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Full Length Research

Evaluating the role of herbal additives in sustainable broiler farming: The case of turmeric and ginger at 0.25% inclusion levels

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ABSTRACT: This study evaluates the role of herbal additives, specifically turmeric and ginger, in enhancing the sustainability of poultry farming by assessing their effects on broiler chickens' growth performance, economic parameters, nutrient digestibility, and blood profiles. A total of 120-day-old broiler chicks were randomly assigned to four treatment groups: control (no herb), turmeric at 0.25%, ginger at 0.25%, and an equal combination of both herbs at 0.25%. Results showed no significant differences in growth performance across the treatments, as all groups exhibited comparable body weight, feed intake, and weight gain. However, the economic analysis revealed that the inclusion of turmeric, ginger, or their combination increased feed costs and total production costs, with the combined treatment resulting in the highest production cost. Despite this, all supplemented diets resulted in negative cost savings, indicating limited financial benefits. Haematological analyses indicated no major changes in red and white blood cell counts, packed cell volume, or haemoglobin levels. However, significant variations were observed in eosinophil and monocyte percentages. Biochemical analyses showed reductions in total protein and albumin levels in the turmeric group, while serum glucose and cholesterol levels increased significantly. Nutrient digestibility was also influenced by the additives, with significant differences observed in dry matter and nitrogen-free extract digestibility, though other parameters like crude protein and crude fibre remained unaffected. Overall, while the herbal additives had minimal effects on growth performance at 0.25% inclusion level, they influenced production costs and certain biochemical markers, suggesting a potential but modest role in sustainable poultry farming.

Keywords: Broiler, ginger, health, herbs, performance, turmeric.

INTRODUCTION

The poultry industry recently encountered significant challenges regarding sustainability and the health of production systems. With growing concerns over the use of synthetic antibiotics, the demand for more natural, eco-friendly alternatives has become more urgent. One such alternative is the use of herbal feed additives, which may offer solutions to improve growth performance, enhance health, and promote sustainability in poultry farming. Among these additives, turmeric (*Curcuma longa*) and ginger (*Zingiber officinale*) have gained attention due to their bioactive compounds, including curcumin in turmeric and gingerol in ginger, which are known for their anti-inflammatory, antioxidant, and immune-enhancing properties (Sunmola *et al*., 2021; Amalraj *et al.,* 2017). These properties not only improve poultry health. It also contributes to sustainable farming by reducing the reliance on synthetic antibiotics and supporting animal welfare.

Turmeric and ginger have long been valued in traditional medicine for their health benefits to both humans and animals (Khan *et al.,* 2012). In poultry production, these

herbs are increasingly recognised as effective feed additives that can positively impact growth performance. Research suggests that adding turmeric and ginger to broiler diets at low inclusion rates, such as 0.25%, can improve feed intake, weight gain, and feed conversion efficiency (Sunmola *et al.*, 2023; Onu, 2010). This is attributed to the antioxidant effects of both herbs, which reduce oxidative stress and enhance nutrient absorption, ultimately leading to improved growth rates. Additionally, these herbs support digestive health by stimulating enzymes and balancing gut microbiota (Sadeghi *et al.,* 2012).

The over-reliance on antibiotics remains a major issue in the poultry industry, contributing to antibiotic resistance (Al-Bahry *et al.* 2006). The use of turmeric and ginger as feed additives may provide an effective, sustainable solution. Both herbs contain bioactive compounds that can reduce antibiotic dependency while maintaining optimal growth performance in broilers (Sunmola *et al.,* 2021; Khan *et al.,* 2012). Furthermore, these herbs can boost chickens' immune systems, increasing resilience to diseases, a key concern in an industry prone to outbreaks and high mortality rates (Nemati *et al.,* 2021).

As demand for less chemically-treated food increases, the adoption of herbal supplements like turmeric and ginger in poultry farming is likely to rise. Hence, the study evaluates the role of herbal additives (ginger and turmeric) in sustainable broiler farming.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Poultry Section of the Livestock, Teaching, and Research Farm located at Joseph Sarwuan Tarka University, Makurdi (JOSTUM). Makurdi serves as the capital of Benue State, situated in the north-central zone of Nigeria. Geographically, the town lies within the Guinea Savanna belt, positioned at latitude 7°44′1.50″ N and longitude 8°31′17.00″ E. The area experiences a rainy season lasting approximately 6 to 8 months, typically from March to October, with annual precipitation levels ranging from 508 mm to 1016 mm. Temperature in the region varies, with minimum and maximum averages recorded at 22.8°C and 40.03°C, respectively. The relative humidity fluctuates between 37.3% and 59.2% (Audu *et al.,* 2022).

Collection and processing of turmeric and ginger

Fresh turmeric and ginger rhizomes were sourced from a local market in Makurdi, Benue State, Nigeria. To remove dirt and soil particles, the rhizomes were first washed by soaking in water. Any long roots and leaf scales were trimmed off, after which the rhizomes were chopped into smaller segments using sharp knives. This step was taken to reduce both the drying duration and the moisture content. The sliced rhizomes were then laid out to sun-dry for six days on a clean, flat concrete surface until their moisture content dropped below 10%. They were arranged in layers approximately 4–6 cm thick to minimise exposure to direct sunlight, which could cause discolouration (Anandraj *et al.,* 2001). Once fully dried, the rhizomes were milled with a 2 mm hammer mill to produce fine turmeric and ginger powder. The resulting powder was sealed in an airtight polyethylene bag, placed in a tightly covered plastic container, and stored properly for later use as a feed additive in feed formulation.

