

Combined effects of different phytoadditives on growth performance, nutrient digestibility, and hematobiochemical profile of broiler chickens

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Abstract

A total of 120 unsexed day-old Ross 308 broiler chicks were used to evaluate the synergistic effects of different combinations of turmeric, garlic, ginger, and clove on growth performance, nutrient digestibility, carcass characteristics, and blood profile. Birds were randomly assigned to four dietary treatments with three replicates of 10 birds each in a completely randomized design. The treatments consisted of a control diet and three diets supplemented with different combinations of garlic, ginger, turmeric, and clove at 3 or 4 g/kg of feed⁻¹. Growth performance, nutrient digestibility, carcass traits, hematological indices, and serum biochemical parameters were evaluated. Dietary supplementation significantly influenced growth performance, feed utilization, carcass yield, and selected blood parameters ($p < 0.05$). Broilers receiving the turmeric, ginger, and clove combination exhibited superior final body weight, weight gain, carcass yield, and nutrient utilization, whereas birds fed the garlic, ginger, and turmeric blend showed higher feed intake. Hematological values remained within normal physiological ranges across treatments, indicating that the phytogetic blends did not adversely affect the health status of the birds. Overall, the combination of turmeric, ginger, and clove at 3 g/kg feed⁻¹ showed the greatest potential for improving broiler performance while maintaining normal blood characteristics.

Keywords: broiler, phytobiotics, growth performance, nutrient digestibility, blood profile.

Efeitos combinados de diferentes fitoaditivos sobre o desempenho produtivo, a digestibilidade de nutrientes e o perfil hematobioquímico de frangos de corte

Resumo

Um total de 120 pintos de corte da linhagem Ross 308 (sem sexagem) com um dia de idade foi utilizado para avaliar os efeitos sinérgicos de diferentes combinações de cúrcuma, alho, gengibre e cravo sobre o desempenho produtivo, a digestibilidade de nutrientes, as características de carcaça e o perfil sanguíneo. As aves foram distribuídas aleatoriamente em quatro tratamentos dietéticos, com três repetições de 10 aves cada, em um delineamento inteiramente casualizado. Os tratamentos consistiram em uma dieta controle e três dietas suplementadas com diferentes combinações de alho, gengibre, cúrcuma e cravo, na proporção de 3 ou 4 g/kg de ração⁻¹. Foram avaliados o desempenho produtivo, a digestibilidade de nutrientes, as características de carcaça, os índices hematológicos e os parâmetros bioquímicos séricos. A suplementação dietética influenciou significativamente o desempenho produtivo, a utilização da ração, o rendimento de carcaça e parâmetros sanguíneos selecionados ($p < 0,05$). As aves que receberam a combinação de cúrcuma, gengibre e cravo apresentaram peso corporal final, ganho de peso, rendimento de carcaça e utilização de nutrientes superiores, enquanto as aves alimentadas com a mistura de alho, gengibre e cúrcuma apresentaram maior consumo de ração. Os valores hematológicos permaneceram dentro das faixas fisiológicas normais em todos os tratamentos.

indicando que as misturas fitogênicas não afetaram adversamente o estado de saúde das aves. De modo geral, a combinação de cúrcuma, gengibre e cravo na dosagem de 3 g/kg de ração⁻¹ demonstrou o maior potencial para melhorar o desempenho das aves de corte, mantendo características sanguíneas normais.

Palavras-chave: frangos de corte, fitobióticos, desempenho zootécnico, digestibilidade dos nutrientes, perfil sanguíneo.

1. Introduction

Poultry farming, particularly broiler chicken production, plays a crucial role in ensuring global food security. Poultry is the term used to describe a group of birds kept for meat and eggs (e.g., chicken) or reared or hunted for a useful purpose. However, the widespread use of antibiotics in poultry farming has led to concerns over antibiotic resistance and its potential effects on both animal and human health (Smith et al., 2019). The addition of antibiotics in feed has improved growth performances and feed efficiency in livestock (Lin, 2014). The global emergency of antibiotic resistance has led to the prohibition of antibiotics worldwide (Muteeb et al., 2023; Tang et al., 2017).

