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Combined Effects of Garlic, Ginger, Scent leaf and Seed under Leaf Meals on Performance and Blood Parameters Quality of Broiler Chickens

By

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Abstract
The research compared the effects of dietary supplementation of garlic, ginger, scent leaf and seed under leaf meals to growth performance, haematology, serum biochemistry and carcass characteristics of broiler chicken. A randomized design of five treatments with three replicas of three hundred (300) day old Cobb 500 broiler chicks was used in a completely randomized design. The Treatment 1 was used as control (no supplementation), Treatment 2, 3, 4 and 5 were fed 25g each of different combinations of garlic, ginger, scent leaf and seed-under-leaf meals per 25kg of popular commercial feed. Monitoring of performance parameters in growth performance parameters was carried out weekly. On day 42, haematological and serum biochemical samples were taken from three birds of each replicate after slaughtering and the carcass evaluated. Data collected were subjected to One way analysis of variance. It was found that final weight, weight gain, daily weight gain and feed conversion ratio (FCR) significantly varied ($p<0.05$) between treatments. Treatment 3 (garlic + seed-under-leaf + scent leaf) had the highest final weight (2262.96±64.01g) and weight gain (2086.10±62.94g) and best FCR (1.87±0.01) whilst control birds had the lowest performance. Displayed was no significant difference in feed intake ($p>0.05$). Haematological parameters were in the normal ranges of physiological processes, except the lymphocyte count that varied significantly ($p<0.01$). Biochemistry analysis of serum biochemistry demonstrated statistically significant differences ($p<0.05$) in the total protein, aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP) and creatinine with Treatment 5 (garlic + ginger + seed-under-leaf) demonstrating significantly high values. Dietary treatments did not have a significant effect ($p>0.05$) on carcass characteristics and organ weights. Adding 25g/kg of garlic, seed-under-leaf and scent leaf (Treatment 3) in the diet enhanced the growth performance and feed efficiency without any negative impact on haematology, serum biochemistry and carcass characteristics, and should be proposed as phytogenic feed additive to broiler production.

Keywords: *Phytogenic feed additives, broiler chickens, growth performance, serum biochemistry, haematology, carcass characteristics*

INTRODUCTION

The world poultry industry is under mounting pressure to minimize or eliminate antibiotic growth promoters (AGPs) because of the emerging concern on antimicrobial resistance and drug residue in poultry products (Windisch et al., 2008; Mehdi et al., 2018). The introduction of multidrug-resistant pathogens of the poultry production systems, Salmonella and Escherichia coli, have sparked serious public health concerns, and regulatory bans on AGP usage have been enacted in most countries (Dhama et al., 2015). As a result, safe, effective and economically viable alternatives are urgently required, which

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will be able to preserve the productivity and guarantee the food safety and acceptance by the consumers (Gadde et al., 2017).

The use of phytogenic feed additives, a class of products that are derived by using herbs, spices and medicinal plants, has become promising due to the variety of bioactive compounds which include antimicrobial, antioxidant, immunomodulatory and growth-promoting activities (Windisch et al., 2008; Hashemi and Davoodi, 2011). These are products of plant origin that have several benefits such as natural origin, the lack of residues and acceptability by the consumer (Brenes & Roura, 2010). It has been shown that phytobiotics have the potential to suppress pathogenic bacteria, regulate intestinal microbial flora, increase the activity of digestive enzymes and improve the efficiency of nutrient use in chickens (Vidanararachchi et al., 2005; Yang et al., 2009).

Medicinal plants are abundant in tropical regions that have potential therapeutic effects that have not been utilized fully on animals (Akinlade et al., 2021). Garlic (*Allium sativum*), ginger (*Zingiber officinale*), scent leaf (*Ocimum gratissimum*) and seed-under-leaf (*Phyllanthus amarus*) are some of them and are easily available and have been used conventionally due to its medicinal values.

Garlic also possesses allicin and other Sulphur compounds that have strong antimicrobial, hypocholesteroleic and immunomodulatory properties (Kyo et al., 2001; Ademola et al., 2009). Research has indicated that supplementation of garlic increases growth performance, lowers gut pathogenic bacteria and boosts immune responses in broiler chicken (Dieumou et al., 2009; Tolba et al., 2010). The hepatoprotective action of garlic is also reported, as the birds fed with garlic had lower levels of serum transaminase (Akinlade et al., 2021).

Ginger (*Zingiber officinale*) is an ingredient that has antioxidant, anti-inflammatory and digestive stimulant properties (Zhang et al., 2009). It has been found that ginger supplementation positively affects the secretion of digestive enzymes, feed consumption and weight gain, and has a positive impact on serum lipid profiles in broilers (Herawati and Marjuki, 2011; Okusanya and Akinlade, 2024). Garlic and ginger have been found to be synergistic in growth performance and immune sufferings (Zaib-ur-Rehman, 2011).

Scent leaf (*Ocimum gratissimum*) contains thymol and eugenol which have been well documented to have antimicrobial, antifungal and anti-inflammatory properties (Ngassoum et al., 2003; Oreagba et al., 2011). Research on the use of scent leaf supplementation in poultry has found that the supplement enhances growth, improves their immune system, and decreases mortality (Akinlade et al., 2021). The scent leaf has phytochemical composition of tannins, saponins, flavonoids, and alkaloids which make it have therapeutic value (Edeoga et al., 2005).

Seed under leaf (*Phytanthus amarus*) has lignans, alkaloids, flavonoids and tannins that are hepatoprotective, immunomodulatory and antiviral (Calixto et al., 1998; Patel et al., 2011). The customary applications of *Phyllanthus* species are the management of liver diseases, jaundice and viral infections (Unander et al., 1995). *Phyllanthus* extracts have been found to have the potential of enhancing liver functions and immune response in poultry (Oni et al., 2018).

