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Original research article

Effects of feeding unripe plantain peel meal on haematological parameters and serum bio-chemicals of growing broilers

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ABSTRACT

Plantain peel has been reported to be rich in minerals and high in energy. These potentials have qualified it to be a research focus as a non-conventional energy source for the preparation of feed for broilers. It was on this background that this experiment was conducted for 6 weeks with eighty-four (84) day old broiler chicks. They were grouped into treatments and replicates at 2 weeks having attained an average weight range of 325.56±2.70 to 329.90±10.06 g to assess the effects of 0, 5, 10, and 20% maize replaced by unripe plantain peel meal (UPPM) in the chickens' diet on their haematological parameters and serum bio-chemicals. The birds were assigned to each of the treatments replicated three times to contain seven birds per replicate using a completely randomized design (CRD). There were no significant differences ($p>0.05$) in the haematological parameters viz; erythrocyte sedimentation rate, packed cell volume, red blood cell count, haemoglobin concentration, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, lymphocytes, heterophils, monocytes, basophils, and eosinophils. The treatment significantly influenced liver function enzymes, high-density lipoprotein, and some metabolites ($p < 0.05$). ALP increased following an increase in the inclusion of UPPM in the diets but was within the normal recommended range. Cholesterol, high-density lipoprotein, and triglycerides were highest in the control; suggesting their serum lowering potential by UPPM which may translate to lowering the risk of cardiovascular disease and high blood pressure. The antioxidant assays revealed an upward rise in superoxide dismutase (SOD) following an increased percentage inclusion of UPPM. Following the outcome of this study, the recommendation of further research on UPPM in broilers' nutrition was made. This may eventually lead to the discovery of a novel natural source of antidyslipidaemic, antihypercholesterolemic, and antioxidant agents from UPPM.

Keywords: antidyslipidaemic, blood, broilers, antioxidant, unripe-plantain-peel

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1. Introduction

One of the greatest threats to the world and national food resources is the rapidly growing population. The population of human beings in the world is currently at a geometrical rate of increment. According to the reports of the Food and Agriculture Organization[1,2] the world's population has been estimated to be around 9.7 to 11 billion by the year 2050. Nigeria is currently the most densely populated country in Africa with over 200 million people. This record is expected to be almost double by the year 2050.[3] This unabated population increase will dovetail with high food demand by the teeming population by 70 % (FAO, 2000). The relevance of food security being the basis of national security cannot be underestimated.[4] Hence, it is expected that the food supply is in tandem with the population growth of any nation.

Therefore, food production, efficiency and enhancement must increase,[5] including meat and other animal products (eggs, milk etc).[6] One of the ways by which the above can be achieved is to apply full-fledged feeding of livestock that satiates their nutrients needs. These nutrients are carbohydrates (energy), protein, ether extract (fat and oil), minerals, fibre, vitamins, and water.

Increased poultry production (layers, broilers, turkeys, ducks etc.) could be one of the best choices for increasing the supply of protein to the ever-growing population because of their inherent attributes. Broilers (also known as fryers) grow very fast and can reach table size/market at the age of 8 to 12 weeks. At this age, it attains about 1.5 kg and above live weight. They have tender meat with soft, pliable, smooth texture skin and flexible breast bone cartilage.[7] The fast growth rate of broilers is traceable to their high feed consumption rate, hence their ability to convert good quality feed to flesh (*protein*) within a very short time.

Peels are the major wastes generated from plantain fruits. Certainly, large quantities of the peels are produced in many countries, where plantain is being consumed. About 40 per cent of the fruit constitutes the peel of plantain, with an estimated 200 tons of waste being generated daily, and this continues to increase as industrial processing of plantains and bananas becomes prevalent in many tropical countries. In Nigeria, the production of chips from unripe plantain also generates tons of plantain peels, which could be processed into feed raw material. Both the ripe and unripe plantain peels are good sources of nutrients, minerals (e.g. iron, copper, manganese, zinc etc.) and phytochemicals.[8,9] These minerals have been reported to have therapeutic significance necessary for normal growth, development and proper functioning of the body.[10] Plantain peels are a potential source of dietary fibre, carotenoids, polyphenols, and other bioactive elements that are advantageous to health.[11] It was also suggested by Shadrach *et al*.[12] in the formulation of livestock feeds based on their proximate composition and screened phytochemicals. To encourage the use of unripe plantain peel in the diets of broiler chickens, this research was carried out. This also necessitated the study of its probable effects on haematological parameters and serum biochemicals of the experimental broiler chickens.