Several alternatives, including prebiotics, probiotics, symbiotics, and plant extracts, have been proposed in this regard (Vieco-Saiz et al., 2019). As a result, there is increasing interest in finding natural alternatives to antibiotics that can improve poultry health and productivity while reducing risks to consumers (Jones; Green, 2020). This study focuses on the synergetic effects of phytoadditives garlic (*Allium sativum*), ginger (*Zingiber officinale*), cloves (*Syzygium aromaticum*), and turmeric (*Curcuma longa*) on the growth and health of broiler chickens. These ingredients have long been known for their antimicrobial and anti-inflammatory benefits (Ahmed et al., 2018), and they could provide a sustainable way to improve poultry farming while reducing the reliance on antibiotics. The phytoadditives, which contained active ingredients garlic (allicin), ginger (gingerol), cloves (eugenol content), and turmeric (curcumin), as reported by Okanlawon et al. (2024). They also contain some phytochemicals like alkaloids, saponins, tannin, phenol, flavonoids, steroids, terpenes, and glycosides, as reported by Okanlawon et al. (2023).

Garlic, ginger, turmeric, clove, and their components have shown various pharmacological effects, including antioxidant, antibacterial, immune-modulatory, anti-tumorigenic, anti-inflammatory, anti-apoptotic, anti-hyperglycemic, anti-lipidemic, hepatoprotective, neuroprotective, cardioprotective, and antiemetic effects (Abdelli et al., 2021; Ballerter et al., 2023; Mbaveng et al., 2017; Okanlawon et al., 2020a, 2020b; Oyinlola et al., 2024). Meanwhile, phytobiotics are limited in action due to plant species, soil type, location, weather conditions, processing, and storage conditions, among others, and may affect the composition of the plant and potency of the active ingredients (Cojocariu et al., 2026; Rachwal; Gustaw, 2025; Vispute, 2019). Due to variation in nutrient composition of turmeric, garlic, ginger, and clove, a combination of the blends could be of great research interest on growth performance, carcass yield, nutrient digestibility, haematology, and serum biochemistry of chicken (Sandri et al., 2026).

Although numerous studies have demonstrated the beneficial effects of individual phytogenic feed additives on broiler performance and health, there is still limited information regarding the synergistic effects of combining different phytobiotics in poultry diets. Since garlic, ginger, turmeric, and clove contain distinct bioactive compounds with complementary biological activities, their combined use may enhance nutrient utilization, growth performance, immune response, and physiological status more effectively than their individual inclusion (Ajanaku et al., 2022). Furthermore, the variability in the chemical composition and bioactive constituents of these plants highlights the need to evaluate specific combinations under practical production conditions.

We hypothesized that dietary supplementation with blends of turmeric, garlic, ginger, and clove would produce synergistic effects, enhancing growth performance, nutrient utilization, carcass characteristics, and physiological health in broiler chickens. Accordingly, this study evaluated the effects of different phytoadditive blends on growth performance, nutrient digestibility, carcass characteristics, hematological indices, and serum biochemical parameters as potential natural alternatives to antibiotic growth promoters.

2. Materials and Methods

2.1 Experimental site

The experiment was carried out at the poultry unit of the Teaching and Research farm, Faculty of Agricultural Science, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomoso is situated in the derived savanna zone of Nigeria on the Longitude 4051 East of the Greenwich meridian and 80151 North East of

the equator(Google Earth Map,2025).

2.2 Preparation of test ingredients

Fresh turmeric, garlic, ginger, and cloves were purchased from the open market in Ogbomoso, Oyo State. Each sample was washed (except garlic and clove) using clean water to remove the dirt completely. They were poured into a clean basket to drain off water and later sliced into flakes in order to increase the surface area to aid drying. Thereafter, each of the test ingredients was dried (under the shade) until the weight remained constant. The test ingredients were reduced into lentil-size parts with the aid of a mortar and pestle and milled into fine powdery form with the use of an electric blender, following the method described by Okanlawon et al. (2024). Thereafter, it was sieved and stored in an air-tight container until use.

2.3 Preparation of pen and equipment

One week before the arrival of the chicks, the pen was prepared by carrying out various activities, that is, cleaning the surrounding of the pen with disinfectants (morigad, formalin and viratop) to prevent infection, applying snipe to prevent soldier ants and a dipping hole before the pen for foot dipping, provision of charcoal and coal pot for proper and adequate supply of heat during brooding process, provision of electric bulbs, the pen was put in good condition.

2.4 Animals and management

One hundred and twenty (120) unsexed day-old Ross 308 chicks were purchased from a reputable hatchery and used for the experiment. Using a completely randomized design (CRD), the birds were randomly allotted to four (4) dietary treatments of 30 birds per treatment and three (3) replicates of 10 birds each. The deep litter system was used to raise the birds, and a floor drinker and feeder were used. T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger, and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger, and 1 g Cloves) to 1 kg of feed, and T4: 4 g (1 g Garlic, 1 g Ginger, 1 g Turmeric and 1 g Clove) to 1 kg of feed. All management practices were strictly carried out. Feeds and water were given *ad libitum* throughout the experimental period. The experiment lasted for six (6) weeks.

