



Carcass Characteristics, Haematology and Serum Biochemistry of Broiler Chickens fed Diets Containing Gayamba Pearl Millet (*Pennisetum glaucum* L.) As Replacement for Red Sorghum

¹Kawu, Y.U., ²Doma, U.D., ²Abubakar, M. and ²Bello, K.M.

¹Federal Ministry of Agriculture & Rural Development, Bauchi, Nigeria

²Department of Animal Production, Abubakar Tafawa Balewa University, Bauchi, Nigeria,

Abstract

A Seven weeks experiment was conducted to investigate the effect of replacing red sorghum (RS) with gayamba pearl millet (GPM) on carcass characteristics, haematology and serum biochemistry of broiler chickens. Three hundred (300) broiler chicks were randomly assigned to four dietary treatments for the starter and finisher phases. At each phase, 0, 33.33, 66.67 and 100% of RS in the diets were replaced with GPM and the diets were coded, 1, 2, 3 and 4 respectively. Each treatment was replicated three times with 25 chicks per replicate in a completely randomized design (CRD). There was a significant ($P<0.05$) influence of diet in all the carcass indices, while most of the organs did not differ among diets. Live weight, plucked weight, eviscerated weight, carcass weight and dressing percentage of birds on 66.67 and 100% GPM were significantly ($P<0.05$) higher than those on other groups. Except for Mean Corpuscular Volume, all haematological parameters significantly ($P<0.05$) differed among treatments. Packed cell volume and haemoglobin concentration were significantly ($P<0.05$) higher on diets 3 and 4. Conversely, white blood cell count was significantly ($P<0.05$) lower on these two diets. Serum biochemical assay revealed that most of the parameters were not significantly influenced. While total protein and albumin were significantly ($P<0.05$) higher on diets 3 and 4, Alanine amino transferase and Aspartate amino transferase, were significantly ($P<0.05$) lower on same diets. The study concluded that GPM can replace RS up to 100% in broiler chickens' diets with improved carcass yield and no adverse effect on haematological and serum biochemical parameters.

Keywords: Broiler chickens, carcass characteristics, blood parameters, gayamba pearl millet, red sorghum

Introduction

Research on non-conventional feedstuff is aimed at exploring cheaper and readily available feed ingredients that have less direct nutritional demand to man as a way of curbing the hike in the cost of poultry feeds. This is due to the fact that feed cost accounts for about 70% of the total cost of poultry production and is at the same time considered the principal yardstick of profitability, sustainability and development of the poultry business (Atteh, 2004). An array of non-conventional energy feedstuffs has been identified among which is pearl millet. Pearl millet has been identified as a

suitable alternative to sorghum in low rainfall and sandy areas. It grows well under erratic rain, high temperature and poor soil conditions (Baurhoo *et al.*, 2011). Previous studies have shown that pearl millet has a metabolizable energy of 3280.94 kcal/kg (Bulus *et al.*, 2014), crude protein, 9.60 – 12.53% (Badau *et al.*, 2002), methionine, 0.28% and lysine 0.35% (Mukarami *et al.*, 2009).

The carcass yield of broiler chickens fed diets containing up to 50% ground millet were equivalent or better than those fed typical maize-soya bean diets (Engberg 2002). This study was conducted to

evaluate the carcass characteristics, haematology and serum biochemistry of broiler chickens fed *gayamba* pearl millet as replacement for red sorghum.

Materials and Methods

The Study Site

The study was conducted at the Poultry Unit, Teaching and Research Farm, Abubakar Tafawa Balewa University, Bauchi, Nigeria during the months of December 2018- February 2019. Bauchi is located within the geographic coordinates of 10°18' 37.2" N and 9° 50' 38.0" E. It is 616 metres above sea level, characterized by two well-defined rainy (May-October) and dry (November-April) seasons. It has an average annual rainfall of 1009 mm with the highest relative humidity of 94% in August and lowest (35%) in February. Ambient temperatures are between 13 - 17°C (December – February) and 36 – 37°C (March – April) (Geodatos, 2019; AccuWeather, 2019).

Source of *gayamba* pearl millet and red sorghum.

