this study is in line with the findings of (4) which reported similar results when broiler chickens (starter phase) were fed Bambara groundnut meal at 20% inclusion

level. This might imply that the different processing methods, at 40% as aided the availability, palatability and hence, utilizability of the nuts. This is equally in line with the findings of (29) which reported that BGM based diets at 30% had no deleterious effect on the growth rate of broiler birds at the finisher phase. On the contrary, the positive effect of the different processed BGM based diets on the final weight gain negate the findings of (30) which reported that birds fed with BGM based diets recorded a drop in weight gain, but gave attribute to autoclaved Bambara nuts, as a result of the processing method to have taken care of antinutritional factors in the nut. The favourable FCR obtained in this study is in line with the findings of (29).

Lipids are a group of fats and fat-like constituents that are important components of cells as well as being expensive roots of energy. A lipid panel estimates the level of definite lipids in the blood. Highest high density lipoprotein cholesterol obtained for birds placed on roasted and raw Bambara groundnut meal diets is in line with the work of (31) that reported an increased high density lipoprotein and a reduced low density lipoprotein when velvet beans were fed to broiler chickens at up to 15- 25%. The obtained results for low density lipoprotein is in line with the work of (32) that reported a low very low density lipoprotein (VLDL) when 66 and 100g squash seed meal /kg were fed to broiler chickens. This implies that the various processing methods confer a positive effect on the LDL cholesterol contents of the nut. Reduced low density lipoprotein should result into reduced triglycerides in the blood, which could have favoured the lower level of triglycerides recorded for birds placed on soaked and fermentation with decantation Bambara groundnut diets. The processing method could have favoured the reduced triglycerides in the duo diets. This correlates with the work of (31) that reported lower level of triglycerides for birds placed on velvet beans for up to 25%. Obtained cholesterol result is in line with the findings of (33), which reported that fat metabolism can be appraised by quantifying the cholesterol content of a feed sample. Seed with high fat content could result into obesity. High cholesterol mean values that deviate too much significantly away from control diets' mean values are usually associated with hypothyroidism, hepatic lipidosis, and some other related diseases. The mean cholesterol values obtained in this research were an indicator of positive virile advantage of adding Bambara groundnut meal to broiler chicks' diet.

It had earlier been reported that Bambara groundnut posed no detrimental effect on diet palatability, and hence did not contain any anti-nutritional factors that could negatively influence feed intake (30). The obtained carcass weight in the present study is in line with the findings of (29, 34), which reported a higher thigh length and thigh diameter for birds on 30% Bambara nuts waste, probably because of the intact availability of essential amino acids (methionine and lysine). This depicts a better protein metabolism for birds' performance when placed on Bambara groundnut substituted meal.

The weight of the organ as a subset of the relative dressed weight of the experimental animal mostly denotes the effect of experimental diets on some organs of interest (35). Results of this study agrees with the work of (22, 36, 37, 38) which reported that the liver and gizzard percent in birds fed raw, cooked and toasted cowpeas respectively compete favourably with those of the birds on the control diet. A 40% replacement of cockerels' diet with raw Bambara nut offal had been reported to pose no deleterious effect on the birds' internal organs (39). No abnormal weight of the different organs measured were noted when broiler birds were fed raw and

toasted Bambara groundnut as sources of protein at 25% (40). The encouraging results noticed in birds fed raw Bambara nut diet could have resulted from a sizeable amount of essential amino acids (lysine and methionine content) present therein.

Conclusion and Applications

1. Bambara groundnut meal-based diet at 40% (finisher phase) inclusion level posed no negative effect on the studied biochemical parameters.
2. It favoured the broiler birds feed conversion ratio
3. It equally improved the weight of the cut parts. Hence, BGM could be used in broiler finisher diets without any detrimental effect.

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Disclosure of Interest

The author report no conflict of interest.

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