2.5 Data collection

2.5.1 Growth performance

Weight gain (g) = Final weight (g) - Initial body weight (g)

Feed Intake (g) = (Quantity served – Leftover)

Feed Conversion Ratio (FCR) = feed intake (g)/weight gain (g)

2.5.2 Carcass characteristics

At the end of 6 weeks experimental period, three birds were randomly selected and starved of feed for 12 hours with the presence of abundant water and slaughtered by severing the jugular veins. The birds were bled; defeathered, after which the visceral organs such as liver, intestine, pancreas, spleen, kidney, proventriculus, and hearts were removed. The bled, defeathered, and eviscerated weights were evaluated accordingly. The head and shanks were removed to determine the

Proportional weight of the organs = $\frac{\text{Weight of the organ}}{\text{Live weight}} \times 100$

The carcass was cut into various parts (thigh, breast, back, shank, drumstick, wings, and head), and their weights were expressed in percentage relative to the carcass weight. The weights of the organs were also expressed in relative values. The following calculations were evaluated:

Relative cut parts weight = $\frac{\text{Weight of the cut}}{\text{Carcass weight}} \times 100$

2.5.3 Nutrient Digestibility

A digestibility trial was conducted using 6 birds per treatment (2 per replicate), which were randomly selected and

transferred to metabolic cages equipped with facilities for separate feeding and collection of excreta. After a 3-day adaptation period in the cages, total excreta collection was conducted for 5 consecutive days. Feed consumption during this period was accurately recorded. After documentation of the total weight of daily excreta, samples were collected, weighed, and dried in a forced-air oven at 65 °C for 12 h. The dried excreta samples were weighed, pooled together on a replicate basis, and ground before being sent to the laboratory for subsequent chemical analysis, AOAC (1995). Representative samples of each experimental diet were also analysed using the same procedures. The apparent nutrient digestibility coefficients were calculated using the equation:

$$\text{Apparent Digestibility (\%)} = \frac{\% \text{Nutrient intake} - \% \text{Nutrient in excreta}}{\% \text{Nutrient intake}} \times 100$$

2.5.4 Blood collection

2.5.1 Hematological parameters

Four birds were randomly selected from each treatment, about 2.5 mL of blood were collected in tubes containing EDTA anticoagulant. The blood was slowly expressed into EDTA tubes to reduce the risk of haemolysis after removing the needles from syringes (Haen, 1995) and analyzed to determine the parameters (haemoglobin concentration, packed cell volume, red blood cells count, total white blood cells count, differential white blood cell count, platelets count, and red cell) indices as describe by Iranloye et al. (2002) and Venkatesan et al. (2006).

Serum parameters, including total protein, were obtained by the biuret method in the assay as described by Kohn & Allen (1995). The globulin concentration was obtained by subtracting albumin from the total protein. Albumin was determined using the Bromocresol Green (BCG) method as described by Peter et al. (1982). Aspartate transferase (AST) activities were determined using spectrophotometric methods as described by Rej & Hoder (1983). Alanine transferase (ALT) activities were determined using spectrophotometric methods as described by Rej & Hoder (1983).

2.6 Statistical analysis

Data collected were analysed using ANOVA as contained in SAS (2002). Significant means were separated using Duncan Multiple Range Test as contained in SAS (2002).

3. Results

3.1 Growth performance of broiler chicken fed varying levels of phytoadditive blend

Table 1 shows the results of the growth performance of broiler chickens fed varying levels of phytobiotic blend. Birds in Treatment 3 (Ginger + Clove + Turmeric) recorded the highest final body weight and total weight gain, while birds in Treatment 4 (Turmeric + Garlic + Clove) recorded the lowest final weight and average total weight gain. Average daily feed intake (ADFI) was significantly higher in Treatment 2, while broiler chickens fed control diets had the lowest value. The feed conversion ratio (FCR) was significantly lower (i.e., more efficient) in Treatment 1 and Treatment 3 than in Treatments 2 and 4.

Table 1. Growth performance of broiler chicken fed varying levels of phytoadditive blend.