Gayamba pearl millet and red sorghum were procured from local markets at Tafawa Balewa and Dass Local Government Areas in Bauchi State. The two cereals were ground to the same particle size (2.0 mm) and incorporated into the diets at the specified levels.

Experimental diets

Four experimental diets were formulated using *gayamba* millet to replace red sorghum at 0, 33.33, 66.67 and 100% levels designated as diets 1, 2, 3 and 4, respectively. The main protein sources were full fat soya bean meal and groundnut cake. The starter diets contained 23% CP while the finisher has 20% CP (Tables 1 and 2).

Experimental birds and management

Three hundred unsexed broiler chickens of the *Cobb* strain were used for the study which lasted for seven (7) weeks. The birds were brooded for a period of 11 days during which they were given a commercial chick mash. At the end of the 11th day, the chicks were weighed and allotted to four (4) dietary treatments of three replicates each containing 25 birds each in a completely randomized design (CRD). Feed and clean drinking water were served *ad libitum* throughout the study period.

Data Collection

At the end of the experiment, two (2) birds were randomly selected per replicate for blood sample collection and subsequent carcass analysis. The birds were fasted overnight before samples collection and subsequent slaughter the next morning. The blood samples were collected in EDTA and EDTA-free vacuum tubes for haematological and biochemical indices determination, respectively. For the carcass measurements, the birds selected and starved were weighed individually before slaughter. Live weights, plucked weights, eviscerated weights and carcass weights (dressed weights) were determined. Dressing percentage was also calculated. Organ measurements (weights) were expressed as percentages of live weights.

Proximate composition of *gayamba* millet and red sorghum used in the experiment was determined according to the methods of AOAC (2011).

Data Analysis

Data collected on both carcass characteristics and blood parameters was subjected to one-way analysis of variance (ANOVA) using the SPSS version 23. Where significant differences between treatment means were observed, Duncan's

Multiple Range Test (Duncan, 1955), was used to separate them.

Results

The Proximate composition of the principal energy sources, *gayamba* millet and red sorghum used in the study are presented in Table 1. The results showed that the crude protein content of *gayamba* pearl millet (13.10%), ether extract

(4.43%) were slightly higher than 12.19 and 3.39% respectively, in red sorghum. However, NFE (73.16 vs 64.67%), ME (3322.80 vs 3139.32 kcal/kg), tannin (6.42 vs 1.46%) and phytate (315.48 vs 238.05 mg/100g) were higher in red sorghum than *gayamba* pearl millet. The percent composition of ingredients in the diets and calculated analysis of all the experimental diets is shown in Tables 2 and 3.

Table 1: Proximate Composition Red Sorghum and Gayamba Millet used in the Study.

Nutrient (%)	Red sorghum	<i>Gayamba</i> millet
Dry Matter	94.62	86.47
Crude protein	12.19	13.10
Crude fibre	3.70	1.96
Ether extract	3.39	4.43
Ash	2.18	2.31
NFE	73.16	64.67
ME (Kcal/kg)	3322.80	3139.32
Tannin (% C.E)	6.42	1.46
Phytate (mg/100g)	315.48	238.05

ME= Metabolizable energy, calculated according to the formula of Ponzenga (1985) as $ME = (37 \times \% CP) + (81 \times \% EE) + (35.5 \times \% NFE)$

NFE= Nitrogen-free-Extract, C.E.= Catechin equivalent

Carcass and organ characteristics

The results for carcass and organ characteristics of broiler chickens fed dietary levels of *gayamba* millet as replacement for red sorghum are presented in Table 4. All the carcass parameters measured were significantly ($P < 0.05$) affected by dietary treatments. Live and plucked weights of broiler birds on diets 3 (2110.39 vs 2006.59g) and 4 (2158.09 vs 2032.00g) were highest ($P < 0.05$) followed by diet 2 (1960.34 vs 1843.25g) while

those fed the control diet (1762.80 vs 1649.52g) had the lowest ($P < 0.05$) weights. Similarly, the respective eviscerated weights, carcass weights, and dressing percentages, were higher and similar in diets 3 (1832.99, 1666.31g and 78.97%) and 4 (1877.96, 1701.75g and 78.85%), but lower ($P < 0.05$) on the control (1468.23, 1269.04g and 72.03%) and diet 2 (1602.82, 1393.21g and 71.02%) which did not differ.