Although these plants were studied separately or in small combinations, there is only a limited amount of information regarding the synergistic property of various combinations of all four plants. Blends of phytogenic additives can have an augmented or modified effect by additive or synergistic interactions of bioactive compounds (Obianwuna et al., 2024). The study of these interactions is vital in the formulation of excellent phytogenic feed additives that are likely to substitute antibiotic growth promoters in chicken rearing. Thus, this research was intended to assess the influence of various mixtures of garlic, ginger, scent leaf and seed-under-leaf meals on growth performance, haematological parameters, serum biochemistry and carcass traits of broiler chickens, and determine what mixtures of phytotransformers are the most effective.

Materials and Methods

Ethical Approval

All experimental procedures involving animals were performed in accordance with international and institutional guidelines for animal care and use, and ethical approval was obtained from the The Federal Polytechnic, Ilaro Research Committee, Ogun State.

Experimental Site

The experiment was carried out at the poultry department of the Department of Animal Production Technology within the Federal Polytechnic Ilaro, the Ogun State in Nigeria. The location lies in the derived savanna area of southwestern Nigeria at a geographical position of 6^{o}3746^{o}5542E 2^{o}4724E to 3^{o}6E and an elevation of 241 feet above the sea level. Mean annual precipitation in the area is 185.42 mm and the range of mean temperatures is 73degF to83degF (Weather Spark, 2017).

Preparation of Phytogenic Meals

The bulbs of fresh garlic (*Allium sativum*), rhizomes of ginger (*Zingiber officinale*), scent leaf (*Ocimum gratissimum*) and seed under-leaf (*Phyllanthus amarus*) were obtained at the Federal Polytechnic Ilaro teaching and research farm. A botanist of Crop Production Technology Department of authenticated plant materials. Garlic bulbs were cut into cloves, cut into thins and dried in the oven at 60^{o}C till they reached the same weight (AOAC, 2005). Ginger root were sponged, cut in thin slices which were dried in the air under shade over a period of seven days. Scent leaf and seed-under-leaf were also air-dried under shade in seven days with frequent turning to ensure the absence of mould development (Akinlade et al., 2021). The dried materials were milled in a laboratory hammer mill to fine powder and put in airtight containers and kept at room temperature until needed to make the feed (Okusanya and Akinlade, 2024).

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Experimental Birds and Management

The hatchlings were three hundred (300) Cobb 500 day-old broilers that were sourced from a reputable hatchery and randomly allocated to five dietary treatments. The treatments were repeated thrice with twenty birds in each replica (60 birds per treatment) in a completely randomised design (CRD) as indicated by Oni et al. (2018). The deep litter pens of 2m x 1.5m (litter material of wood shavings) were used to house the birds. During the 42 days of experiment, the usual management practices with broilers were observed. Food and water were fed on ad libitum. The use of vaccination and medication programs was according to schedules (Zaib-ur-Rehman, 2011).

Experimental Diets and Treatments

During the course of the experiment, all the birds were fed a normal commercial broiler diet. The phytogenic supplements were supplemented by adding 25g of each of the plant materials to every kg of the feed as per treatment requirement (Ademola et al., 2009). The dietary treatments were:

Treatment 1: Control (basal diet) (not supplemented)
Treatment 2: Basal diet + 25g/kg of garlic, ginger and scent leaf meal.
Treatment 3: Basal diet + 25g /kg each of garlic, seed-under-leaf and scent leaf meal.
Treatment 4: Basal diet + 25g/kg each, ginger, seed-under-leaf, and scent leaf meal,
Treatment 5: Basal diet + 25g/kg of each, garlic, ginger and seed-under-leaf meal.

Growth Performance Parameters

Feed Intake

The daily weight of the feed offered was calculated as the difference between the weight of feeds fed after 24 hours and the weight of feeds fed at the end of 24 hours (Tolba et al., 2010).

Body Weight and Weight Gain

A sensitive digital scale was used to take the individual body weights on a weekly basis. The difference of the final weight and the initial weight was considered to be the weight gain (Zhang et al., 2009).

Feed Conversion Ratio (FCR)

Feed conversion ratio was intake of total feed divided by the total weight gain (Herawati and Marjuki, 2011).

Carcass Evaluation

On day 42, three birds per replicate (nine birds per treatment) were randomly chosen, weighed and slaughtered through the destruction of the jugular vein in a humane manner (Oni et al., 2018). Birds were skinned and open-gutted. Parameters of carcass that were measured comprised live weight, dressed weight (eviscerated carcass weight), head, neck, wing, back, breast, thigh, drumstick, shank, gizzard and proventriculus, weight expressed as a percentage of live weight (Dieumou et al., 2009). Weight of the kidney, lungs, heart, liver, and spleen were taken. The parameters that were measured in intestines covered duodenum, jejunum, ileum, caeca and colon weights and lengths.

Haematological Analysis

In the fourth week, day 42, three birds per replicate (nine birds per treatment) were randomly picked and blood samples (3 mL) were taken at the wing vein with the help of sterile syringes and needles. As a preservative to haematological analysis of blood, the blood samples were transferred into sample bottles that contained ethylenediaminetetraacetic acid (EDTA), as an anticoagulant (Jain, 1993). The haematological parameters that had been determined were the red blood cell count (RBC), packed cell volume (PCV), haemoglobin concentration (Hb), platelet count, total white blood cell count (WBC), lymphocytes (LYM), heterophils (HRTE), monocytes (MONOC), eosinophils (EOSINO), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC). The automated haematology analyzer (Sysmex XT-2000i) was used as per the protocols of the manufacturer (Dieumou et al., 2009).

Serum Biochemical Analysis

The samples of blood (without anticoagulant, 3 mL) were left to clot at room temperature and centrifuged in 3000 rpm over 15 minutes to extract serum (Akinlade et al., 2021). Serum samples were kept at -20^{o}C till analysis. Total protein (TP), albumin (ALB), globulin (GLB), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), blood urea nitrogen (BUN) and creatinine were the serum biochemical parameters identified by commercial diagnostic kits (Randox Laboratories, UK). The spectrophotometer (Shimadzu UV-1201) was used to perform the analyses by standard procedures (Meluzzi et al., 1992).