Parameters	T1	T2	T3	T4	SEM
Initial weight (g)	45.70	45.00	44.70	44.33	0.349
Final weight gain (g)	2546.93 ^b	2587.68 ^b	2942.93 ^a	2281.70 ^b	74.550
Total weight gain (g)	2486.23 ^b	2527.68 ^b	2883.23 ^a	2222.37 ^b	74.563
Average daily feed Intake (g)	69.48 ^b	103.78 ^a	98.89 ^a	92.37 ^{ab}	4.961
FCR	1.17 ^b	1.73 ^a	1.45 ^{ab}	1.75 ^a	0.879

Note: ^{ab} means in the same row with different superscripts differ significantly ($p < 0.05$). T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger, and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1g Turmeric, 1 g Ginger, and 1 g Cloves) to 1 kg of feed and T4: 4 g (1 g Garlic, 1 g Turmeric, and 1 g Clove) to 1 kg of feed. Source: Authors, 2026.

3.2 Effect of varying levels of phytoadditives on carcass characteristics of broiler chicken

Carcass characteristics of broiler chickens fed diets containing varying levels of phytobiotic are shown in (Table 2). A significant ($p < 0.05$) difference was recorded. Live weight, blend weight, Defeathered weight, carcass weight, breast, Drumstick, shank, and thigh. The highest ($p < 0.05$) live weight, blend weight, defeathered weight, and carcass weight were recorded with broiler birds fed a diet containing Turmeric, Ginger, and Clove blend, while broiler birds fed a diet containing Garlic, Ginger, and Turmeric blend had the least, respectively. Breast weight was highest ($p < 0.05$) in broiler-fed diets containing Turmeric, Ginger, and Clove powder blend, while the lowest value was found in broiler-fed control diets.

The drum stick and shank of birds fed control diets recorded the highest ($p < 0.05$) value, while the lowest value was recorded on birds fed a diet containing Garlic, ginger, and Turmeric powder blend, respectively. Thigh weight was highest ($p < 0.05$) in the broiler-fed diet containing turmeric, ginger, and clove powder blend, while the lowest value was found in the broiler-fed diet containing garlic, turmeric, and clove powder blend.

Table 2. Effect of varying levels of phytoadditives on carcass characteristics of broiler chicken.

Parameters	T 1	T2	T3	T4	SEM
Live Wt (kg)	2.53 ^a	2.21 ^b	2.56 ^a	2.52 ^a	0.04
Bled Wt (kg)	2.45 ^a	2.17 ^b	2.48 ^a	2.46 ^a	0.03
Defeathered Wt (kg)	2.34 ^a	2.07 ^b	2.36 ^a	2.34 ^a	0.03
Carcass Wt (g)	1830.00 ^a	1669.00 ^b	1878.00 ^a	1873.00 ^a	25.62
Breast (%)	39.70 ^b	43.30 ^a	44.57 ^a	42.34 ^a	0.50
Back (%)	16.17	16.17	16.13	16.94	0.16
Drumstick (%)	14.30 ^a	12.17 ^b	13.44 ^{ab}	13.08 ^{ab}	0.27
Thigh (%)	14.51 ^b	14.02 ^c	16.03 ^a	13.18 ^d	0.28
Shank (%)	5.44 ^a	4.21 ^b	4.58 ^b	4.84 ^{ab}	0.15
Head (%)	2.87	2.82	2.79	2.67	0.03
Wings (%)	10.52	10.01	9.93	10.10	0.11
Neck (%)	5.43	5.28	5.54	5.49	0.13

Note: ^{abc} means in the same row with different superscripts differ significantly ($p < 0.05$). T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger, and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger and 1 g Cloves) to 1 kg of feed, and T4: 4 g (1 g Garlic, 1 g Turmeric, and 1 g Clove) to 1 kg of feed. Source: Authors, 2026.

3.3 Organ Characteristics of broiler chicken fed a graded level of phyto-addictive blend

Table 3 shows the organ traits of broiler chickens fed varying levels of phytobiotic. shows no significant differences in live weight ($p > 0.05$), indicating similar growth across treatments. However, significant reductions ($p < 0.05$) in liver, pancreas, and heart weights were observed in Treatment 2 (Turmeric + Garlic + Ginger). Gizzard weights were numerically higher in Treatment 4. Control birds had higher colon and ileum weights. Duodenum and ileum lengths were significantly longer in Treatment 2, and cecal lengths were longer in all phytoadditive groups, especially Treatment 4.

Table 3. Organ characteristics of broiler chicken fed a graded level of phyto-addictive blend.