2. Materials and Methods

2.1 Experimental site

The present research was carried out at the Animal Production and Health Research Unit of the Federal University of Technology Akure, Ondo State Nigeria. The experimental site is located on latitude 7.29°, and longitude 5.15°. This location has a tropical climate with an average annual temperature of 26.7° C, and an average annual rainfall of 2378 mm.

2.2 Preparation of experimental materials

The unripe plantain peels (UPP) used for this experiment were procured, processed, and packaged as unripe plantain peel meal as reported in our earlier research.[13] Necessary preparations, like sweeping of the pen, cleaning, washing with disinfectant, spreading of wood shavings,

installation of brooding equipment, etc. were carefully done before the arrival of birds.

2.3 Experimental design and preparation of experimental diets

The study involved the use of eighty-four (84) day-old broiler chicks which became growing broilers in the course of the experiment. These were distributed using a completely randomized design (CRD) into four treatments replicated three times with seven birds per replicate. The treatments include T1, T2, T3, and T4 representing 0 %, 5 %, 10 %, and 20 % inclusion of unripe plantain peel meal as substitution for maize in broilers' diets, respectively. The compositions of the four prepared diets are shown in Table 1.

Table 1. Constituents (%) of the tested diets.

Ingredients	Diets			
	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**
Maize	60.00	57.00	54.00	48.00
Soybean meal	9.00	9.00	9.00	7.00
Groundnut cake	24.00	24.00	24.00	26.00
Unripe plantain peel meal (UPPM)	0.00	3.00	6.00	12.00
Fish meal	4.00	4.00	4.00	4.00
Di-calcium phosphate	0.10	0.10	0.10	0.10
Bone meal	2.20	2.20	2.20	2.20
Broiler premix	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values				
Crude protein (%)	23.04	23.10	23.16	23.30
Metabolizable energy (cal/g)	3034	3025	3016	3001
Crude fat (%)	5.00	5.00	5.00	5.00
Crude fibre (%)	4.40	4.50	4.70	5.00
Calcium (%)	1.00	1.00	1.00	1.00
Phosphorus (%)	0.60	0.60	0.60	0.60
Lysine	0.94	0.93	0.92	0.90
Methionine	0.34	0.33	0.33	0.31

UPPM= Unripe Plantain Peel Meal, Diet 1 = 0 % UPPM, Diet 2 = 5 % replacement value of maize with UPPM, Diet 3 = 10 % replacement value of maize with UPPM, and Diet 4 = 20 % replacement value of maize with UPPM.

2.4 Activities upon the arrival of a day-old broiler chicks

On the arrival day of the broiler chicks, they were counted and weighed using a Kerro® BL 20001 Electronic Compact Digital Scale. They were carefully checked for any mortality, deformity, or weakness, and other necessary observations were made before placing them. The broiler chicks were clean, stood firmly, walked well, were alert, and active, with no deformities, and yolk sacs fully retracted with properly healed navel. Thereafter, anti-stress was administered to them orally, and feeding also commenced.

Fig.1. One day old broiler chicks in cartons.

Fig.2. Aerial view of broiler chicks.

Fig.3. Checking the chicks.

Fig.4. Weighing at one day old.

2.5 Activities during the brooding/rearing of the broiler chicks

The birds were served fresh, cool, clean water, and fed *ad libitum*. They were fed commercial starter crumble for two weeks of acclimatization (Table 2) . The feeding of the experimental diets commenced after the two weeks of acclimatization when the birds were allotted into treatments and replicates. The experiment lasted for six weeks while necessary medications and vaccinations were administered as shown in Table 3.

Table 2. Composition of the commercial broiler starter.