Table 2: Ingredients Composition (%) and Calculated Analysis of Dietary Levels of *Gayamba* Millet as Replacement for Red Sorghum Fed to Starter Broilers (1-4 weeks)

Levels of RS Replaced with <i>Gayamba</i> Pearl Millet				
INGREDIENT	1 (0%)	2 (33.33%)	3 (66.67%)	4 (100%)
Red Sorghum (RS)	46.33	30.89	15.44	0.00
<i>Gayamba</i> Millet	0.00	15.44	30.89	46.33
Full-Fat Soya bean	19.17	19.17	19.17	19.17
Groundnut cake	13.00	13.00	13.00	13.00
Wheat offal	10.00	10.00	10.00	10.00
Fish Meal	5.00	5.00	5.00	5.00
Palm oil	2.00	2.00	2.00	2.00
Bone Meal	2.50	2.50	2.50	2.50
Limestone	1.00	1.00	1.00	1.00
Salt (NaCl)	0.25	0.25	0.25	0.25
Premix*(Starter)	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00
Calculated Analysis (%)				
ME (Kcal/kg)	2849.30	2842.11	2836.38	2828.76
Crude Protein	23.00	23.00	23.00	23.00
Crude Fibre	4.32	4.04	3.78	3.51
Ether Extract	6.20	6.41	6.63	6.86
Calcium	1.80	1.79	1.78	1.77
Phosphorus	0.84	0.83	0.82	0.81
Methionine	0.65	0.67	0.68	0.70
Lysine	1.29	1.32	1.36	1.39

ME; Metabolizable energy

*Vit/mineral premix supplied/Kg of Diet: Vit. A, 12,500 IU; Vit. D₃, 2,500 IU; Vit. E, 30 IU; Vit. K, 2.5mg; Riboflavin, 6mg; Pantothenic acid, 10mg; Vit. B, 2mg; Niacin, 30mg; Vit. B₁₂, 22mg; Biotin, 0.05mg; Folic acid, 1mg; Choline chloride, 0.3mg; Antioxidant, 0.125mg; Iron, 100mg; Manganese, 100mg; Zinc, 100mg; Iodine, 1.5mg; Cobalt, 0.5mg; Selenium, 0.1mg and Copper 10mg.

Except for relative weights of shank, small intestine and liver, no organ was significantly ($P<0.05$) affected. The relative weight of shank was higher ($P<0.05$) in diet 4 (2.91%) followed by diet 3 (2.62%) and lower in diets 1 (2.41%) and 2 (2.45%). Small intestine weight decreased significantly ($P<0.05$) with an increase level of *gayamba* millet in the diet. Birds fed diet 1 exhibited the highest

($P<0.05$) value (3.53%), followed by diets 2 (3.02%), 4 (2.72%) and 3 (2.47%) in that order. Liver weight was also highest ($P<0.05$) in the control (2.29%), followed by diet 2 (1.97%), then diets 3 (1.64%) and 4 (1.65%), which were similar. Head weight ranged between 1.55% on diet 4 and 1.62% on diet 2. Values for lungs weight ranged from 0.46% on the control to 0.53% on diet 3. Kidney weight was

from 0.22% on the control to 0.24% on diet 2. Abdominal fat weight as per cent liveweight, ranged from 1.79% on diet 1 and 3 to 1.85% on diet 2. Others are, heart weight, 0.47% on diet 2 to 0.53% on diet 3, gizzard weight, from 2.54% on diet 1 to 2.80% on diet 4 and caecal weight, from 0.48% on diet 1 to 0.52 on diet 3. The weight of large intestine too, was from 0.38% on diet 1 to 0.43% on diet 4, pancreas weight from 0.24% on diet 2 to 0.28% on diet 4, and lastly, spleen weight which ranged from 0.16% on diet 1 to 0.20% on diet 4.