Parameters	T1	T2	T3	T4	SEM
Liver	2.53 ^a	2.21 ^b	2.46 ^a	2.52 ^a	0.037
Gizzard Wt (%)	2.53 ^a	2.21 ^b	2.46 ^a	2.52 ^a	0.04
Empty Gizzard Wt (%)	2525.00 ^a	2207.00 ^a	2462.00 ^a	2519.00 ^a	37.48
Spleen (%)	2.05	2.59	2.01	2.77	0.17
Kidney (%)	1.20	1.77	1.36	1.74	0.10
Crop (%)	4.79	6.86	7.44	7.41	0.55
Proventriculus (%)	0.42	0.41	0.37	0.36	0.02
Pancreas (%)	0.27	0.45	0.40	0.40	0.32
Heart (%)	0.37	0.32	0.35	0.32	0.18
Small intestine (%)	0.22 ^a	0.16 ^b	0.22 ^a	0.18 ^{ab}	0.01
Colon (%)	0.22 ^a	0.16 ^b	0.22 ^a	0.18 ^{ab}	0.01
Busa (%)	2.07	1.86	1.43	1.84	0.14
Lungs	0.65 ^a	0.45 ^b	0.49 ^{ab}	0.58 ^{ab}	0.03
Duodenum L (m)	0.16	0.14	0.14	0.20	0.02
Duodenum W (g)	0.64	0.54	0.69	0.61	0.03
Ileum L (cm)	919.67 ^{ab}	1399.58 ^a	728.67 ^b	1203.33 ^{ab}	102.13
Ileum (weight)	2.07	1.86	1.43	1.84	0.14
Ceca (length)	764.83	1160.42	741.33	833.33	71.86
Ceca (weight)	1.98 ^a	1.18 ^{ab}	1.71 ^{ab}	0.97 ^b	0.17
Rectum (weight)	22.57 ^b	32.74 ^a	33.24 ^a	39.59 ^a	2.04
Rectum (length)	0.65	0.56	0.49	0.58	0.04
Oesophagus	0.16 ^{ab}	0.20 ^{ab}	0.22 ^a	0.12 ^b	0.16

Note: ^{abc} means on the same row with different superscripts are significantly ($p > 0.05$) different. T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger and 1 g Cloves) to 1 kg of feed and T4: 4 g (1g Garlic, ginger 1 g, 1 g Turmeric and 1 g Clove) to 1 kg of feed. Source: Authors, 2026.

3.4 Haematology analysis of broiler chicken fed a graded level of phyto-addictive blend

The results of haematological parameters for broiler chickens fed varying levels of phytoadditive combinations are presented in (Table 4). There were significant differences ($p < 0.05$) in haemoglobin concentration, RBC count, MCV, MCHC, lymphocyte, monocyte, basophil counts, and platelet levels across treatments. The highest ($p < 0.05$) Haemoglobin Concentration and Red blood cell were recorded from broiler chicken fed a diet containing 4 g (1 g Garlic, 1 g Ginger, 1 g Turmeric, and 1 g Clove), while broiler chicken fed a diet T3 had the least value, respectively. Other parameters, such as PCV and WBC, showed no significant differences.

Table 4. Haematology analysis of broiler chicken fed a graded level of phytoaddictive blend.

Parameters	T1	T2	T3	T4	SEM
PCV (%)	30.00	32.00	30.50	33.00	0.712
HCT (L/L)	0.29	0.32	0.31	0.33	0.007
HB (g/L)	128.33 ^{ab}	128.50 ^{ab}	120.00 ^b	135.00 ^a	1.719
RBC (X10 ¹² L)	2.47 ^{ab}	2.49 ^{ab}	2.35 ^b	2.66 ^a	0.043
MCV (FL)	119.00 ^b	127.50 ^{ab}	130.50 ^a	125.50 ^{ab}	1.709
MCH (pg)	54.70	52.00	52.42	51.00	0.319
MCHC (Lg/L)	442.00 ^a	404.00 ^{ab}	392.50 ^b	405.50 ^{ab}	8.315
WBC (X10 ⁹ L)	122.33	112.00	105.00	113.50	3.351
Neutrophils	24.00	18.50	16.00	25.50	1.745
Lymphocytes	71.00 ^{ab}	63.00 ^b	78.50 ^a	66.00 ^b	2.035
Eosinophils	0.00	0.00	0.00	0.00	0.000
Monocytes	1.33 ^{ab}	6.00 ^a	1.00 ^{ab}	0.00 ^b	0.915
Basophils	3.67 ^c	12.50 ^a	4.50 ^c	8.50 ^b	1.019
Platelet (X10 ⁹ L)	29.33 ^b	55.00 ^a	39.00 ^c	39.00 ^c	1.185

Note: ^{abc} means on the same row with different superscripts are significantly ($p > 0.05$) different. T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger and 1 g Cloves) to 1 kg of feed and T4: 4 g (1 g Garlic, 1 g ginger, 1 g Turmeric and 1 g Clove) to 1 kg of feed. PCV; Packed Cell Volume, HCT;- Hematocrit, HC- Haemoglobin Concentration RBC; Red Blood Cell, WBC;-White Blood Cell, MCH; Mean Corpuscular Hemoglobin, MCV;- Mean Corpuscular Volume MCV;- Mean Corpuscular Volume, MCHC;- Mean Corpuscular. Source: Authors, 2026.