Parameters	Composition (%)
Crude protein	22.00
Crude fat	4.50
Crude fibre	5.00
Calcium	1.10
Phosphorus	0.50
Lysine	1.33
Methionine	0.60
Metabolizable energy (cal/g)	2950

Table 3. Medications and vaccinations schedule.

Week	Medications/vaccinations	Route
1	Multivitamins, antibiotics and infectious bursal disease vaccine I (1st dose)	Oral
2	Anticocci and infectious bursal disease vaccine II (booster dose)	Oral
3	Multivitamins	Oral
4	Anticocci and Newcastle disease vaccine	Oral
5	Antibiotics and multivitamins	Oral
6	Anticocci and calcium supplement	Oral

2.6 Ethical code

The present research was conducted following the guidelines of the World Health Organization[14] as well as the Ethical Code of the Federal University of Technology Akure (FUTA) on Animal Use.

2.7 Blood collection

The birds were starved overnight prior to the termination of the experiment at 6 weeks old. Three birds were randomly selected among the seven birds per replicate and sacrificed for blood collection. Exactly 6 mL of whole blood was carefully drawn from the bird's jugular vein with the aid of a sterilized needle and syringe of which 2 mL was poured into an EDTA (ethylene diamine tetra-acetic) bottle for haematological parameters analyses. The remaining 4 mL was poured into laboratory test tubes and allowed to rest at room temperature for 2 hours in a slanting position. The formed serum was harvested into plain bottles for serum biochemical analyses.

2.8 Haematological parameters

Haematological parameters were determined at the Diagnostic Laboratory of Animal Production and Health of the Federal University of Technology, Akure. Erythrocyte sedimentation rate, packed cell volume, red blood cell, haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, lymphocytes, heterophils, monocytes, basophils, and eosinophils were analyzed following standard procedures as reported by Heshu and Arogbodo *et al*.[15,16]

2.9 Serum biochemicals

The serum biochemicals of the broiler chickens were evaluated at the Department of Bio-Chemistry of the Federal University of Technology, Akure using standard kits/reagents. Total protein and albumin were obtained by biuret and bromocresol green methods. Total globulin was obtained by subtracting albumin value from total protein. The division of albumin values by that of globulin gave albumin-globulin ratio. Urea was determined as described by Gudiso, *et al*. [17] Cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and triglycerides were determined using quantitative colorimetric procedures. The assays were prepared and incubated for 30 minutes at room temperature and the optical density (OD) was read at 570nm. The concentrations in the serum samples were calculated in mg/dL for cholesterol, HDL, and LDL while that of triglycerides was recorded in mmol/L.[18]

$$\text{Cholesterol} = \frac{ODTotal - ODBlank}{ODStandard - ODBlank} \text{ X } 100$$

$$\text{HDL} = \frac{ODHDL - ODBlank}{ODStandard - ODBlank} \text{ X } 100$$

$$\text{LDL} = \frac{ODTLDL - ODBlank}{ODStandard - ODBlank} \text{ X } 100$$

$$\text{Triglycerides} = \frac{OD\ of\ the\ sample - OD\ of\ Water\ blank}{Slope} \text{ X n}$$

Where n stands for dilution factor.

Total glutathione (GSH) was obtained by colorimetric determination of reduced glutathione at 412 nm and expressed in mg/dL through the usage of 5, 5'-dithiobis-2-nitronbenzoic acid. Glutathione peroxidase (GSHpx) was determined by quantitative colorimetric glutathione peroxidase determination by measuring the absorbance at 412 nm in µmol/L protein. Superoxide dismutase (SOD) activity was also obtained by quantitative colorimetric superoxide dismutase determination which employs the use of xanthine oxidase. Through colour intensity, the SOD activity was determined at 440 nm in U/mL nitrite unit as reported by Marcos, Bai *et al*., and Wang *et al*.,[19-21] with slight modifications.

Obtained data were subjected to one-way-ANOVA statistical analysis using SPSS computer software package version 23 and Duncan's Multiple Range Test (DMRT) of the same package was employed for mean variation analysis.