Table 3: Ingredients Composition (%) and Calculated Analysis of Dietary Levels of *Gayamba* Millet as Replacement for Red Sorghum Fed to Finisher Broilers (5-7 weeks)

Levels of RS Replaced with <i>Gayamba</i> Pearl Millet				
INGREDIENT	1 (0%)	2 (33.33%)	3 (66.67%)	4 (100%)
Red Sorghum (RS)	49.16	32.77	16.39	0.00
<i>Gayamba</i> Millet	0.00	16.39	32.77	49.16
Full-Fat Soya bean	22.34	22.34	22.34	22.34
Wheat offal	15.00	15.00	15.00	15.00
Bone Meal	2.50	2.50	2.50	2.50
Fish meal	5.00	5.00	5.00	5.00
Palm oil	4.00	4.00	4.00	4.00
Limestone	1.00	1.00	1.00	1.00
Salt (NaCl)	0.25	0.25	0.25	0.25
Premix*(Finisher)	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00
Calculated Analysis (%)				
ME (Kcal/kg)	2976.08	2968.34	2959.10	2947.27
Crude Protein	20.00	20.00	20.00	20.00
Ether Extract	6.25	6.48	6.71	6.95
Crude fibre	4.37	4.08	3.80	3.52
Calcium	1.81	1.79	1.78	1.76
Phosphorus	0.86	0.84	0.83	0.81
Methionine	0.62	0.64	0.65	0.67
Lysine	1.20	1.24	1.28	1.32

ME; Metabolizable Energy

*Vit/mineral premix supplied/Kg of Diet: Vit. A, 8,500IU; Vit. D₃, 2,000IU; Vit. E, 10mg; Vit. K₃, 1.5mg; Vit. B₁, 1.6mg; Vit. B₂, 4mg; Niacin, 20mg; Pantothenic acid, 5mg; Vit. B₆, 1.5mg; Vit. B₁₂, 0.01mg; Folic acid, 0.5mg; Biotin, 0.75mg; Choline chloride, 175mg; Cobalt, 0.2mg; Copper, 3mg; Iodine, 1mg; Iron, 20mg; Manganese, 40mg; Selenium, 0.2mg; Zinc, 30mg and Antioxidant, 1.25mg.



Haematology and Biochemistry

Haematological and serum biochemical indices of broiler chickens fed *gayamba* millet-based diets are presented in Tables 5 and 6. The results showed that except for MCV, all haematological parameters were significantly ($P<0.05$) influenced by diet. The PCV of birds fed diet 4 (34.60%) was highest ($P<0.05$) followed by those on diet 3 (32.89%). Broiler birds fed diets 1 (30.22%) and 2 (29.66%), had the lowest

($P<0.05$) values of packed cell volume which did not differ. Similarly, RBC count was higher ($P<0.05$) on diet 4 ($3.37 \times 10^6/\mu\text{l}$) which was comparable to diets 2 ($2.83 \times 10^6/\mu\text{l}$) and 3 ($2.89 \times 10^6/\mu\text{l}$) and lower ($P<0.05$) on diet 1 (2.53) which was similar to diets 2 and 3. However, Hb concentration was significantly ($P<0.05$) higher in birds fed diets 3 (11.72) and 4 (12.76 g/dl) than those on diets 1 (9.94 g/dl) and 2 (9.75 g/dl), which were similar.

Table 4: Carcass and Organ Characteristics of Broiler Chickens Fed *Gayamba* Millet as Replacement for Red Sorghum

Parameter	Levels of RS Replaced with <i>Gayamba</i> Pearl Millet				SEM
	1	2	3	4	
Live weight (g)	1762.80 ^c	1960.34 ^b	2110.39 ^a	2158.09 ^a	48.85*
Plucked weight (g)	1649.52 ^c	1843.25 ^b	2006.59 ^a	2032.00 ^a	72.82*
Eviscerated weight (g)	1468.23 ^b	1602.82 ^b	1832.99 ^a	1877.96 ^a	117.83*
Carcass weight (g)	1269.04 ^b	1393.21 ^b	1666.31 ^a	1701.75 ^a	106.35*
Dressing percentage	72.03 ^b	71.02 ^b	78.97 ^a	78.85 ^a	5.09*
Head, shank and visceral organs weights expressed as percentage of live weight					
Head	1.58	1.62	1.59	1.55	0.07 ^{NS}
Shank	2.41 ^c	2.45 ^c	2.62 ^b	2.91 ^a	0.09*
Lungs	0.46	0.47	0.53	0.52	0.08 ^{NS}
Small intestine	3.53 ^a	3.02 ^b	2.47 ^d	2.72 ^c	0.63*
Kidney	0.22	0.24	0.23	0.23	0.03 ^{NS}
Liver	2.29 ^a	1.97 ^b	1.64 ^c	1.65 ^c	0.06*
Abdominal fat	1.79	1.85	1.79	1.84	0.09 ^{NS}
Heart	0.50	0.47	0.53	0.52	0.06 ^{NS}
Gizzard	2.54	2.68	2.63	2.80	0.27 ^{NS}
Caeca	0.48	0.49	0.52	0.50	0.04 ^{NS}
Large intestine	0.38	0.42	0.41	0.43	0.04 ^{NS}
Pancreas	0.27	0.24	0.26	0.28	0.03 ^{NS}
Spleen	0.16	0.17	0.18	0.20	0.03 ^{NS}

