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ANTIBIOTIC GROWTH PROMOTERS (*CINNAMOMUM CEYLON, ZINGIGBER OFFICINALE* AND *MORINGA OLEIFERA*) AS PHYTOGENIC FEED ADDITIVES IN BROILER PRODUCTION: EFFECTS ON HEMATOLOGY, ANTIOXIDANT STATUS, INTESTINAL MICROBIOTA, CARCASS ANALYSIS AND SENSORY EVALUATION.

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Abstract
An eight-week feeding trial was conducted to evaluate the effect of 0.2% Cinnamon powder, 0.2% ginger root powder, and 0.2% *Moringa oleifera* leaf meal on the hematological, antioxidant activities in serum, intestinal microbiota, carcass analysis, internal organs, and sensory evaluation of broiler chickens. One hundred and twelve broiler chicks were randomly allocated to four experimental diets replicated four times (28birds per diet; 7 birds per replicate) using a Completely Randomized Design. A basal diet was divided into four portions designated diet 1 (control) and diets 2, 3, and 4 supplemented with 0.2% cinnamon powder, 0.2% ginger root powder, and 0.2% *Moringa oleifera* leaf meal, respectively. At the end of the 56th day, four birds were randomly selected from each treatment for the determination of the aforementioned parameters. The results showed that packed cell volume (PCV), red blood cell (RBC) and hemoglobin (Hb) were significantly ($P<0.05$) influenced by the treatments. The phytogenic feed additive supplementation increased ($P<0.05$) the levels of catalase and glutathione peroxidase in broilers compared to the birds on control diet. The intestinal microbiota of broiler chickens was not influenced ($P>0.05$) by phytogenic feed additives supplementation. The 0.2% Moringa oleifera leaf meal supplementation enhanced broilers' carcass characteristics. There was significantly ($P<0.05$) decrease in the texture and juiciness of breast meat of broilers fed diet 2 at 7.45 and 7.25, respectively. The color and flavor of breast meat of broilers fed diet 3 were significantly ($P<0.05$) decreased. It was concluded that the inclusion of 0.2% *Moringa oleifera* leaf meal in the diet of broiler chickens has beneficial effects.

Introduction

In recent years, the demand for poultry meat and meat-related products has increased. In 2020, 137 million tons of chicken meat were produced globally, making it the most popular meat in the world. Consequently, the chicken

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business makes a considerable contribution to the consumption of animal proteins, human nutrition, and global food security (1). Significant advancements in poultry health and performance have recently been achieved. The primary component of the chicken industry is feed, which exposes the digestive system to various substances that can impair gut health (2). Antibiotic growth promoters were previously employed to manage gastrointestinal infections and lessen the impact of stresses on gut health. However, restrictions on the use of antibiotics in chicken production have been imposed as a result of rising consumer knowledge of the harmful effects of antibiotics on human health, as well as increased bacterial resistance and concerns about food safety. Due to this circumstance, researchers and industry are looking for AGPs (Antibiotic Growth Promoters) alternatives while concentrating on creating more sustainable nutritional interventions to improve poultry health generally (3). Due to the detrimental effects of antibiotics on the poultry industry and the feed industry, research into alternate naturally occurring antibiotic growth promoters has become more urgent (4). Among these, phytogenic herbal goods or medicinal plants have drawn significant interest as natural feed supplements because they have grown in popularity with customers (5).

In recent years, the feed industry has come to understand the potential of compounds produced from plants for many animal species. Phytogenic Feed Additives (PFA) are therefore being increasingly employed, primarily in feeding regimens for pigs and poultry. Commercial goods on the market today vary greatly in terms of their formulation complexity, physical characteristics, and component composition. Currently, this group of feed additives is extensively utilized as an alternative to antibiotic growth promoters in the nutrition of pigs and poultry. Spices, herbs, and many plant extracts are examples of natural plant products that can be used as alternatives to antibiotics as growth promoters to enhance the performance of broilers. Different plant extracts used to make spices and herbs have palatable, digestion-stimulating properties as well as antimicrobial effects. According to (6), herbs are beneficial replacements for food in the poultry industry for nutrition and health. They may have antibacterial or anticoccidial properties, or may stimulate feed intake or endogenous secretion. Medicinal plants are used as natural feed additives in poultry diets to enhance the performance, anti-oxidative status, and immune response of chickens. (7)

The high use of synthetic additives in feed has led to many carcinogenic and toxic problems. Colorants and flavors were found to cause cancer and lead to DNA damage. Therefore, natural products have been studied as alternatives to synthetic compounds with the objective of providing safe and wholesome food to mankind. Therefore, this study aimed to assess the effects of phytogenic feed additives on broiler chickens.