Statistical Analysis

One-way analysis of variance (ANOVA) was conducted on the obtained data using SPSS software (Version 10.0, SPSS Inc., Chicago, IL, USA) as per the procedure given by Steel and Torrie (1980). The statistical model adopted was as follows:

Yij = m + Ti + eij
Where:
Yij = individual observation
m = population mean
Ti = effect of ith treatment
eij = random error

Duncan New Multiple Range Test was used to separate significant difference among treatment means (Duncan, 1955). The p-value that was taken to be significant was 0.05.

Results

Growth Performance of Broiler Chickens Fed Diets Supplemented with Phytogenic Combinations

Table 1 represents the effects of dietary phytogenic supplements on the growth performance of broiler chicken. The initial body weights were statistically equivalent (p>0.05) in all treatments between 173.53±2.93g to 181.73±3.3 0g; that is, the allocation of birds at the beginning of the experiment was uniform. The final weight, weight gain, daily weight gain and feed conversion ratio (FCR) were significantly different

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($p<0.05$). Final weight 3 (garlic + seed-under-leaf + scent leaf) had the highest final weight of 2262.96±64.01g that was significantly better ($p<0.05$) than all other treatments. The final weight in Treatment 1 (control) was lowest (1810.52±37.56g). The final weight of Treatments 2, 4 and 5 were intermediate (2001.98±24.52g, 2116.67±61.19g) and significantly different, though similar, to each other. The same was evident in weight gain where Treatment 3 recorded the greatest gain (2086.10±62.94g) and Treatment 1 recorded the least gain (1628.79±34.30g). The average of the weight gain daily was 38.78±0.82g/day in Treatment 1 and 49.67±1.50g/day in Treatment 3. Dietary treatments had a significant impact ($p<0.05$) on feed conversion ratio. The FCR was in Treatment 3 the highest (1.87±0.01), which means that it was most efficient in feed, and in Treatment 1, the FCR was the lowest (2.59±0.17). Treatments 2, 4 and 5 had a moderate FCR value (1.89±0.07 to 2.19±0.09). There were no significant differences ($p>0.05$) in the feed intake among treatments but there were numerical differences of Treatment 5 3656.93±12.20g, and Treatment 1 4222.93±278.93g

Table 1: Growth Performance of Broiler Chickens Fed Diets Supplemented with Phytogenic Combinations

Treatment	Initial weight (g)	Final weight (g)	Weight gain (g)	Daily weight gain (g/d)	Feed intake (g)	FCR
1 (Control)	181.73±3.30	1810.52±37.56[c]	1628.79±34.30[c]	38.78±0.82[c]	4222.93±278.93	2.59±0.17[a]
2	173.53±2.93	2001.98±24.52[b]	1828.44±26.78[b]	43.53±0.64[b]	4007.70±172.83	2.19±0.09[b]
3	176.87±1.07	2262.96±64.01[a]	2086.10±62.94[a]	49.67±1.50[a]	3911.56±132.58	1.87±0.01[c]
4	177.53±2.60	2062.59±8.12[b]	1885.06±10.51[b]	44.88±0.25[b]	3718.93±29.59	1.97±0.03[b]
5	175.27±2.85	2116.67±61.19[b]	1941.40±61.16[b]	46.22±1.46[b]	3656.93±12.20	1.89±0.07[bc]
P-value	0.32	0.00	0.00	0.00	0.16	0.00

a,b,c: Means within a column with different superscripts differ significantly ($p<0.05$). Values are mean ± SEM.

Carcass Characteristics of Broiler Chickens Fed Phytogenic-supplemented Diets

Table 2 gave the carcass traits of broiler chicken fed on experimental diets. The live weight at slaughter was 1912.00±108.56g Treatment 1 and 2044.00±109.05g Treatment 3 without significant differences ($p=0.78$) between treatments. Dressed percentage was 63.90±1.09% in Treatment 2 and 71.64±4.36% in Treatment 3 with a statistically significant difference among treatments ($p=0.47$). The percent of neck was between 3.40±0.14% to 3.63±0.22, wings between 5.92±0.61% to 7.81±0.47, back between 11.30±0.96% to 12.60±1.58, breast between 20.75±1.30% to 24.72±0.50, thigh between 9 All these parameters were not significantly different ($p>0.05$) across treatments

Table 2: Carcass Characteristics of Broiler Chickens Fed Phytogenic-supplemented Diets

Treatment	Live weight (g)	Dressed (%)	Neck (%)	Wings (%)	Back (%)	Breast (%)	Thigh (%)	Drumstick (%)
1	1912.00±108.56	64.90±4.02	3.45±0.30	7.81±0.47	12.06±0.76	20.75±1.30	9.78±1.02	9.42±0.39
2	1915.67±67.32	63.90±1.09	3.63±0.22	5.92±0.61	11.85±0.34	20.78±0.45	9.74±0.31	9.55±0.17

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Treatment	Live weight (g)	Dressed (%)	Neck (%)	Wings (%)	Back (%)	Breast (%)	Thigh (%)	Drumstick (%)
3	2044.00±109.05	71.64±4.36	3.55±0.59	6.31±0.29	12.60±1.58	24.72±0.50	11.93±0.93	9.48±0.32
4	1941.33±30.12	65.02±1.41	3.40±0.14	6.87±0.51	11.30±0.96	22.61±0.57	10.59±0.60	9.09±0.40
5	2006.67±103.68	69.18±4.39	3.50±0.40	6.83±0.66	11.88±0.95	24.21±1.66	11.12±1.09	10.20±0.69
P-value	0.78	0.47	0.99	0.19	0.92	0.06	0.36	0.56

Values are mean ± SEM. No significant differences (p>0.05) were observed among treatments.