^{abcd} Means bearing different superscripts within the same row differ; * = ($P<0.05$).

NS= Not significant; SEM = Standard Error Means

The MCV, was not significantly affected and ranged from 116.99 fl on diet 1 to 125.58 fl on diet 4. For MCH, the mean

values for birds on diets 3 (44.18 pg) and 4 (44.85 pg) were significantly ($P<0.05$) higher, followed by diet 1 (42.04 pg) while

diet 2 (38.39 pg) had the lowest ($P<0.05$). Similarly, MCHC, was higher ($P<0.05$) on birds fed diet 4 (34.01g/dl) and lower ($P<0.05$) on diets 1 (29.15 g/dl), 2 (30.62 g/dl) and 3 (3.17 g/dl) which were similar. Conversely, White Blood Cell count was significantly ($P<0.05$) higher on diet 1 ($2.50 \times 10^3/\mu\text{l}$), followed by diet 2 ($2.24 \times 10^3/\mu\text{l}$) and lower ($P<0.05$) on diets 3 (2.05

$\times 10^3/\mu\text{l}$) and 4 ($1.97 \times 10^3/\mu\text{l}$), which were the same. A higher ($P<0.05$) platelets' count was recorded on diet 2 ($2.87 \times 10^3/\mu\text{l}$), which did not differ from diets 1 ($2.64 \times 10^3/\mu\text{l}$) and 3 ($2.59 \times 10^3/\mu\text{l}$) and lower ($P<0.05$) on diet 4 ($2.42 \times 10^3/\mu\text{l}$). However, diets 1 and 3 were comparable to diet 4.

Table 5: Haematological Values of Broiler Chickens Fed Graded levels of *Gayamba* Millet as a replacement for Red Sorghum

Parameter	Levels of RS Replaced with <i>Gayamba</i> Pearl Millet				SEM
	1	2	3	4	
PCV (%)	30.22 ^c	29.66 ^c	32.89 ^b	34.60 ^a	0.84*
RBC ($\times 10^6/\mu\text{l}$)	2.53 ^b	2.83 ^{ab}	2.89 ^{ab}	3.37 ^a	0.32*
Hb (g/dl)	9.94 ^b	9.75 ^b	11.72 ^a	12.76 ^a	0.67*
MCV (fl)	116.99	120.60	125.01	125.58	9.23 ^{NS}
MCH (pg)	42.04 ^b	38.39 ^c	44.18 ^a	44.85 ^a	0.66*
MCHC (g/dl)	29.15 ^b	30.62 ^b	31.17 ^b	34.01 ^a	1.15*
WBC ($\times 10^3/\mu\text{l}$)	2.50 ^a	2.24 ^b	2.05 ^c	1.97 ^c	0.09*
Platelets ($\times 10^3/\mu\text{l}$)	2.64 ^{ab}	2.87 ^a	2.59 ^{ab}	2.42 ^b	0.15*

NS= Not significant, SEM= Standard Error of the Mean, ^{abc} Means bearing different superscripts within the same row differ; * = ($P<0.05$), PCV= Packed Cell Volume, RBC= Red Blood Cells, Hb= Haemoglobin, MCV= Mean Corpuscular Volume, MCH= Mean Corpuscular Haemoglobin, MCHC= Mean Corpuscular Haemoglobin Concentration, WBC = White Blood Cells.