3. Results

The results of the analyzed parameters from the experimental broilers are presented in Tables 4 to 8. They reveal biochemical parameters including liver enzymes, serum lipoproteins, other serum metabolites, and some endogenous antioxidant markers. Haematological parameters include erythrocyte sedimentation rate, packed cell volume, red blood cell count, haemoglobin, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration, lymphocytes, heterophils, monocytes, basophils, and, eosinophils. The p- values as indicated in Table 4 show that the parameters were not significantly ($p>0.05$) influenced by inclusion of UPPM in the diets of the broilers.

Table 4. Haematological parameters of the experimental broiler chickens.

Parameters	Treatments				p-values
	T1	T2	T3	T4	
ESR (mm/hr)	4.44±1.33	3.78±0.83	4.22±0.83	4.56±0.53	0.313
PCV (%)	24.78±2.49	26.00±2.00	24.78±1.48	24.22±1.09	0.235
RBC ($10^6 mm^3$)	2.03±0.47	2.29±0.37	2.08±0.29	1.96±0.26	0.242
HB (g/dL)	8.23±0.83	8.64±0.65	8.23±0.51	8.03±0.37	0.217
MCV (fL)	125.35±16.80	114.86±10.12	120.68±11.28	125.14±11.12	0.268
MCH (pg)	41.65±5.55	38.20±3.43	40.09±3.65	41.50±3.64	0.280
MCHC (%)	33.23±0.06	33.25±0.08	33.22±0.12	33.16±0.12	0.298
LYMP (%)	59.44±1.67	58.78±1.09	59.44±1.13	59.89±0.93	0.313
HET (%)	24.44±1.24	24.78±1.99	24.67±2.24	24.56±2.13	0.985
MON (%)	11.22±1.72	11.33±1.73	11.11±1.90	10.56±1.33	0.769
EOS (%)	3.44±0.53	3.56±0.53	3.44±0.53	3.44±0.53	0. 959
BAS (%)	1.44±0.53	1.56±0.53	1.33±0.50	1.56±0.53	0.771

Means±Standard deviation, ESR=Erythrocyte sedimentation rate, PCV=Packed cell volume, RBC=Red blood cell, HB= Haemoglobin, MCV= Mean corpuscular volume, MCH= Mean corpuscular haemoglobin, MCHC= Mean corpuscular haemoglobin concentration, LYMP= Lymphocytes, HET= Heterophils, MON=Monocytes, BAS=Basophils, and EOS=Eosinophils.

Table 5 shows the liver function enzymes ALP (Alkaline phosphatase), ALT (Alanine transaminase), and AST (Aspartate transaminase). The values for ALP for T1, T2, T3, and T4 are 1028. 56, 1222. 68, 1404. 84, and 1668. 88 U/ L, respectively. ALT 13.8, 21.40, 17.87, and 23.60, AST 22.33, 18.83, 22.33, and 11.00 U/L in that order for T1, T2, T3, and T4. Significant differences ($p<0.05$) were observed in the three parameters across the treatments with the p- values of 0. 039, 0. 014, and 0. 00 recorded for ALP, ALT, and AST, respectively.

Data on the serum lipoproteins of the experimental broilers for the four respective treatments are shown in Table 6. Cholesterol (23.49, 21.34, 22.20, and 21.88 mg/dL for T1, T2, T3, and T4), HDL (16.08, 13.38, 14.46, and 14.06 mg/dL for T1, T2, T3, and T4), low-density lipoprotein (-1.93, 5.63, 0.16, and 2.18 mg/dL for T1, T2, T3, and T4) and the triglycerides (46.71, 11.68, 37.90, and 28.21 mg/dL for T1, T2, T3, and T4, respectively). Diets with UPPM inclusion (T2, T3, and T4) reduced the cholesterol, high-density

lipoprotein, and triglycerides relative to the control significantly ($p<0.05$). The low-density lipoprotein was lowest in the control (T1) and highest in T2.

Table 5. Liver function enzymes of experimental broiler chickens.