Materials and Methods

Location of the experimental site

The study was carried out in the poultry unit of the department of Agricultural Technology. The Federal polytechnic Ado, Ekiti state, Nigeria. The state is located in the South West Nigeria, and Ekiti State covers a land area of 6,353km square (2453sqmi) with two distinct seasons: the rainy season (April to October) and the dry season (November to March). Ado-Ekiti has a temperature range of 21°- 28° with high humidity, the South Western wind, and the North East trade that blows in the rainy seasons and dry (harmattan) season respectively, the tropical forest exists in the south of Ekiti State, while savannah occupies the northern peripheries. The land mass is surrounded by rock, low lying forested areas with an average rainfall of 2,100mmHg which is bimodal in nature with peak in May and August.

Site preparation

The poultry house was thoroughly washed and fumigated with disinfectant. The house was allowed to stay for two weeks before the arrival of the experimental birds, and proper weeding of the surrounding area was carried out to prevent reptiles.

Experimental animals

The one hundred and twelve (112) birds were randomly allocated into four treatment groups and replicated four times. Treatment one was the control diet i.e. diet with no supplement, treatment two was supplemented with cinnamon powder, treatment three was supplemented with ginger root powder and treatment four was supplemented with *Moringa oleifera* leaf meal.

Test ingredients

The cinnamon and ginger root were purchased from a local market in Ado-Ekiti while the *Moringa oleifera* leaf were harvested from the premises of the Federal Polytechnic, Ado. Cinnamon, ginger root and Moringa leaf were air-dried for 7 days in order to reduce the moisture content. They were milled into fine particles to formulate the diets.

Management of experimental birds

A total number of one hundred and twelve (112) Cobb-500 breed were used in this study. The birds were purchased from a reputable hatchery. The chicks were brooded for two weeks using electric bulbs as the source of light and heat in the pen. In the brooder house, enough provision was made for space and ventilation. Polythene was also used to cover the pen to provide warmth and protection against predators and extreme of whether. They were fed with the starter diets from 0-28day and finisher diet from 29-56 day. Proper and adequate management practices were implemented. All vaccinations were given as appropriate throughout the duration of the experiment. Feed and water were given *ad-libitum*.

Experimental diets

- Diet 1: control diet without supplementation
- Diet 2: 0.2% cinnamon powder supplementation
- Diet 3: 0.2% ginger root powder supplementation
- Diet 4: 0.2% *Moringa oleifera* leaf meal supplementation

Table 1: Composition of experimental diets (%) for broiler starter

Ingredients	1	2	3	4
Cinnamon powder	**-**	**0.2**	**-**	**-**
Ginger root powder	-	-	0.2	-
Moringa leafmeal powder	-	-	-	0.2
Maize	49	49	49	49
Soyabean cake	24	24	24	24
Groundnut cake	18	18	18	18
Fish meal	2	2	2	2
Bone meal	3	3	3	3
Limestone	2	2	2	2
Broiler premix	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Vegetable oil	1	1	1	1
Total	100	100	100	100
Calculated composition				
Metabolizable energy(Kcal/kg)	2820	2820	2820	2820
Crude Protein (%)	23.5	23.5	23.5	23.5
Average calcium	1.99	1.99	1.99	1.99
Average phosphorus	0.84	0.84	0.84	0.84
Lysine	1.27	1.27	1.27	1.27

Table 2: Composition of experimental diets (%) for broiler finisher

Ingredients	1	2	3	4
Cinnamon powder	-	0.2	-	-
Ginger root powder	-	-	0.2	-
Moringa leafmeal powder	-	-	-	0.2
Maize	53	53	53	53
Soyabean cake	22	22	22	22
Groundnut cake	16	16	16	16
Fish meal	2	2	2	2
Bone meal	3	3	3	3
Limestone	2	2	2	2
Broiler premix	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Vegetable oil	1	1	1	1
Total	100	100	100	100
Calculated composition				
Metabolizable energy(Kcal/kg)	2980	2980	2980	2980
Crude Protein (%)	21.8	21.8	21.8	21.8
Average calcium	1.99	1.99	1.99	1.99
Average phosphorus	0.69	0.69	0.69	0.69
Lysine	1.33	1.33	1.33	1.33

Experimental design

The experimental design used was Completely Randomized Design (CRD) with a total number of sixteen experimental units. Four treatments which was replicated 4 times with 7 birds per replicate. The total number of birds used in this study was one hundred and twelve (112) broiler chicks.