Most of the serum biochemical parameters assayed were similar among diets. Nevertheless, total proteins, albumin, globulins, Alanine amino transferase (ALT) and Aspartate amino transferase (AST) differed significantly ($P<0.05$) among birds fed graded levels of *gayamba* millet-based diets. Total proteins were significantly ($P<0.05$) higher on diets 4 (4.52 g/dl) and 3 (4.19 g/dl) and lower ($P<0.05$) on diets 1 (3.57 g/dl) and 2 (3.49 g/dl) which were the same. Serum albumin was also significantly ($P<0.05$) higher on

diets 4 (3.25 g/dl) and 3 (2.83 g/dl), and lower ($P<0.05$) on diets 1 (2.47 g/dl) and 2 (2.52 g/dl) which did not differ. However, globulin concentration was higher ($P<0.05$) on birds fed diet 1 (1.10 g/dl) which was comparable to diet 2 (1.07 g/dl), and lower ($P<0.05$) in diets 4 (0.95 g/dl) and 3 (0.94 g/dl) which were the same. Parameters for the hepatic enzymes; ALT and AST, followed to a certain degree, the same trend. For ALT, diets 1 (74.47iu/l) and 2 (72.24iu/l) recorded higher ($P<0.05$) and similar values than diets 3 (63.47iu/l)

and 4 (61.98iu/l) which did not differ. Values for AST were also highest (P<0.05) on diets 1 (171.26iu/l) and 2 (169.97iu/l), followed by diet 3 (150.35iu/l) and lowest (P<0.05) on diet 4 (135.88iu/l).

Table 6: Serum Biochemical Parameters of Broiler Chickens Fed Dietary Levels of *Gayamba* Millet as Replacement for Red Sorghum

Parameter	Levels of RS Replaced with <i>Gayamba</i> Pearl Millet				SEM
	1	2	3	4	
Total protein (g/dl)	3.57 ^b	3.49 ^b	4.19 ^a	4.52 ^a	0.31*
Albumin (g/dl)	2.47 ^b	2.52 ^b	2.83 ^a	3.25 ^a	0.21*
Globulin (g/dl)	1.10 ^a	1.07 ^{ab}	0.94 ^b	0.95 ^b	0.07*
Total Cholesterol (mg/dl)	129.02	129.21	129.67	127.34	2.13 ^{NS}
Triglycerides (mg/dl)	6.56	6.30	6.70	6.85	0.63 ^{NS}
Creatinine (mg/dl)	0.88	0.94	0.91	0.90	0.07 ^{NS}
Uric acid (mg/dl)	7.42	7.20	7.04	6.93	0.66 ^{NS}
Sodium (mmol/dl)	148.15		146.75	145.82	7.11 ^{NS}
Potassium (mmol/dl)	3.14	145.54	2.62	2.55	0.37 ^{NS}
Calcium (mmol/dl)	9.40	7.93	9.02	8.44	0.73 ^{NS}
ALT (iul)	74.47 ^a		63.47 ^b	61.98 ^b	3.53*
		72.24 ^a			
AST (iul)	171.26 ^a		150.35 ^b	135.88 ^c	4.10*
		169.97 ^a			

NS= Not significant, SEM= Standard Error of the Mean, ^{abc} Means bearing different superscripts within the same row differ; * = (P<0.05). ALT= Alanine aminotransferase, AST= Aspartate aminotransferase

Mean values for total cholesterol, which did not significantly (P>0.05) differ among diets, ranged from 127.34 mg/dl on diet 4 to 129.67 mg/dl on diet 3, and triglycerides, from 6.30 mg/dl on diet 2 to 6.85 mg/dl on diet 4. Similarly, the hepatic biomarker, creatinine, ranged from 0.88 mg/dl on diet 1 to 0.94 mg/dl on diet 2, while uric acid level stood at 6.93 mg/dl on diet 4 to 7.42 mg/dl on diet 1. In the same way, the level of sodium, one of the serum

electrolytes, ranged from 145.54 mmol/dl on diet 2 to 148.15 mmol/dl on diet 1. Potassium concentration also ranged between 2.55 mmol/dl on diet 4 and 3.14 mmol/dl on diet 1. Numerical values obtained for calcium were between 7.93 mmol/dl on diet 2 and 9.40 mmol/dl on diet 1.