Parameters	Treatments				p-values
	T1	T2	T3	T4	
ALP (U/L)	1028.56±57.24^{b}	1222.68±53.26^{b}	1404.84±153.93^{ab}	1668.88±189.63^{a}	0.039
ALT (U/L)	13.80±1.60^{c}	21.40±1.56^{ab}	17.87±2.37^{bc}	23.60±0.42^{a}	0.014
AST (U/L)	22.33±1.30^{a}	18.83±0.67^{a}	22.33±0.88^{a}	11.00±1.26^{b}	0.000

Means of three determinations ± Standard Error of Mean (SEM). ^{a,b,c} along the same row means statistically significant ($p < 0.05$). ALP= Alkaline phosphatase, ALT = Alanine transaminase, AST= Aspartate transaminase, T=Treatment.

Table 6. Serum lipids of the experimental birds.

Parameters	Treatments				p-values
	T1	T2	T3	T4	
Cholesterol (mg/dL)	23.49±0.56^{a}	21.34±0.01^{b}	22.20±0.03^{b}	21.88±0.02^{b}	0.04
High-density lipoprotein (mg/dL)	16.08±0.70^{a}	13.38±0.01^{b}	14.46±0.04^{b}	14.06±0.03^{b}	0.04
Low-density lipoprotein (mg/dL)	-1.93±0.32^{d}	5.63±0.05^{a}	0.16±0.23^{c}	2.18±0.17^{b}	0.00
Triglycerides (mmol/L)	46.71±2.21^{a}	11.68±0.22^{d}	37.90±1.10^{b}	28.21±0.80^{c}	0.00

Means of three determinations ±Standard Error of Mean (SEM). ^{a,b,c,d} along the same row means statistically significant ($p < 0.05$). T=Treatment.

Other serum metabolites results are shown in Table 7. The table clearly shows that the treatments significantly ($p<0.05$) influenced the majority of the parameters including glucose, total protein, globulin, albumin-globulin ratio, bilirubin, and creatinine. Albumin and urea were not significantly ($p>0.05$) influenced.

Table 8 shows the evaluated antioxidant markers in the serum of the broilers used in the present experiment. The SOD values are 69.70, 81.82, 86.67, and 88.79 %. GSH values include 172.72, 170.16, 170.02, and 175.77 µg/mL; GSHpx 5.11, 7.38, 6.60, and 3.12 µg/mL for T1, T2, T3, and T4, respectively. These values were observed not to follow a dose-dependent trend with the exception of SOD. Likewise, SOD was not significantly ($p>0.05$) influenced by the treatments while GSH and GSHpx were significantly ($p<0.05$) influenced. The highest and the lowest values for SOD were recorded in T4 and T1, respectively. T4 has the highest and lowest value for GSH and GSHpx, respectively, while T2 recorded the highest value for GSHpx. The highest value for GSHpx was observed in T2.

4. Discussion

Blood parameters are indispensable bio-tools for ascertaining the wellness of animals. It was observed from the present study that treatment effect showed no significant difference ($p > 0.05$) in all the evaluated haematological parameters (Table 4). This finding agrees in part with Uchegbu *et al.*,[22] who reported no significant difference ($p > 0.05$) in PCV, HB, red blood cell count, MCH, MCV, and MCHC of the blood of finisher broilers fed with plantain peel in their diets. The ESR and PCV appeared to be inversely related while the PCV and HB were directly proportional. This observation agrees with the report of

Adejumo[23] that PCV and HB are correlated. The values from all the treatments were within the range of 22.0 – 35 %, 7 – 13g/dL, 90 – 140 fl, 33.0 – 47.0 pg, 26.0 – 35.0 %, 45 – 70%, 15 – 40 %, 5 – 10 %, and 1.5 – 6.0 % for PCV, HB, MCV, MCH, MCHC, LYMP, HET, MON, and EOS, respectively for normal chickens.[7] The red blood cell count and basophil (BAS %) in the present study also fall within the normal range of 2.30 – 3.90 x 10^6 mm^3 and 0 – 2 %, respectively, as recommended by Abdi-Hachesoo *et al*.[24, 25]

Table 7. Other serum metabolites of the broiler chickens.