Data collection

Blood samples collection was done in the morning after the birds have been starved overnight in order to attain a stable serum evaluation. Four birds were randomly selected from each treatment, and blood samples were collected from the jugular vein at the termination of the experiment. Hematological parameters were collected from the jugular vein using a 5ml syringe and placed in sterilized bottles containing ethylene diamine tetra-acetic (EDTA) anticoagulant for determination of the hematological values (8).

Blood samples for antioxidant parameters were collected in plain bottles without anti-coagulant sent to the laboratory. The tubes were placed in a slanting wooden rack and the bloods samples were allowed to clot overnight. The serum samples were deep frozen prior to analysis to determine the anti-oxidant activities on serum catalase, superoxide dismutase and glutathione peroxidase. Serum catalase, superoxide and glutathione peroxidase levels were determined as described by (9), (10) and (11) respectively.

The contents of the caeca from the experimental birds (1 bird/replicate) were collected for bacterial analysis. A day before collection of caeca content, sterile bottles were prepared to collect the samples. The aerobic bacteria were cultured in nutrient agar, lactic acid-producing bacteria were cultured in Man Rogosa agar while the coliforms and intestinal negative lactose bacteria were cultured in Mac Conkey agar (12, 13).

The selected slaughtered experimental birds were scaled at 50^0C in a water bath, defeathered, dressed and weighed. Thereafter, the dressed percentage was estimated as the percentage of a liveweight. The internal organs (liver, kidney, heart, lung, pancreas, abdominal fat, gallbladder, gizzard, proventriculus, bursa of fabricus and spleen) were carefully excised, wiped clean with tissue paper and weighed using a sensitive scale. The relative internal organ weight was expressed as a percentage of the bird's live-weight.

The meat sample was collected from the breast, and the breast meat was subjected to microwave treatment at a temperature of 80^0C for 20 minutes using compact oven (PR305225m model). The sensory evaluation of microwave-sampled broiler meat from four birds per treatment was carried out by 12 panelists. The panelists consist of 12 semi-trained students of Food Science and Technology, The Federal Polytechnic, Ado. Each member of the panelists rinsed their mouth with warm water after assessing each meat sample to avoid carrying over effects. The parameters evaluated comprise texture, juiciness, color, flavor, tenderness and overall acceptability. Scores were awarded using nine (9) scale hedonic points.

9 Like extremely
8 Like very much
7 Like moderately
6 Like slightly
5 Neither like nor dislike
4 Dislike slightly
3 Dislike Moderately
2 Very much dislike
1 Dislike extremely

Statistical analysis

All data collected in this study were subjected to analysis of variance using SPSS software. Duncan's Multiple Range test of one way ANOVA was used to analyze the mean differences of the same parameter. Significant differences were considered where necessary at a level of ($P>0.05$).

Results and discussion

Table 3 shows the effect of phytogenic feed additives supplements on the hematological parameters of broiler chickens. The packed cell volume of birds fed control diet was significantly ($P<0.05$) higher than the packed cell volume of other birds on treated group. The highest packed cell volume was recorded for birds fed the control diet at 27.00% while the least was recorded for birds on cinnamon powder at 20.50%. The red blood cells of birds fed the control diet, diets 2 and 4 were significantly ($P<0.05$) higher than red blood cell of birds fed diet 3. The highest red blood cell value was recorded for birds on control diet at 3.75 while the least value was recorded for birds on diet 3 at 1.90. The hemoglobin value recorded for birds on diet 2 was significantly ($P<0.05$) lower than those values recorded for birds on control diet and diet 4. The mean corpuscular hemoglobin concentration, mean cell volume and mean corpuscular hemoglobin were not significantly affected by the phytogenic feed additive supplements

Table 3: Effect of phytogenic feed additives supplements on hematological parameters of broiler chicken

Parameters	Control diet	Diet 2	Diet 3	Diet 4	±SEM	P-Value
PCV (%)	27.00^a	20.50^c	22.00^{bc}	24.30^{ab}	0.86	0.01
RBC ($\times10^{12}$/L)	3.75^a	3.05^{ab}	1.90^b	3.64^a	0.28	0.03
Hb (g/dl)	9.00^a	6.80^c	7.35^{bc}	8.15^{ab}	0.29	0.01
MCHC (%)	33.33	33.46	33.40	35.27	0.04	0.53
MCV (fl)	55.38	54.67	54.03	55.14	0.03	0.62
MCH (pg)	25.23	25.18	25.14	25.08	0.04	0.54

^{a,b} means in the same row with different superscripts are significantly ($p<0.05$) different; SEM: standard error of the mean. PCV: Packed cell volume, RBC: Red blood cell, Hb: Hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, MCV: Mean cell volume, MCH: Mean corpuscular hemoglobin, Diet 1: Control diet, Diet 2: 0.2% cinnamon powder, Diet 3: 0.2% Ginger root, Diet 4: 0.2% Moringa leaf meal.