Discussion

The CP of *gayamba* pearl millet obtained in this experiment is lower than 17% reported by Abate and Gomez (1983/1984) but higher than 12.00% (Batal and Dale, 2011). In the same way, the metabolizable energy of *gayamba* pearl millet is higher than 2736 kcal/kg (Rama Rao *et al.*, 2004) and comparable to 3093 kcal/kg (Baurhoo *et al.*, 2011). The analyzed tannin content of *gayamba* millet was lower than 2.25 - 2.32% reported by Kulthe *et al.* (2016) in different pearl millet cultivars. Phytic acid content of *gayamba* obtained in this study was also lower than 825.70 mg/100g reported by Kumar and Chaudan (1993). This implies that the tannin content is not much above the tolerable level of 1% reported by Begovic *et al.* (1978). The calculated analysis of the experimental diets revealed that the metabolizable energy content (2828.76 – 2976.08 kcal/kg) has met the minimum requirement of 2800 kcal/kg reported by Kekeocha (1984) for broiler starter and finisher diets. Similarly, the 23% and 20% CP level in the starter and finisher diets has met the requirements for broiler chickens in these phases of growth (Aduku, 1993).

The significant ($P<0.05$) influence of diet on carcass parameters recorded in this study is line with Luis *et al.* (1980) who observed a significant ($P<0.01$) influence in all carcass parameters of birds fed Proso millet. Similarly, the result is also in agreement with Adamu *et al.* (2000). However, it is in conflict with Kwari *et al.* (2014) who reported a significantly ($P<0.05$) lower dressing percentage (68.72 vs 81.25%) in birds fed 100% dietary substitution of millet for sorghum and Ibe *et al.* (2014) who found no significant difference in dressing percentage between birds fed sorghum (68.10%) and those fed millet-based (66.86%) diets. Be that as it may, the dressing percentage of birds in this study was higher than 70.77 and 65.70% reported by Ravindran and

Savakanesan (1996) and Salami *et al.* (2004) as the ideal dressing percentage for well-finished broiler chickens.

It is a common practice in feeding trials to use the weight of some internal organs like liver and kidney as indicators of toxicity. Bone (1979) reported that if there are any toxic elements in the feed, abnormalities in weights of liver and kidney would be observed. These abnormalities would arise because of the increased metabolic rate of the organs in an attempt to reduce these toxic elements or convert them into non-toxic metabolites (Njidda and Isidahomen, 2011). The significantly ($P<0.05$) lower small intestine and liver weights obtained in this work could be attributed to the comparatively lower dietary tannin content in the millet-based diets. Dietary tannins are known to cause toxicity and inflammation of the liver (Calislar, 2018). Higher liver weights have also been earlier reported in broilers fed un-supplemented sorghum/palm kernel meal-based diets (Oloyo, 1991). However, the results contradicted the report of Ibe *et al.* (2014) who reported no significant difference in liver weight (2.16 vs 1.97%) and intestinal weight (3.66 vs 4.00%) in yellow sorghum and pearl millet -based diets.

The relative weight of abdominal fat pad was not influenced by dietary replacement of *gayamba* millet for red sorghum. This could be attributed to the relatively lower energy level in *gayamba* millet. This finding is in conflict with earlier reports by Rama Rao *et al.* (2002) and Torres *et al.* (2013) who observed that relative abdominal fat weight was significantly ($P<0.05$) higher in birds fed millet-based diets and Medugu *et al.* (2010) who reported significantly ($P<0.05$) lower abdominal fat weights in birds fed millet-based diets than those fed either maize or high-tannin sorghum-based diets.