Management and disease control

Five days prior to the arrival of the chicks, the poultry house, along with all associated equipment, was thoroughly cleaned, disinfected, and fumigated. Each pen was lined with wide sheets of newspaper, which served as bedding for the first seven days. This was done to prevent chicks from ingesting coarse wood shavings that could potentially harm their digestive systems. After the initial week, the chicks were transitioned to clean, mould-free wood shavings that were evenly spread as litter material. To ensure proper brooding conditions, 200-watt heating bulbs were turned on 24 hours before chick placement, maintaining the temperature between 85°F and 90°F; an optimal range for brooding in the Guinea Savanna region of Nigeria. The temperature within the brooder was adjusted based on the chicks' behavioural cues. The birds were reared under an intensive management system with a stocking density of 10 chicks per square meter. They were provided with specially formulated experimental diets: a starter feed from weeks 0 to 4, and a finisher feed from weeks 5 to 8. Both feed and fresh, clean water were available to the chicks at all times throughout the trial.

Experimental design and diet formulation

A total of 120 unsexed day-old broiler chicks of the *Abor acre* plus strain were sourced from a recognised hatchery located in Ibadan, Oyo State, in the southwestern region of Nigeria. Upon arrival, each chick was weighed using a precision Metler scale, and the average initial weight was calculated by dividing the total weight by the number of birds. The chicks were randomly assigned to four dietary treatment groups, each comprising three replicates with 10 birds per replicate. They were kept in deep litter pens enclosed with wire mesh for proper ventilation and monitoring. All experimental diets were formulated to be isonitrogenous and isocaloric, based on maize and soybean meal, with incorporated at 0%, 0.25 % turmeric, 0.25% ginger, and their mixture at 0.25% for treatments T1, T2, T3, and T4, respectively. Treatment T1 served as

Table 1. Gross composition of the experimental diets.

Ingredients (kg)	Starter	Finisher
Maize	45.00	57.00
Toasted soyabean	28.00	22.00
Groundnut cake	15.00	10.00
Blood meal	2.00	3.00
Bone meal	3.00	3.00
Rice bran	6.00	4.00
Lysine	0.25	0.25
Methionine	0.25	0.25
*Premix	0.25	0.25
Salt	0.25	0.25
Total	100	100
Calculated analysis		
Metabolizable energy (kcal/kg)	3,000	3,160
Crude protein (%)	23.00	20.96
Crude fibre (%)	4.00	4.00
Ether extract (%)	7.00	7.30
Calcium (%)	1.20	1.30
Phosphorus (%)	0.60	0.60
Lysine (%)	1.10	1.12
Methionine (%)	0.60	0.62

*To provide the following per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E- 30,000IU, Vitamin K3,000mg, Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B6- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg, Folic acid 2,000mg, choline 300,000mg, Iron 60,000mg, manganese 80,000mg, copper 25,000mg, Zinc 80,000mg cobalt 150mg, Iodine 500mg. (feed formulation was done using the feedwin software application).

the control group and did not include the herb. The feed formulations were designed to meet the standard nutritional requirements for broilers, as recommended by the NRC (1994), for both the starter and finisher phases, as detailed in Table 1. The 0.25% inclusion rate was selected based on the optimal level suggested by Sunmola *et al.* (2023) and Onu (2010) for improved broiler performance.

Growth data collection

Data were collected weekly on feed intake, body weight and weight gain. Feed intake was calculated as the quantity difference between the feed given and the leftover after 24 hours. Weight gain was determined as the difference in the weight of the birds after 28 days period. Feed: weight gain ratio was calculated as the feed intake per weight gain.

Production cost

The cost of feed was determined based on the prevailing prices of the individual ingredients used during the feed formulation. The total cost for each experimental diet was computed using the prices of ingredients as of December 2024. All relevant production cost parameters were assessed as outlined below:

The feed cost per kilogram was estimated and presented in Nigerian Naira (₦). This value was obtained using the following formula:

$$\text{Cost/kg feed} = \frac{\text{Cost of Ingrediets}}{100}$$

The feed cost per unit of weight gain (₦) was determined by multiplying the cost per kilogram of feed by the total feed consumed and then dividing the result by the total weight gained.

Feed cost per chick (₦) was calculated by multiplying the amount of feed consumed per bird by the number of feeding days and the cost per kilogram of feed.

Operational cost per bird (₦) was derived by summing all other expenditures, excluding the cost of feed and the price of day-old chicks.

Cost savings attributed to the test ingredient (₦) were obtained by subtracting the total production cost of each treatment group from that of the control group.

The percentage of feed cost in relation to total production cost (₦) was computed by dividing the feed cost per kilogram by the total production cost and multiplying the result by 100.