Table 4 shows the effect of phytogenic feed additives supplements on the antioxidant activities in the serum of broiler chickens. The serum catalase concentration in birds fed diet 3 was significantly ($P<0.05$) higher than those birds fed diets 2 and 4 which were similar ($P>0.05$). The lowest serum catalase (CAT) concentration was recorded for birds fed control diet. The serum glutathione peroxidase concentration of birds fed diets 3 and 4 were similar

(P>0.05) but significantly (P<0.05) higher than serum glutathione peroxidase concentration of birds fed diet 2 and control diet. The highest serum glutathione peroxidase concentration was recorded for birds on diet 4, whereas the lowest concentration was recorded for birds on control diet. The phytogenic feed additives had no influence on the superoxide dismutase concentration.

Table 4: Effect of phytogenic feed additives supplements on serum antioxidant activities of broiler chickens

Parameters	Control diet	Diet 2	Diet 3	Diet 4	±SEM	P-Value
catalase mg/ml	61.86[c]	89.74[b]	103.32[a]	79.27[b]	7.45	0.04
Gpx mg/ml	59.59[c]	169.09[b]	193.84[a]	195.09[a]	5.48	0.01
SOD	74.15	75.61	74.92	74.92	0.28	0.35

[a,b] means in the same row with different superscripts are significantly (p<0.05) different; SEM: standard error of the mean. GPx: glutathione peroxidase; SOD: superoxide dismutase. Diet 1: Control diet, Diet 2: 0.2% Cinnamon powder, Diet 3: 0.2% Ginger root, Diet 4: 0.2% Moringa leaf meal

Table 5 presents the effect of phytogenic feed additives supplements on the intestinal microbiota of broiler chickens. Lactic acid-producing bacteria, total aerobic bacteria, coliforms and intestinal negative bacteria were not significantly (p>0.05) affected by phytogenic feed additives supplements.

Table 5: Effect of phytogenic feed additives supplements on the intestinal microbiota of broiler chickens

Parameters	Control diet	Diet 2	Diet 3	Diet 4	±SEM	P-Value
LAPB	9.11	9.08	8.94	8.89	0.07	0.71
TAB	10.38	10.19	10.14	10.20	0.05	0.29
Coliforms	8.98	8.63	8.87	8.89	0.07	0.29
INB	9.89	9.80	9.74	9.80	0.07	0.28

[a,b] means in the same row with different superscripts are significantly (p<0.05) different; SEM: standard error of the mean. LAPB-Lactic Acid Producing Bacteria; TAB- Total Aerobic Bacteria; INB- Intestinal Negative Bacteria Diet 1: Control diet, Diet 2: 0.2% Cinnamon powder, Diet 3: 0.2% Ginger root, Diet 4: 0.2% Moringa leaf meal

Table 6 shows the effect of phytogenic feed additives supplements on carcass analysis and internal organs of broiler chickens. The liveweight, slaughtered weight, and eviscerated weight of birds fed diet 4 were significantly (P<0.05) higher compared to the control diet, cinnamon and ginger root. The internal organs spleen, pancreas, and lungs were significantly affected (P<0.05) by phytogenic feed additives.

Table 6: Effect of phytogenic feed additives supplements on carcass analysis and internal organs of broiler chickens