Haematological Parameters of Broiler Chickens Fed Phytogenic-supplemented Diets Table 3 showed the haematological parameters of broiler chicken fed on experimental diets. The counts of red blood cells (RBCs) in Treatment 4 and Treatment 2 were 2.55±0.31 x 1012/L and 4.36±0.32 x 1012/L respectively and there are no significant differences between treatments (p>0.05). The values of the packed cell volume (PCV) were 22.67±0.88% in Treatment 1 and 31.33±1.76% in Treatment 2 and were statistically the same (p>0.05). There were no significant differences in the haemoglobin (Hb) concentration in the Treatment 1 (7.57±0.19 g/dL) and Treatment 2 (10.40±0.59 g/dL). The counts of the platelets differed significantly (p<0.05) with Treatment 4 recording the lowest (15667±27285 x 103/mL) and Treatment 1 recording the highest (25333±13333 x 103/mL). The numbers of total white blood cells (WBC) were between 8633±3755 x 103/mL in Treatment 5 and 18000±1000 x 103/mL in Treatment 1 with a lot of difference in value (p<0.05). The counts of lymphocytes (LYM) had a significant variation among treatments (p=0.01). The rate of lymphocytes in Treatment 1 was the highest lymphocytes (11357±248) and compared with that of Treatment 5 (3663±1684), the difference was significant. There was the lowest number of lymphocytes in Treatment 5, intermediate values in Treatments 2 (6472±1109), 3 (7379±863) and 4 (7971±1218). The number of heterophiles ranged between 4080±642 in Treatment 4 and 8223±3229 in Treatment 1, which are not significant (p>0.05). There were also no significant differences in the number of monocyte (MONOC) and eosinophil (EOSINO) among treatments (p>0.05). Dietary treatments did not have any significant effect (p>0.05) on mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC). MCH values were between 23.92±0.69 pg and 30.60±0.82 pg, MCV was 72.07±2.14 fL to 96.59±0.76 fL and MCHC 31.68±0.82 g/dL to 33.43±0.68 g/dL.

Table 3: Haematological Parameters of Broiler Chickens Fed Phytogenic-supplemented Diets

Treatment	RBC ($\times 10^{12}$/L)	PCV (%)	Hb (g/dL)	WBC ($\times 10^3/\mu L$)	LYM	HRTE	MONOC	EOSINO
1	2.98±0.30	22.67±0.88	7.57±0.19	18000±1000^{a}	11357±248^{a}	8223±3229	560±385	520±140
2	4.36±0.32	31.33±1.76	10.40±0.59	15350±1125^{ab}	6472±1109^{b}	7929±943	827±433	622±128
3	3.95±0.68	29.67±3.28	9.67±1.17	13467±1737^{ab}	7379±863^{b}	5617±1333	118±60	353±49

*Corresponding Author: **O. O. Akinlade.**

Treatment	RBC ($\times 10^{12}$/L)	PCV (%)	Hb (g/dL)	WBC ($\times 10^{3}$/µL)	LYM	HRTE	MONOC	EOSINO
4	2.55±0.31	24.67±2.96	7.77±0.75	12533±1794^{ab}	7971±1218^{ab}	4080±642	145±94	337±74
5	3.91±0.96	30.33±4.98	10.00±1.63	8633±3755^{b}	3663±1684^{c}	4317±2035	336±254	457±304
P-value	0.22	0.27	0.21	0.09	0.01	0.41	0.41	0.72

a,b,c: Means within a column with different superscripts differ significantly (p<0.05). Values are mean ± SEM.

Serum Biochemistry of Broiler Chickens Fed Phytogenic-supplemented Diets

Table 4 shows the serum biochemical indices of broiler chicken fed experimental diets. Treatment showed a significant difference ($p<0.006$) in total protein (TP) with the highest value being 3.60±0.06 g/dL in the Treatment 3 and the lowest value being 3.85±0.03 g/dL in the Treatment 5. Treatment 5 had was much higher in TP when compared to Treatment 1, 3 and 4, whereas Treatment 2 had intermediate values. Albumin (ALB) in Treatment 4 and Treatment 5 were 0.55±0.03 g/dL and 0.85±0.09 g/dL with significant differences ($p>0.185$). The mean of the Globulin (GLB) was statistically comparable ($p>0.737$) and was 3.00±0.06 g/dL to 3.10±0.00 g/dl. There were strong treatment differences ($p<0.021$) in aspartate aminotransferase (AST) activity. The highest AST value (183.50±0.87 U/L) was obtained in treatment 5 and this was considerably greater than all other treatments. The statistical similarity of the ASTs of Treatments 1, 2, 3 and 4 ranged between 178.33±0.33 U/L and 180.00±0.87 U/L and the significant differences were found between Treatment 3 and 5 ($p<0.034$). Treatment 2 and Treatment 5 demonstrated a high value of ALT in comparison to Treatment 1, Treatment 3 and Treatment 4. The difference ($p<0.015$) between the Alkaline phosphatase (ALP) activity in Treatment 4 (147.00±17.90 U/L) and Treatment 5 (199.50±0.87 U/L) was found to be significantly different. Treatment 4 had very low ALP in comparison with all other treatments which were not statistically different. The mean blood urea nitrogen (BUN) in Treatment 3 (1.30±0.06mg/dl) was not significantly different ($p>0.061$) compared to Treatment 5 (1.75±0.14mg/dl) although Treatment 5 tended to have higher values. The difference in creatinine level was very significant ($p<0.003$) with a range of 0.50±0.00mg/dL in Treatment 3 and Treatment 4 and 0.85±0.09mg/dL in Treatment 5. Treatment 5 had a large value of creatinine than all other treatments.

Table 4: Serum Biochemistry of Broiler Chickens Fed Phytogenic-supplemented Diets

Treatment	TP (g/dL)	ALB (g/dL)	GLB (g/dL)	AST (U/L)	ALT (U/L)	ALP (U/L)	BUN (mg/dL)	CREAT (mg/dL)
1	3.63±0.03^{ab}	0.60±0.10^{ab}	3.03±0.07	178.33±0.33^{a}	19.67±0.67^{a}	178.33±0.67^{b}	1.37±0.09^{a}	0.53±0.03^{a}
2	3.73±0.03^{bc}	0.67±0.12^{ab}	3.07±0.09	179.67±0.33^{a}	20.67±0.88^{b}	189.67±5.78^{b}	1.53±0.09^{b}	0.63±0.03^{a}
3	3.60±0.06^{a}	0.60±0.06^{ab}	3.00±0.06	178.33±0.88^{a}	19.33±0.33^{a}	181.67±3.76^{b}	1.30±0.06^{a}	0.50±0.06^{a}
4	3.65±0.03^{ab}	0.55±0.03^{a}	3.10±0.00	180.00±1.73^{a}	19.50±0.29^{a}	147.00±17.90^{a}	1.45±0.09^{ab}	0.50±0.00^{a}
5	3.85±0.03^{c}	0.85±0.	3.00±0	183.50±0	22.50±0.	199.50±0.	1.75±0.	0.85±0.0

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Treatment	TP (g/dL)	ALB (g/dL)	GLB (g/dL)	AST (U/L)	ALT (U/L)	ALP (U/L)	BUN (mg/dL)	CREAT (mg/dL)
		09^{b}	.06	.87^{b}	87^{b}	87^{b}	14^{b}	9^{b}
P-value	0.00	0.18	0.73	0.02	0.03	0.01	0.06	0.00

a,b,c: Means within a column with different superscripts differ significantly (p<0.05). Values are mean ± SEM.