The significantly ($P<0.05$) lower Packed Cell Volume (PCV), Red Blood Cell (RBC) and Haemoglobin (Hb) levels recorded for birds fed the red sorghum control diet confirms a report by Medugu *et al.* (2010) that broiler chickens fed high-tannin sorghum showed lower ($P<0.05$) PCV, RBC and Hb levels than those fed millet. This could be as a result of the higher tannin and phytate levels in the diet. The two anti-nutritional factors (ANF) have earlier been reported to reduce the bioavailability of minerals, especially, iron which is a precursor for haemoglobin (Hallberg, 1983). However, all the values obtained were within the normal ranges of 22-35%, $2.50 - 3.50 \times 10^6/\mu\text{l}$ and 7-13 g/dl for PCV, RBC and Hb, respectively reported by Jain (1993) for healthy chickens. This implied that the birds were not anaemic. However, the substitution of red sorghum at 33.33% and above, has appeared to enhance the oxygen-carrying capacity of the RBCs which may translate into better respiration, metabolism and general performance. The higher ($P<0.05$) WBC count recorded in birds fed diet 1 followed by 2, did not agree with the report of Kwari *et al.* (2014) who found no significant difference in WBC count between birds fed sorghum and millet-based diets. Since WBCs are involved in body defense mechanism, the higher count could probably be triggered by the presence of ANF in sorghum which have challenged the body's immune system.

Serum chemistry is routinely used to detect abnormalities in physiological processes and pathology of organs in domestic animals. (Iyayi and Tewe, 1998). Total protein (TP) and its fractions (albumin and globulin) supply the information required to interpret the protein quality of the feed, occurrence of dehydration, infections, immune diseases, and inflammatory responses. The higher ($P<0.05$) TP values obtained in birds fed diets 3 (4.19g/dl) and

4 (4.52g/dl) could reflect the protein quality of *gayamba* millet. Eggum (1970) reported that TP reflects the quality of protein fed. However, all values obtained in this study were lower than 26.00 and 29.00g/dl in pearl millet and high-tannin sorghum reported by Medugu *et al.* (2010) but were within the normal reference range in healthy chickens (3.00 – 4.90 g/dl) reported by CDD (1990).

Higher ($P<0.05$) albumin levels recorded in the serum of birds fed diets 3 (2.83 g/dl) and 4 (3.25 g/dl) could be as a result of lower levels of ANF, thus the hepatic cells could maximize their potential for albumin synthesis. However, all mean values obtained were within the reference range of 2.50- 3.48 g/dl for normal healthy chickens reported by Wikivet (2012). According to Silva *et al.*, (2007), the only clinical situation that may cause an elevation in serum albumin is acute dehydration. The significant ($P<0.05$) decrease in serum globulin (GLB) in birds fed diets 3 (0.94 g/dl) and 4 (0.95 g/dl) which were similar to diet 2 (1.07 g/dl), might reduce the capacity of birds to defend the body against antigens, since GLB functions in body defense system (Werner and Reavill, 1999). The mechanism by which this occurs is not very clear. Nonetheless, the values obtained were within the normal range (0.50 – 1.80 g/dl) for healthy birds reported by Thrall (2007) but lower than 15.50 and 16.33 g/dl reported by Medugu *et al.* (2010) for birds fed millet and high-tannin sorghum respectively.

Similarly, the values obtained for triglycerides in this study were lower than the reference value of 27 mg/dl reported by Bell and Freeman (1971). This could perhaps be due to climate. Woerpel and Roskopf (1984) have earlier opined that triglyceride levels may vary based on climate, hormone influence, diet, and

gender. However, a closer value of 0.45 mmol/L (7.5 mg/dl) has also been reported by Dong *et al.* (2015). The significant ($P < 0.05$) decrease in the activity of ALT (61.98 – 74.47 IU/l) and AST (135.88 – 171.26 IU/l) with increased substitution of *gayamba* millet in the diets obtained in this work, could be as a result of lower levels of ANF in these diets. However, all values obtained were within the reference range for healthy chickens 10.00 – 106.00 IU/l ALT and 123.00 – 175.00 IU/l AST reported by CDD (1990) and Kaneko (1989) respectively. All values obtained for other haematological and biochemical parameters in this study were also within the ranges reported in literature.

Conclusion and Recommendation

The results of this experiment have indicated that *gayamba* pearl millet can completely replace red sorghum in broiler chickens' diets without any adverse effect on carcass yield and blood constituents. Accordingly, the use of *gayamba* millet as an alternative to red sorghum in broiler chickens rations is hereby recommended.

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