Parameters	Control diet	Diet 2	Diet 3	Diet 4	±SEM	P-Value
Liveweight (g)	1572.50[ab]	1701.00[ab]	1481.50[ab]	1950.51[a]	77.48	0.15
Slaughtered weight (%)	96.72[b]	96.44[b]	96.69[a]	98.34[a]	0.29	0.04
Dressed weight (%)	93.63	92.28	92.11	94.02	0.41	0.27
Eviscerated weight (%)	73.73[ab]	71.84[bc]	70.05[c]	75.63[a]	0.72	0.01
Liver (%)	2.77	2.34	2.34	2.39	0.09	0.28
Kidney (%)	0.81	0.79	0.79	0.78	0.08	0.12
Heart (%)	0.42	0.40	0.40	0.42	0.02	0.62
Spleen (%)	0.18[b]	0.16[a]	0.14[c]	0.15[bc]	0.01	0.11
Pancreas (%)	0.27[a]	0.26[ab]	0.27[a]	0.2[b]	0.01	0.06
Lungs (%)	0.61[a]	0.62[ab]	0.61[b]	0.62[a]	0.01	0.12
Proventiculus (%)	0.42	0.43	0.44	0.43	0.01	0.67
Abdominal fat (%)	1.11	1.13	1.15	1.13	0.01	0.06
Gallbladder (%)	0.14	0.15	0.13	0.13	0.02	0.11
Bursal Fabricus (%)	0.06	0.07	0.06	0.06	0.01	0.01
Gizzard (%)	2.25	2.21	2.39	1.49	0.19	0.37

[a,b] means in the same row with different superscripts are significantly (p<0.05) different; SEM: standard error of the mean. Expressed in percentage liveweight. Diet 1: Control diet, Diet 2: 0.2% Cinnamon powder, Diet 3: 0.2% Ginger root, Diet 4: 0.2% Moringa leaf meal

Table 7 shows the effect of the sensory evaluation of broiler chickens fed different phytogenic feed additives supplements. There was significantly ($P<0.05$) decrease in the texture and juiciness of breast meat of broiler fed diet 2 at 7.45 and 7.25, respectively. The color and flavor of breast meat of broilers fed diet 3 were significantly ($P<0.05$) decreased. The highest value recorded for color and flavor of breast meat of birds fed diet 3 were 7.50 and 7.45, respectively. Tenderness and overall acceptability were not significantly affected by phytogenic feed additives supplements.

Table 7: Sensory evaluation of broiler chickens fed different phytogenic feed additives supplements

Parameters	Control diet	Diet 2	Diet 3	Diet 4	±SEM
Texture	8.35^{a}	7.45^{b}	7.90^{ab}	7.47^{b}	0.12
Juiciness	8.30^{a}	7.25^{b}	7.70^{ab}	7.65^{ab}	1.12
Color	8.05^{a}	7.75^{ab}	7.50^{b}	7.70^{ab}	0.90
Flavor	8.40a	8.00^{ab}	7.45^{b}	7.75^{b}	0.11
Tenderness	7.95	7.40	8.00	7.55	0.12
Overall acceptability	8.10	7.55	7.80	7.80	0.09

^{a,b} means in the same row with different superscripts are significantly ($p<0.05$) different; SEM: standard error of the mean. Diet 1: Control diet, Diet 2: 0.2% Cinnamon powder, Diet 3: 0.2% Ginger root, Diet 4: 0.2% Moringa leaf meal

Discussion

The rich phytochemical constituents of the feed additives Cinnamon powder, ginger root powder and *Moringa oleifera* suggest that they confer enrichment on the diets fed to the birds. The phytogenic feed additives supplements possess flavonoids (kaempferol and quercetin), glycosides, steroids and phenolic acids (gallic, chlorogenic, ellagic and ferulic acid) (14), glucosinolates are valuable source of β-carotene (precursor of vitamin A) and vitamins (B-complex, C, D and K) (15), which confer high antioxidant activities. The hematological parameters are well-known excellent markers of the animal's physiological state (16). These results corroboration the findings of (17), which showed that phytogenic supplements have a significant effect on blood indices based on their nutritional status. These values of parameters are of good result for the physiological profile, pathological status and nutritional roles of animals can explain the effect of dietary agents and additive supplements in diet. Among the treatment groups in this study, birds on diet 4 had the highest values of Pcv, Rbc , and Hb levels. This study supports the findings of (18), who discovered an increase in Pcv, Rbc, and Hb with *Moringa oleifera* leaf meal supplementation levels of 20%. Mean Cell Hemoglobin Concentration (MCHC), Mean Cell Volume (MCV) and Mean Cell Hemoglobin (MCH) were not affected by the phytogenic supplements due to their various bioactive ingredients. Hematological indices for PCV in this study contradicted the range of 28.75 - 29.33% the values reported by (19). According to (20), the packed cell volume is involved in the transport of oxygen and absorbed nutrients. Increased packed cell volume shows better transportation and thus results in an increased primary and secondary polycythemia. The RBC range of $1.9 – 3.75 \times 10^{12}$/ L reported in this study for broiler chickens fell within the values of $1.5–3.9\times10^{12}$/L. This may indicate that the use of the phytogenic feed additives supplements in this study ensured effective transport of hemoglobin through the red blood cells of the broilers. This further gave a clear indication of adequate oxygen transportation within the tissues of the birds for the oxidation of digested feed. Results showed that the hemoglobin (Hb) level was within the normal range for healthy birds. This may indicate proper vitamin synthesis and optimal functioning of the bone marrow of the birds, in addition to the significant effect of feed additives on the hemoglobin and red blood cell, since hemoglobin functions as a carrier of oxygen to target organs by forming oxy-hemoglobin, a situation that indicates that the birds were not anemic nor lacked oxygen (21). Mean Cell Hemoglobin Concentration (MCHC), Mean Cell Volume (MCV) and Mean Cell Hemoglobin (MCH) were not affected by the phytogenic supplements due to their various bioactive ingredients.

Catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx) are enzymes that protect against oxidative stress (22). The study found that birds fed a diet supplemented with cinnamon powder, ginger root powder, and *Moringa oleifera* leaf meal had higher catalase and glutathione peroxidase activities, revealing the antioxidant and anti-stress properties of these phytogenic (23). The higher antioxidant activities observed in birds fed phytogenic feed additives supplements could be attributed to the phytogenic polyphenolic content (flavonoids or phenolic acids) (24). According to (25) the phytogenic active ingredients produce strong antioxidant effects that scavenge free radicals or increase the activities of CAT, SOD and GPx. According to (26) who reported that antioxidants play a significant role in chicken performance.

It was shown that all bacterial target groups had numerically reduced values of birds administered feed additives. All bacterial target groups were reduced as a result of the addition of phytogenic feed additives supplements to the experimental diets, which was consistent with (27) report. The phytogenic feed additives supplementation of the experimental diet regulated antimicrobial phytogen adhesion and subsequent modification of the gut microbiota, enhancing intestinal epithelial integrity. Although (28) found that lactobacillus spp. have a propensity to proliferate following the addition of phytogenic supplements, this finding does not corroborate the findings of the present investigation. However, comparable findings regarding the decrease and coliform bacteria were noted. The improved live weight, slaughtered weight, and eviscerated weight recorded for the birds fed *Moringa oleifera l*eaf meal supplements diet in this study agreed with an earlier report that supplementation of broiler chickens diet with phytochemicals such as lemon balm, cinnamon improved the carcass weight (29).This suggests that the phytogenic supplements used in this study have phytoconstituents or bioactive compounds that played a positive role on carcass. (29).These plant based compound have a similar structure to that of natural animal hormones. They could interact with the BETA -adrenergic receptor to modulate animal metabolism by increasing lipolysis and protein synthesis and by decreasing lipogenesis (30). There was decrease in the spleen values of birds fed diets 2, 3, and 4 compared with the values recorded for birds fed the control diet. This has been reported as a possible response of internal organs to toxins in their diets. (31). The higher spleen values recorded in birds fed the control diet may be as a result of the absence of toxins in the diets. The similarity in the growth response of these animal internal organs to phytogenic feed additive supplementation in this study suggests that the supplementation supports the normal functioning of birds' internal organs. The meat quality attributes of broiler chickens were not affected by the use of phytogenic supplements. (32) opined the perception and preference of sensory attributes as tenderness and overall acceptability, both perceived with sense of touch that different in the sensory assessment of meat. This result confirmed that the inclusion rate of phytogenic feed additives supplement did not influence meat organoleptic characteristics.

Conclusion

1. The study showed that among the dietary treatments, 0.2% moringa leaf meal supplementation increased the packed cell volume, red blood cell and hemoglobin of broiler chickens.
2. The supplementation of 0.2% cinnamon powder, 0.2% ginger root powder and 0.2% *Moringa oleifera* leaf meal increased the levels of serum antioxidant enzymes in broiler chickens.
3. The supplementation of 0.2% cinnamon powder, 0.2% ginger root powder and 0.2% *Moringa oleifera* leaf meal regulated antimicrobial phytogen adhesion and subsequent modification of the gut microbiota, which enhanced intestinal epithelial integrity.

4. The 0.2% moringa leaf meal dietary supplement improved the liveweight, slaughtered weight, dressed weight and eviscerated weight of the broiler chickens.

5. The supplementation of 0.2% cinnamon powder, 0.2% ginger root powder and 0.2% *Moringa oleifera* leaf meal did not affect the texture, color, juiciness, flavor, tenderness, and overall acceptability of the sensory evaluation of broiler meat.

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