Metabolites	Treatments				p- values
	T1	T2	T3	T4	
Glucose (mg/dL)	55.83±2.20^{ab}	65.83±3.25^{a}	37.92±2.73^{c}	47.92±8.55^{bc}	0.020
Total protein (mg/dL)	4.58±1.10^{a}	1.30±0.05^{b}	3.96±0.44^{a}	3. 74±0.08^{a}	0.020
Albumin (mg/dL)	1.15±0.05	1.10±0.06	1.12±0.09	0.99±0.09	0.470
Globulin (mg/dL)	3.43±1.07^{a}	0.25±0.02^{b}	2.84±0.45^{a}	2.76±0.04^{a}	0.020
AG Ratio	0.40±0.11^{b}	4.46±0.62^{a}	0.43±0.09^{b}	0.36±0.04^{b}	0.000
Urea (mg/dL)	33.74±0.24	35.85±1.77	33.99±2.04	36.16±1.35	0.690
Bilirubin (mg/dL)	1.59±0.17^{b}	0.95±0.06^{c}	1.23±0.11b^{c}	2.06±0.19^{a}	0.003
Creatinine (mg/dL)	0.41±0.05^{b}	0.55±0.01^{b}	0.51±0.07^{b}	0.77±0.09^{a}	0.025

Means of three determinations ± Standard Error of Mean (SEM). a,b,c along the same row means statistically significant ($p < 0.05$). T=Treatment and AG= Albumin-Globulin.

Table 8. Serum antioxidant markers of the broiler chickens.

Markers	Treatments				p- values
	T1	T2	T3	T4	
SOD (U/mL)	69.70±9.46	81.82±7.57	86.67±7.95	88.79±0.30	0.315
GSH (mg/dL)	172.72±0.35^{b}	170.16±0.37^{c}	170.02±0.26^{c}	175.77±1.14^{a}	0.001
GSHpx (µmol/L protein)	5.11±0.44^{b}	7.38±0.57^{a}	6.60±0.12^{a}	3.12±0.38^{c}	0.000

Means of three determinations ± Standard Error of Mean (SEM). T=Treatment, SOD= Superoxide Dismutase, GSH= Total Glutathione, and GSHpx = Glutathione Peroxidase. a,b,c along the same row means statistically significant ($p < 0.05$).

Liver function tests help in diagnosis, evaluating prognosis, and checking on the therapy of the disease of the liver. Increased serum bilirubin may be due to many reasons but normally results in jaundice (e. g. obstructive jaundice). In the event of chronic liver disease like cirrhosis, there may be prolonged prothrombin time, owing to the affected synthesis of factors responsible for coagulation. In acute viral hepatitis, serum ALT and AST are usually high several days before the onset of jaundice. ALT is more specific for liver disease than AST. This is because AST is elevated in cardiac or skeletal muscle injury while ALT is not. ALP activity increases in obstructive jaundice as well as in disease of the bone. The liver enzyme markers of the broiler chickens in this study were significantly ($p < 0.05$) influenced by the treatments. However, ALT and AST did not follow a definite trend. ALT was highest in the birds fed 20 % UPPM and lowest in the control while AST was highest in the control and 10 % UPPM diets. AST values in this study were generally low compared with the report of Meluzzi *et al*.,[26]

who recommended 70 – 220 U/L. This may be an indication that the experimental broilers did not have any liver disease. ALP differs significantly with control having the lowest value. This parameter increases following an increase in the inclusion of UPPM in the diets but remains within a recommended range of 568 – 8831 U/L[27] which suggests normal health. ALT showed a significant difference ($p < 0.05$) in the treatments with the highest value recorded in T4 and the lowest in T1. Obtained values were within the limits (9 – 43 U/L) reported by Gudiso *et al*.,[17] relevant references for exhaustive comparison of the effects of UPPM inclusion in broiler's diets on their serum biochemicals (ALT, AST, ALP, albumin, total protein, albumin, cholesterol, etc.) are scarce in the literature.