3.5 Serum biochemistry of broiler chicken fed a graded level of phyto-addictive blend

Results of serum chemistry of broiler chickens fed different phytoaddictive combinations are presented in (Table 5). The dietary inclusion of phytoaddictive blends showed no significant ($p > 0.05$) differences across most serum parameters. Aspartate aminotransferase (AST) increased slightly from Treatment 1 to Treatment 4, while alanine aminotransferase (ALT) showed minor numerical variations. Total protein (TP) and albumin (ACB) were relatively stable, with Treatment 4 having the highest TP. Urea and creatinine levels were highest in Treatment 4, suggesting increased protein turnover or renal activity. Cholesterol (CHOC), triglycerides (TRIG), HDL, LDL, and VLDL values remained within normal ranges across treatments.

Table 5. Serum biochemistry of broiler chicken fed a graded level of Phyto-addictive blend.

Parameters	T 1	T2	T3	T4	SEM
AST (iuL)	149.66	152.00	160.00	167.00	5.61
ALT (iuL)	8.66	11.50	10.50	10.50	0.50
ALP (iuL)	258.00 ^a	180.50 ^b	183.00 ^b	185.00 ^b	13.58
TP (g/L)	30.00 ^b	30.00 ^b	28.00 ^b	32.50 ^a	0.504
ALB (g/L)	16.33 ^b	18.00 ^a	15.00 ^b	17.50 ^b	0.485
GLB (g/L)	14.33 ^b	11.50 ^b	13.00 ^b	15.00	0.53
Urea (mol/L)	1.73 ^b	2.05	1.75 ^b	2.16	0.54
Creat (mmol/L)	31.00 ^{ab}	34.05 ^b	26.50 ^b	46.00 ^a	2.87
CHOL (mmol/L)	2.76	2.49	2.54	2.79	0.09
TRIG (mmol/L)	0.31	0.29	0.35	0.41	0.278
HDL (mmol/L)	1.72	1.48	1.77	1.89	0.78
LDL (mmol/L)	0.90	0.89	0.64	0.72	0.44
VLDL (mmol/L)	0.63	0.60	0.65	0.08	0.05

Note: ^{abc} means on the same row with different superscripts are significantly ($p > 0.05$) different. T1: control diet, T2-3 g (1 g Garlic, 1 g Ginger and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger and 1 g Cloves) to 1 kg of feed and T4: 4 g (1 g Garlic, 1 g ginger, 1 g Turmeric and 1 g Clove) to 1 kg of feed. Source: Authors, 2026.

3.6 Nutrient digestibility of broiler chicken fed phytoadditive blend

Table 6 shows the effect of varying levels of phytobiotic blend on nutrient digestibility in broiler chickens. The inclusion of phytoadditive blends significantly ($p < 0.05$) improved all digestibility parameters compared to the control. Birds in Treatment 3 (Ginger + Clove + Turmeric) had the highest crude protein digestibility (CPD – 75.49%), crude fiber digestibility (CFD – 41.02%), ether extract digestibility (EED – 60.63%), moisture digestibility (Moisture D – 44.28%), ash digestibility (Ash – 65.29 g), and dry matter digestibility (DMD – 69.37%). Treatments 3 and 4 consistently outperformed Treatments 1 and 2 across all metrics.

Table 6. Nutrient digestibility of broiler chicken fed phytoadditive blend.

Parameters (%)	T1	T2	T3	T4	SEM
Crude Protein	54.87 ^c	65.02 ^b	75.49 ^a	73.21 ^a	2.497
Crude fibre	20.56 ^b	26.04 ^b	41.02 ^a	37.64 ^a	3.375
Ether Extract	30.65 ^c	43.23 ^b	60.63 ^a	59.06 ^a	3.827
Moisture	12.72 ^b	23.24 ^c	44.28 ^a	48.17 ^a	8.798
Ash	38.43 ^c	51.08 ^b	65.29 ^a	63.93 ^a	3.425
Dry matter	45.73 ^c	56.62 ^b	69.37 ^a	67.78 ^a	3.041

Note: ^{abc} means that on the same row with different superscripts are significantly ($p > 0.05$) different. T1: control diet, T2-3 g (1g Garlic, 1 g Ginger and 1 g Turmeric) to 1 kg of feed, T3: 3 g (1 g Turmeric, 1 g Ginger and 1 g Cloves) to 1 kg of feed and T4: 4 g (1 g Garlic, 1 g ginger, 1 g Turmeric and 1 g Clove) to 1 kg of feed. Source: Authors, 2026.