Organ Weights of Broiler Chickens Fed Phytogenic-supplemented Diets

Table 5 shows the weights of the organs and the percentage of gizzard/proventriculus. There was a percentage range of 1.60±0.08 to 1.85±0.06, 0.39±0.03 to 0.46±0.04, 0.34±0.03 to 0.57±0.09, 0.49±0.03 to 0.67±0.09, 0.34±0.03 to 0.57. All these parameters did not have significant difference (p>0.05) between treatments.

Table 5: Organ Weights of Broiler Chickens Fed Phytogenic-supplemented Diets

Treatment	Gizzard (%)	Provent (%)	Kidney (%)	Lungs (%)	Heart (%)	Liver (%)	Spleen (%)
1	1.85±0.06	0.39±0.03	0.39±0.00	0.49±0.05	0.38±0.04	1.93±0.15	0.10±0.03
2	1.60±0.08	0.41±0.07	0.34±0.10	0.67±0.09	0.39±0.05	2.40±0.44	0.10±0.00
3	1.77±0.19	0.44±0.00	0.57±0.09	0.49±0.03	0.44±0.05	2.21±0.11	0.15±0.03
4	1.83±0.07	0.46±0.04	0.43±0.06	0.57±0.09	0.34±0.03	1.95±0.14	0.10±0.05
5	1.62±0.12	0.44±0.03	0.38±0.04	0.65±0.02	0.38±0.02	1.95±0.16	0.07±0.02
P-value	0.43	0.79	0.21	0.18	0.54	0.55	0.45

Values are mean ± SEM. No significant differences (p>0.05) were observed among treatments.

Intestinal Parameters of Broiler Chickens Fed Phytogenic-supplemented Diets

Table 6 gives the intestinal parameters of broiler chickens fed on experimental diets. The duodenum weight was between 1.21±0.04g and 1.44±0.10g, duodenum length was 1.49±0.19 cm to 1.91±0.07 cm, jejunum weight was 1.78±0.09g to 2.24±0.41g, jejunum length was 3.59±0.20 cm to 4.25±0 All these parameters did not have significant difference (p>0.05) between treatments.

Table 6: Intestinal Parameters of Broiler Chickens Fed Phytogenic-supplemented Diets

Treatment	Due wt (%)	Dou lght (%)	Jeju wgt (%)	Jeju lnt (%)	Ile wgt (%)	Ile lnt (%)	Ceac wgt (%)	Cea lnt (%)	Colo wgt (%)	Col lnt (%)
1	1.44±0.10	1.91±0.07	1.98±0.24	3.59±0.20	1.86±0.42	4.01±0.30	0.41±0.03	0.78±0.04	0.16±0.04	0.34±0.01

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Treatment	Due wt (%)	Dou lght (%)	Jeju wgt (%)	Jeju lnt (%)	Ile wgt (%)	Ile lnt (%)	Ceac wgt (%)	Cea lnt (%)	Colo wgt (%)	Col lnt (%)
2	1.39± 0.03	1.82± 0.09	2.24± 0.41	4.01± 0.40	1.72± 0.37	4.05± 0.48	0.96± 0.28	0.89± 0.09	0.26± 0.07	0.45±0.07
3	1.32± 0.03	1.74± 0.10	1.78± 0.09	4.18± 0.31	1.24± 0.04	3.57± 0.11	0.52± 0.11	0.79± 0.03	0.23± 0.04	0.42±0.06
4	1.21± 0.04	1.49± 0.19	1.91± 0.23	4.25± 0.26	1.60± 0.10	3.51± 0.17	0.78± 0.06	0.90± 0.08	0.39± 0.06	0.48±0.02
5	1.24± 0.07	1.67± 0.06	1.80± 0.16	4.25± 0.12	1.23± 0.11	3.43± 0.21	0.64± 0.12	0.84± 0.04	0.34± 0.10	0.45±0.05
P-value	0.11	0.18	0.70	0.45	0.37	0.42	0.15	0.52	0.19	0.31

Values are mean ± SEM. No significant differences (p>0.05) were observed among treatments.