The plasma lipids profile of the experimental birds showed significant difference ($p < 0.05$) with birds in the control group having the highest levels. Despite the observed significant differences, the values were at par with the recommendation of Gudiso [17] on the normal range of cholesterol in chickens. Cholesterol is essential for the formation of hormones and cell membranes. Cholesterol, high- density lipoprotein, and triglycerides were highest in the control group. This suggests that UPPM may have the potential to lower serum cholesterol, high- density lipoprotein, and triglycerides. This observation corroborates the blood-cholesterol lowering capability of plantain as reported by Cafasso, Hamendra and Anand[33,34] owing to its appreciable fibre content. Interestingly, the blood pressure lowering potential of plantain and plantain peels was also reported because it is rich in substantial amount of minerals and electrolytes. In addition, hypocholesterolaemic activity of different parts of plantain including the root, peel and peel extract have been reported.[26,34,36,37] All these parts contribute to lowering blood pressure and thereby prevent diseases like arteriosclerosis and hypertension in broilers and possibly in other animal species.

It was observed that albumin and urea levels (Table 8) were not significant ($p > 0.05$) while other tested biochemicals were statistically different ($p < 0.05$) . Albumin is a synthesized product of the liver which is very important for the transportation of insoluble items in the blood. Whenever too much albumin is found in the blood, this may be due to dehydration and low volume may be caused by infection and poor nutrition.[28] The level of glucose in this study was lower than the recommendation (125.0 – 200 mg/dL) of Abdi-Hachesoo. [24] The value of creatinine generally used to be very low in birds. However, increased physical activity may raise the value. Creatinine values agree with the reports of Meluzzi *et al*., MLAB, and Miturka *et al*.,[26,29,30] as well as that of Nathaniel *et al*.,[31] who recommended 0.90 – 1.85 mg/dL. Urea from the present study was a little bit higher than the recommendation (5 – 20mg/dL) of Afriyie *et al*.,[32] Albumin and globulin were slightly lower than the recommended (albumin 1.8– 3.3 mg/dL; globulin 3.9–6 mg/dL).[17] Globulin is very rich in antibodies and enzymes necessary for fighting foreign agents and infections in the body of animals. The recorded level of globulin in T2 appears to be too low which also translates to the low AG ratio observed. This treatment also witnessed low protein. This may suggest that the birds in this group were incubating unidentified infection but yet to manifest during the course of the study. Total protein was within the range of 3.10 – 5.72 mg/dL and 3.0 – 4.9 mg/dL recommended by Meluzzi *et al*., and Banergee [7,26] for T1, T3, and T4.

Dietary inclusion of unripe plantain peel meal at varying levels significantly influenced GSH ($p < 0.05$) and GSHpx, though with not well-defined trend. SOD was not significantly influenced by the treatments ($p > 0.05$) but its values followed an increasing pattern as the level of UPPM increases in the respective diets. This may point to the right

or positive activity of SOD in the broilers. However, the increased SOD in all the treatments, highest GSH in Treatment 4, and highest GSHpx in Treatment 2 compared to the control suggests a significant antioxidant potential of UPPM. This finding agrees with the antioxidant potential of plantain peel reported by Arun *et al*.[11] GSH, GSHpx, SOD, and catalase are known as liver antioxidant stress bio-markers Afriyie *et al*.[32] According to Surai *et al*.,[37] SOD has been observed to be the first line of defence as it converts superoxide to hydrogen peroxide with the final conversion of hydrogen peroxide to water and gaseous oxygen being executed by GSHpx. Antioxidant agents are very important as they inhibit cellular damage through electrons donation capable of neutralizing free radicals. Their functions also reduce the ability of free radicals to induce diseases and cell damage. [39] Unavailability, scarcity or inaccessibility of sufficient and relevant information in literature on the use of UPPM for broiler production has limited the present research.

5. Conclusion

The inclusion of UPPM in the diets of experimental broilers at graded levels did not have negative effects on their haematological indices and serum bio-chemicals. Rather, it increased the serum antioxidant activity of SOD and GSH. It also demonstrated significant reduction of serum cholesterol, high-density lipoprotein, and triglycerides. Further research on the unripe peels of plantain as a natural source of antioxidants, antihypercholesterolemic as well as anti-dyslipidaemic agents for broilers is therefore strongly recommended.

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Conflicts of Interest

There exists no conflict of interest to declare by the authors.

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