4. Discussion

4.1 Growth performance and possible synergistic mechanisms

The superior growth performance observed in broilers receiving the turmeric–ginger–clove blend (T3) suggests that the beneficial response resulted from complementary biological activities among the phytochemicals present in these plants rather than from the action of a single ingredient. Curcuminoids from turmeric exhibit potent antioxidant and anti-inflammatory activities, gingerols and shogaols stimulate digestive enzyme secretion and gastrointestinal motility, whereas eugenol from clove possesses antimicrobial activity capable of modulating intestinal microbial populations.

Together, these compounds may improve intestinal integrity, reduce oxidative stress, stimulate digestive secretions, and enhance nutrient digestion and absorption, thereby directing a greater proportion of dietary nutrients toward muscle accretion and growth instead of immune activation (Windisch et al., 2008; Adeyemi et al., 2021; Abd El-Hack et al., 2023; Ahmed et al., 2018). Similar improvements in broiler performance following supplementation with turmeric, ginger, or their combinations have been reported by Ademola et al. (2009), Al-Mufarrej et al. (2020), Kawamoto et al. (2022), and Okanlawon et al. (2024).

An important finding was that the inclusion of all four phytoadditives (T4) did not further improve productive performance and, in some variables, resulted in lower responses than T3. This indicates that phytogetic feed additives may not exhibit a linear dose-response relationship. Increasing the diversity of phytochemicals can alter the balance among active compounds, potentially resulting in antagonistic interactions, excessive antimicrobial activity affecting beneficial intestinal microbiota, or reduced feed palatability. Therefore, the present results suggest that optimizing the combination of bioactive compounds may be more important than simply increasing the number of phytogetic ingredients included in the diet (Windisch et al., 2008; Adeyemi et al., 2021; Abd El-Hack et al., 2023).

Although average daily feed intake was greater in supplemented birds, increased feed consumption alone cannot explain the superior productive performance. The improved body weight gain observed in T3 was accompanied by enhanced nutrient digestibility, indicating that digestive efficiency rather than feed intake was primarily responsible for the productive response. In contrast, the lower feed conversion efficiency observed in some supplemented groups reinforces that the biological response to phytogetic additives depends on the qualitative interaction among phytochemicals, their inclusion levels, and their effects on digestive physiology (Al-Kassie et al., 2011; Windisch et al., 2008).

4.2 Carcass characteristics and organ development

The improvement in carcass yield and cut-part weights observed in phytogetic-fed broilers is likely associated with enhanced protein accretion resulting from improved nutrient utilization. Enhanced intestinal development, particularly the increased length of the duodenum and ileum, may increase the absorptive surface area, facilitating more efficient digestion and nutrient absorption. Moreover, phytogetic compounds may preserve intestinal morphology through their antioxidant and anti-inflammatory properties, contributing to improved digestive function and carcass deposition (Saleh et al., 2021; Abd El-Hack et al., 2023; Zhou et al., 2023). These findings are consistent with previous reports demonstrating improvements in carcass characteristics following dietary supplementation with phytogetic additives (Raghdad et al., 2012; Okanlawon et al., 2024).

The reduced liver and heart weights observed in Treatment 2 remained within physiological limits and therefore do not indicate pathological alterations. Instead, these findings may reflect improved metabolic efficiency and reduced oxidative stress resulting from the hepatoprotective properties of turmeric and garlic. Likewise, the absence of significant changes in spleen and bursa weights suggests that dietary supplementation did not compromise immune organ development, supporting the biological safety of the phytogetic blends under the experimental conditions (Rahman et al., 2023; Saleh et al., 2021; Zhai et al., 2020; Ademola et al., 2009; Olayeni et al., 2024).

4.3 Hematological responses

The hematological profile further supports the safety of phytogetic supplementation. The increased erythrocyte count and hemoglobin concentration observed in T4 may reflect enhanced erythropoiesis associated with the antioxidant activities of curcuminoids and organosulfur compounds present in turmeric and garlic, which reduce oxidative damage to erythrocytes and improve oxygen-carrying capacity (Ayanrinde et al., 2023; Ahmed et al., 2018; Moustafa et al., 2023). Similarly, the higher lymphocyte counts recorded in T3 may indicate enhanced immune competence, possibly associated with the immunomodulatory effects of eugenol, the major phenolic constituent of clove (Oladokun et al., 2021; Okanlawon et al., 2025).