Discussion

Marked increase in final weight, weight gain, daily weight gain and feed ratio in the groups fed on supplementation over the control indicates the growth promoting capacity of the phytogenic combinations assessed. Treatment 3 (garlic + seed-under-leaf + scent leaf) showed better performance, indicating that there were synergistic interactions between these three plants that promoted the utilization and growth of nutrients. These results concur with earlier research conducted on the same subject stating enhanced performance in regard to growth of broilers that were fed on phytogenic supplements (Windisch et al., 2008; Hashemi and Davoodi, 2011). The increase in the growth performance could be explained by a number of mechanisms. Phytogenic additives have been shown to stimulate the release of digestive enzymes, increase nutrient absorption as well as alter the composition of gut microbiota (Yang et al., 2009; Brenes and Roura, 2010). Allicin and other sulphur compounds found in garlic have antimicrobial effects, which decrease the pathogenic load of bacteria and enable more nutrients to grow (Ademola et al., 2009). Dieumou et al. (2009) indicated that Escherichia coli and other Enterobacteria counts in the ileo-caecal digesta of the broilers were significantly decreased by the garlic essential oil, which led to better gut health and nutrient exploitation. Ginger also includes gingerols and shogaols which promote gut motility and digestive enzymes (Zhang et al., 2009). Herawati and Marjuki (2011) had found improved growth in broilers when ginger extract was fed and explained the reaction by the ability to digest and absorb nutrients in their feeds. The birds that were fed ginger water had the biggest intake of feed (2956.8g), weight gain (1746.67g) and best feed ratio (1.76) according to Okusanya and Akinlade (2024), which aligns with the better FCR of supplemented groups in the current study. *Ocimum gratissimum* is a scent leaf plant, which has thymol and eugenol and is an antimicrobial and antioxidant (Ngassoum et al., 2003; Oreagba et al., 2011). According to Vidanararachchi et al. (2005), this could have helped to improve gut health by reducing the number of pathogenic bacteria and increasing the number of beneficial microbiota by the addition of scent leaf to the Treatment 3. Seed under leaf (*Phylanthus amarus*) has hepatoprotective lignans and alkaloids (Calixto et al., 1998; Patel et al., 2011), which could have improved liver functionality and nutrient metabolism, helping in increased growth performance. The fact that there are no significant differences in feed intake among treatments points to the fact that the enhanced growth was because the fed was more readily utilized as opposed to consumed as it was represented in the significantly better FCR. The observation aligns with that noted by Tolba et al. (2010) which indicated enhanced FCR of broilers fed on garlic supplemented diets with no major alterations on feed intake. The highest FCR was recorded in Treatment 3 (1.87), which can be compared with the value of 2.17 of birds feeding on phytogenic supplements that Okusanya and Akinlade (2024) reported. The high performance of Treatment 3 over the rest combinations implies that the combination of garlic, seed-under-leaf and scent leaf gave the best synergistic effect. Combination effects of phytogenic compounds can increase their biological effects more than the isolated effects do (Obianwuna et al., 2024). The research of phytobiotic mixtures has proved that some of them have better antioxidant, antimicrobial and growth-promoting activities than individual mixtures (Gadde et al., 2017).

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The lack of meaningful change in the carcass traits, organ weights and intestinal factors between treatments shows that the phytogenic supplements showed no negative effects on the carcass yield or organ growth. The implication of this finding on the commercial application is that any adverse impacts on carrases quality would limit the applicability of these additives (Dieumou et al., 2009).

The statistically insignificant numerically bigger breast percentage (24.72%) and thigh percentage (11.93), in Treatment 3, could have been due to the higher growth performance in the given group. Mostly, the beneficial part of the broiler carcass is the breast muscle, and any disposition to rise in the level of breast yield is productive (Oni et al., 2018). Statistical significance could be absent because the sample size was rather small and carcass measurements are subject to inherent variability.

Hematological parameters are valuable members of health and physiological status of the animal, which reflects how the body reacts to food and environmental conditions (Jain, 1993). The lack of any significant differences in the majority of haematological parameters (RBC, PCV, Hb, platelets, WBC, heterophils, monocytes, eosinophils, MCH, MCV, MCHC) indicate that the phytogenic supplements did not have any negative effect on the haematopoietic system in the levels studied. The result is in line with Akinlade et al. (2021) who noted that aqueous solutions of garlic, ginger and scent leaf at the concentrations of 50 mL/L of drinking water kept haematological indices in reference ranges in broiler chickens.

RBC values of 2.55-4.36 x 10 -1 /L, PCV of 22.67-31.33 and Hb of 7.57-10.40 g/dl are within the normal physiological ranges of broilers chickens according to Meluzzi et al. (1992) and Jain (1993). This supports the fact that the birds have been healthy during the period of the experiment and that the phytogenic supplements did not cause anaemia or erythrocyte disorders. Dieumou et al. (2009) also indicated that even the highest level of essential oils of garlic and ginger at 40 mg/kg/day did not negatively impact haematological parameters in broilers.

The large difference between the lymphocyte counts among treatments is notable and it suggests aspects of immunomodulatory action of the phytogenic supplements. Lymphocytes are important in adaptive immune system and previous studies have reported on the phytogenic additives modulation (Kyo et al., 2001). The control birds had the highest lymphocyte count (11357) than the supplemented groups, which could be as a result of subclinical immune challenge in the control birds, whereas supplemented birds could have had lower immune stimulation because of antimicrobial effects of the phytogenic additives.

According to Zaib-ur-Rehman (2011), dietary supplementation of garlic and ginger had significant impacts in raising the lymphocyte counts and antibody titers against Newcastle disease and Infectious Bursal disease in broilers and showed an improvement in immune response. The reduced number of lymphocytes in Treatment 5 (3663) could be either due to redistribution of the lymphocytes to the tissues or due to disinhibited immune activation as postulated by Humphrey and Klasing (2004). This idea that phytogenic additives have the potential to lower the energy requirement of the immune system enabling greater investment into growth is justified by the greater growth performance seen in the supplemented groups.

Biochemical parameters in serums are useful in the assessment of metabolic status and organ functioning, which represents the influence of dietary interventions on the protein metabolism, liver functioning and kidney functioning (Meluzzi et al., 1992). The dramatic changes in total protein, AST, ALT, ALP and creatinine demonstrate that the phytogenic mixtures affected the metabolic values.

Treatment 5 (3.85 g/dL) and Treatment 3 (3.60 g/dL) had the highest and lowest total protein respectively, indicating the nutritional status and the ability to synthesize hepatic proteins. According to Akinlade et al. (2021), there was a significant enhancement in albumin, total serum protein and globulin of broilers with the use of garlic aqueous blend, which indicated an enhanced protein synthetic activity. The increased total protein in Treatment 5 can be attributed to increase in protein synthesis or decrease in protein catabolism in line with the better growth in this group.

Nevertheless, Treatment 5 also exhibited high AST (183.50 U/L) and ALT (22.50 U/L), which can, possibly be the signs of higher liver metabolism or slight hepatocyte effects. AST and ALT are intracellular enzymes that are discharged into the circulation following damage of the hepatocellular or elevated membrane permeability (Duncan and Prasse, 1986). According to Dieumou et al. (2009), essential oils of garlic and ginger (up to 40mg/kg/day) did not cause any noticeable alterations to serum transaminases meaning that the essential oils were not toxic. The found values of this study are in acceptable proportions of broiler chicken as found by Meluzzi et al. (1992), which imply that the elevations, though all found to be significant, might not imply any pathological liver lesions.

It has been reported that garlic and Phyllanthus species possess hepatoprotective properties (Patel et al., 2011; Calixto et al., 1998). The reduced AST and ALT levels in Treatments 3 and 4 relative to Treatment 5 indicate the possibility of hepatoprotective effects of the combinations containing sensorleaf that alleviate the possible stress on the liver. Akinlade et al. (2021) support this finding by mentioning that the AST and ALT levels decreased with the help of garlic aqueous blend, which confirmed the hepatoprotective properties of this substance.

ALP is an enzyme that is related to the metabolism of bones and biliary, which demonstrated a great variation with the Treatment 4 recording the lowest value (147.00 U/L). It is possible that the difference among the lower ALP in Treatment 4 is the less bone turnover or the varying metabolic impact of the ginger + seed-under-leaf + scent leaf mix. The findings of Zhang et al. (2009) indicated that the bone metabolism indicators in broilers were affected by ginger

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supplementation, which is consistent with the changes in ALP in this study.

Creatinine, a biological indicator of kidney activity and muscular metabolism, was substantially high in Treatment 5 (0.85 mg/dL) in comparison with the rest of the treatments. As it has been reported in some studies that garlic and ginger have nephroprotective effects (Nasri et al., 2013), integrations of various herbs might have diverse effects. Oni et al. (2018) have indicated that dietary phytomix supplementation (garlic, ginger and Chaya leaf) up to 10.0 g/kg had significant effects on the serum chemistry parameters except creatinine and AST that did not significantly change. Both Treatment 5 and numerically higher BUN (1.75mg/dL) indicate that this combination can potentially have mild effects on renal going, which is worth further research.

The lack of great variation in weights of organs (liver, heart, kidney, lungs, spleen) indicate that the phytogenic supplements did not result in organ swelling or disease. This is in tandem with Dieumou et al. (2009) who stated that the garlic and ginger essential oil treatments did not cause any changes in the organ weights and carcass traits, other than a decrease in relative liver weight in birds which was treated with the garlic oil. The research on the use of oil mixes of garlic and ginger has revealed that there are no traces of inflammation in the internal organs like liver, kidney and spleen indicating that these supplements are safe (Zaib-ur-Rehman, 2011).

The treatment did not also affect intestinal parameters (weights and lengths of duodenum, jejunum, ileum, caeca and colon) and it was possible that the enhanced nutrient utilization in the growth performance came about by an increase in the activity of digestive enzymes or an increase in the absorptive capacity of the intestine rather than by morphological alterations. According to Obianwuna et al. (2024), the action of phytobiotics on gut health included the effects on gut morphology, gut integrity, gut microflora composition, antioxidant capacity and immune function. Studies have found out that some mixtures of phytobiotics may enhance considerably the height of villus and depth of the crypt, which has led to the improvement of nutrient absorption (Brenes & Roura, 2010).

Conclusion and Recommendation

This research concluded that dietary supplementation of 25g /kg of garlic, ginger, scent leaf and seed-under-leaf meal, especially the garlic, seed-under-leaf and scent leaf (Treatment 3) mixture had positive effect on growth performance and feed conversion ratio in broiler chicken.

The analysis of serum biochemicals showed that although the majority of the parameters were in the normal physiological ranges, Treatment 5 (garlic + ginger + seed-under-leaf) was linked with higher liver enzymes (ALT, AST and ALP) and creatinine values, which might indicate the slight effects on liver and kidney functioning and require additional research.

This research recommends the mixture of garlic, seed-under-leaf and scent leaf in 25g each to 25kg of basal diet to be as a good phytogenic feed additive in broiler chickens providing an alternative to antibiotic growth promoters.

CONFLICT OF INTEREST

All authors declared no conflict of interest in the conduct or the presentation of the research.

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References

1. Ademola, S. G., Farinu, G. O. & Babatunde, G. M. (2009). Serum lipid, growth and haematological parameters of broilers fed garlic, ginger and their mixtures. *International Journal of Poultry Science*, 8(5), 452-458.
2. Akinlade, O. O., Okusanya, P. O. & Okparavero, O. O. (2021). Effect of aqueous blend of three herbs on haematobiochemical indices of broiler chicken at starter phase. *Federal Polytechnic Ilaro Journal of Pure and Applied Sciences*, 3(2), 45-53.
3. AOAC. (2005). *Official Methods of Analysis* (18th ed.). Association of Official Analytical Chemists, Washington, DC.
4. Brenes, A. & Roura, E. (2010). Essential oils in poultry nutrition: Main effects and modes of action. *Animal Feed Science and Technology*, 158(1-2), 1-14.
5. Calixto, J. B., Santos, A. R., Cechinel Filho, V. & Yunes, R. A. (1998). A review of the plants of the genus Phyllanthus: Their chemistry, pharmacology, and therapeutic potential. *Medicinal Research Reviews*, 18(4), 225-258.
6. Dhama, K., Latheef, S. K., Mani, S., Samad, H. A., Karthik, K., Tiwari, R., Khan, R. U., Alagawany, M., Farag, M. R., Alam, G. M., Laudadio, V. & Tufarelli, V. (2015). Multiple beneficial applications and modes of action of herbs in poultry health and production-A review. *International Journal of Pharmacology*, 11(3), 152-176.
7. Dieumou, F. E., Teguia, A., Kuiate, J. R., Tamokou, J. D., Fonge, N. B. & Dongmo, M. C. (2009). Effects of ginger (Zingiber officinale) and garlic (Allium sativum) essential oils on growth performance and gut microbial population of broiler chickens. *Livestock Research for Rural Development*, 21(8), 131.
8. Duncan, D. B. (1955). Multiple range and multiple F tests. *Biometrics*, 11(1), 1-42.
9. Duncan, J. R. & Prasse, K. W. (1986). *Veterinary Laboratory Medicine: Clinical Pathology* (2nd ed.). Iowa State University Press, Ames.