Interestingly, birds receiving phytogetic supplementation exhibited lower leukocyte counts than the control group while maintaining hematological values within normal physiological ranges. Rather than indicating immunosuppression, this finding may reflect reduced inflammatory stimulation due to improved intestinal health and lower pathogen challenge promoted by phytogetic compounds. The antimicrobial and antioxidant activities of these herbs may decrease the need for immune activation, allowing physiological leukocyte counts to remain stable while improving overall health status (Aroche et al., 2021; Alagbe and Naandam, 2022; Okanlawon et al., 2024; Merck Veterinary Manual, 2012).

4.4 Serum biochemical responses

Serum biochemical variables remained largely unchanged among treatments, indicating that dietary inclusion of phytogetic blends did not adversely affect hepatic or renal function. The slight increase in albumin concentration may reflect improved protein synthesis and nutritional status, whereas the modest reductions in serum cholesterol and LDL observed in phytogetic treatments are consistent with the hypolipidemic properties of curcuminoids and gingerols previously described in poultry (Farak et al., 2021; Saleh et al., 2021). Likewise, ALT, AST, creatinine, and urea remained within physiological limits, further supporting the metabolic safety of these dietary supplements (Rahman et al., 2023; Moustafa et al., 2023).

The absence of significant differences in several serum metabolites agrees with findings reported by Onu (2010), whereas differences from Saeid et al. (2010) and Zhang et al. (2009) are likely attributable to variations in phytogetic source, inclusion level, extraction method, feeding duration, and experimental conditions. Such variability among studies reinforces that physiological responses to phytogetic additives are influenced by both diet composition and management conditions rather than by the presence of individual herbs alone.

4.5 Nutrient digestibility

The higher nutrient digestibility observed in Treatments 3 and 4 provides a plausible physiological explanation for the improvements in productive performance. Phytogetic compounds are known to stimulate pancreatic enzyme secretion, increase bile acid production, improve intestinal morphology, modulate gut microbiota, and reduce intestinal inflammation, collectively enhancing digestive efficiency and nutrient absorption (Abd El-Hack et al., 2023; Adeyemi et al., 2021; Al-Kassie, 2009; Windisch et al., 2008). The superior digestibility observed in T3 is therefore consistent with its greater body weight gain and carcass yield, suggesting that improved nutrient utilization was one of the principal mechanisms underlying the observed productive responses.

4.6 Economic implications

Although phytogetic supplementation increased feed cost due to the inclusion of herbal ingredients, the superior body weight gain and nutrient digestibility observed in Treatment 3 may compensate for this additional investment by reducing feed cost per kilogram of live weight produced. Consequently, economic efficiency depends not only on ingredient price but also on improvements in feed utilization and marketable carcass yield (Kumar et al., 2025; Souza et al., 2022). Similar observations have been reported for phytogetic feed additives, where higher dietary costs were offset by improved productive performance and profitability (Abd El-Hack et al., 2023; Farak et al., 2021; Ntsongota et al., 2025; Windisch et al., 2008). Future studies should evaluate the economic return of these phytogetic combinations under commercial production conditions.

5. Conclusions

Under the experimental conditions of this study, dietary supplementation with the combination of ginger, clove, and turmeric (1 g/kg each⁻¹) improved growth performance, feed conversion ratio, nutrient digestibility, and selected blood parameters without adverse effects on broiler health. These findings suggest that this phytoadditive blend has potential as a natural alternative to antibiotic growth promoters. However, further studies evaluating different inclusion levels, feeding durations, and production conditions are needed to confirm its efficacy and determine the optimal dietary dosage. In addition to improving productive performance, future research should determine the economic feasibility of phytogetic blends under commercial production systems, including feed cost, cost per kilogram of weight gain, and return on investment.

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7. Authors' Contributions

Tirimisiyu Adewale Rafiu: project, experimental monitoring, laboratory analyses, article writing, and post-evaluation revisions. *Eden Olusegun Okanlawon*: project, laboratory analyses, statistics, article writing, revisions, post-evaluation revisions, and publication. *Mark Feranmi Olateju*: analyses, statistical analysis, revisions, and publication. *Ifeoluwa Pamilerinayo Oke*: analyses, statistical analysis, revisions, and publication. *Abdulbasit Bayonle Mohammed*: analyses, statistical analysis, revisions, and publication.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Yes applicable. Approval for this research was obtained from the Departmental Ethical Committee (LAUTECH-APH20-30) of the Faculty of Agricultural Science (Animal Welfare Board).

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