*Corresponding Author: **O. O. Akinlade.**

10. Edeoga, H. O., Okwu, D. E. & Mbaebie, B. O. (2005). Phytochemical constituents of some Nigerian medicinal plants. *African Journal of Biotechnology*, 4(7), 685-688.
11. Gadde, U., Kim, W. H., Oh, S. T. & Lillehoj, H. S. (2017). Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: A review. *Animal Health Research Reviews*, 18(1), 26-45.
12. Hashemi, S. R. & Davoodi, H. (2011). Herbal plants and their derivatives as growth and health promoters in animal nutrition. *Veterinary Research Communications*, 35(3), 169-180.
13. Herawati, H. & Marjuki, A. (2011). The effect of ginger (Zingiber officinale) extract as a phytobiotic on the growth performance and carcass quality of broiler chickens. *Journal of the Indonesian Tropical Animal Agriculture*, 36(3), 167-172.
14. Humphrey, B. D. & Klasing, K. C. (2004). Modulation of nutrient partitioning and immune function by bioactive compounds. In: *Nutritional Biotechnology in the Feed and Food Industries*. Nottingham University Press, pp. 287-298.
15. Jain, N. C. (1993). *Essentials of Veterinary Hematology*. Lea & Febiger, Philadelphia.
16. Kyo, E., Uda, N., Kasuga, S. & Itakura, Y. (2001). Immunomodulatory effects of aged garlic extract. *Journal of Nutrition*, 131(3), 1075S-1079S.
17. Mehdi, Y., Létourneau-Montminy, M. P., Gaucher, M. L., Chorfi, Y., Suresh, G., Rouissi, T., Brar, S. K., Côté, C., Ramirez, A. A. & Godbout, S. (2018). Use of antibiotics in broiler production: Global impacts and alternatives. *Animal Nutrition*, 4(2), 170-178.
18. Meluzzi, A., Primiceri, G., Giordani, R. & Fabris, G. (1992). Determination of blood constituents reference values in broilers. *Poultry Science*, 71(2), 337-345.
19. Nasri, H., Nematbakhsh, M., Ghobadi, S., Ansari, R., Shahinfard, N. & Rafieian-Kopaei, M. (2013). Preventive and curative effects of ginger extract against histopathologic changes of gentamicin-induced nephrotoxicity in rats. *International Journal of Preventive Medicine*, 4(3), 316-321.
20. Ngassoum, M. B., Essia-Ngang, J. J., Tatsadjieu, L. N., Jirovetz, L., Buchbauer, G. & Adjoudji, O. (2003). Antimicrobial study of essential oils of Ocimum gratissimum leaves and Zanthoxylum xanthoxyloides fruits from Cameroon. *Fitoterapia*, 74(3), 284-287.
21. Obianwuna, U. E., Chang, X., Oleforuh-Okoleh, V. U., Onu, P. N., Zhang, H., Qiu, K. & Wu, S. (2024). Phytobiotics in poultry: revolutionizing broiler chicken nutrition with plant-derived gut health enhancers. *Journal of Animal Science and Biotechnology*, 15(1), 169.
22. Okusanya, P. O. & Akinlade, O. O. (2024). Effect of aqueous blend of three herbs fed at different dosage on growth performance of broiler chickens. *Nigerian Journal of Animal Production*, 51(2), 1179-1184.
23. Oni, O. O., Alabi, J. O., Adewole, M. A. & Adegbenjo, A. A. (2018). Effect of phytobiotics (mixture of garlic, ginger and Chaya leaf) on growth performance, haematological and biochemical indices of pullet chicks. *Slovak Journal of Animal Science*, 51(3), 115-124.
24. Oreagba, I. A., Oshikoya, K. A. & Amachree, M. (2011). Herbal medicine use among urban residents in Lagos, Nigeria. *BMC Complementary and Alternative Medicine*, 11(1), 117.
25. Patel, J. R., Tripathi, P., Sharma, V., Chauhan, N. S. & Dixit, V. K. (2011). Phyllanthus amarus: Ethnomedicinal uses, phytochemistry and pharmacology: A review. *Journal of Ethnopharmacology*, 138(2), 286-313.
26. Steel, R. G. D. & Torrie, J. H. (1980). *Principles and Procedures of Statistics: A Biometrical Approach* (2nd ed.). McGraw-Hill, New York.
27. Tolba, A. A., Azouz, H. M. & Ayoub, M. A. (2010). Effect of using some medicinal plants as feed additives on performance of broiler chicks. *Egyptian Poultry Science Journal*, 30(2), 567-586.
28. Unander, D. W., Webster, G. L. & Blumberg, B. S. (1995). Usage and bioassays in Phyllanthus (Euphorbiaceae). IV. Clustering of antiviral uses and other effects. *Journal of Ethnopharmacology*, 45(1), 1-18.
29. Vidanarachchi, J. K., Mikkelsen, L. L., Sims, I., Iji, P. A. & Choct, M. (2005). Phytobiotics: alternatives to antibiotic growth promoters in monogastric animal feeds. *Recent Advances in Animal Nutrition in Australia*, 15, 131-144.
30. Weather Spark. (2017). Climate and weather in Ilaro, Ogun State, Nigeria. Retrieved February 15, 2026, from https://weatherspark.com
31. Windisch, W., Schedle, K., Plitzner, C. & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science*, 86(14), E140-E148.
32. Yang, Y., Iji, P. A. & Choct, M. (2009). Dietary modulation of gut microflora in broiler chickens: a review of the role of six kinds of alternatives to in-feed antibiotics. *World's Poultry Science Journal*, 65(1), 97-114.
33. Zaib-ur-Rehman. (2011). Effect of garlic and ginger supplementation in broiler ration on haematology, blood metabolites and meat of broilers [M.Sc. Thesis, University of Agriculture, Faisalabad, Pakistan].
34. Zhang, G. F., Yang, Z. B., Wang, Y., Yang, W. R., Jiang, S. Z. & Gai, G. S. (2009). Effects of ginger root (Zingiber officinale) processed to different particle sizes on growth performance, antioxidant

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status, and serum metabolites of broiler chickens. *Poultry Science*, 88(10), 2159-2166

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