Income per bird (₦) was estimated by multiplying the bird's average live weight by the market price per kilogram of live weight.

Profit per bird (₦) was calculated as the difference between total income and total expenditure.

The cost-to-benefit ratio was determined by dividing total expenses by total income.

Finally, total production cost per kilogram (₦/kg) was calculated by adding together the cost of a day-old chick, feed cost per bird, and operational expenses.

Nutrient digestibility

A nutrient digestibility trial was conducted during the final phase of the experiment, starting at the end of the seventh week and concluding at the end of the eighth week. From each replicate group, two birds whose weights closely matched the group's average were selected, identified, and moved into metabolic cages. The birds were given a three-day adjustment period to acclimate to the new

environment, during which they were fed their assigned experimental diets. Following this, data collection began and continued for four consecutive days, during which daily feed intake and faecal output were recorded. Faecal samples were collected once daily at 8:00 am from each replicate, weighed, and then dried in a hot-air oven at 70°C until a constant weight was achieved. The dried faeces were then pooled per replicate and ground using a RESCH Hammer mill fitted with a 0.8 mm screen. Both the experimental diets and faecal samples were analysed for their proximate composition using the standard procedures outlined by AOAC (2006). Nutrient digestibility was then calculated using the formula below:

Digestibility (%) = {Nutrient intake} - {Nutrient in feces} \ {Nutrient intake} x 100

Where:

Nutrient intake = Feed intake (g) × % nutrient in feed

Nutrient in feces = Feces output (g) × % nutrient in feces

Apparent digestibility values are calculated individually for CP, CF, EE, and NFE

Blood constituent evaluation

Blood analysis was carried out following the method described by Jain (1986). At the conclusion of the feeding trial, blood samples were taken from each treatment group. Three birds per treatment were selected and bled using a sharp knife, with blood collected from the jugular vein for analysis. Approximately 5 ml of blood was drawn from each bird; 2 ml was transferred into properly labelled and sterilised bijou bottles containing ethylene diamine tetra-acetic acid (EDTA) to prevent clotting. These samples were used to assess haematological parameters. The remaining portion of the blood was left to clot in order to obtain serum, which was then used for biochemical evaluations. All blood analyses were conducted within three hours of collection. Parameters such as red blood cell (RBC) and white blood cell (WBC) counts, packed cell volume (PCV), and haemoglobin (Hb) levels were measured. The clotted blood samples were centrifuged at 3000 revolutions per minute for 10 minutes to separate the serum. The resulting serum was used to determine biochemical markers, including total protein, albumin, globulin, and glucose. Additional serum components such as creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) were also evaluated.

Statistical analysis

The collected data were analysed using a one-way Analysis of Variance (ANOVA) with the aid of the SAS software package (2002 version). Where significant differences were observed ($p<0.05$), the means were compared using Duncan's Multiple Range Test (DMRT).

RESULTS

Effects of turmeric, ginger and their mixture at 0.25% inclusion levels as feed additives on growth performance of broiler chickens

Table 2 presents the effects of incorporating turmeric, ginger, and their blend at a 0.25% inclusion rate on the growth performance of broiler chickens. The results showed no statistically significant differences across all measured performance indicators when compared to the control group. Parameters such as average initial weight (AIW), average final body weight (AFBW), average daily weight gain (ADWG), average daily feed intake (ADFI), and feed conversion ratio (FCR) exhibited closely related values across all dietary treatments (T1 to T4).

The effects of dietary turmeric and ginger powder on the apparent coefficient of digestibility of broiler finisher chickens

Apparent nutrient digestibility was also influenced by the dietary additives (Table 3). The digestibility of dry matter (DM) and nitrogen-free extract (NFE) showed significant treatment effects, while crude protein (CP), crude fibre (CF), and ether extract (EE) were unaffected. DM digestibility was highest in the control group (T1) at 77.57% and lowest in T2 at 68.55%. For NFE, the control group also recorded the highest value (85.86%), with T2 showing the lowest (75.25%), and intermediate values observed in T3 (81.15%) and T4 (79.57%). CP digestibility ranged from 64.96% in T4 to 70.52% in T3, CF from 71.06% in T3 to 76.27% in T1, and EE from 65.75% in T3 to 72.40% in T4, but none of these showed significant differences among treatments.

Effect of turmeric, ginger and their mixture at 0.25 % on haematological parameters of finisher broiler chickens

With regard to haematological responses (Table 4), dietary inclusion of turmeric, ginger, or their combination did not significantly alter most of the blood parameters ($p>0.05$). Packed cell volume (PCV) was relatively consistent, ranging from 23.50% in T1 and T3 to 24.50% in T2. Red blood cell (RBC) counts varied slightly between treatments, from 2.10×10^{12}/L in T3 to 2.35×10^{12}/L in T2. White blood cell (WBC) counts were lowest in T4 (5.90×10^{9}/L) and highest in T1 and T2 (7.00×10^{9}/L). Haemoglobin levels remained comparable across treatments, ranging between 7.83 g/dL and 8.17 g/dL.

Table 2. Effects of turmeric, ginger and their mixture at 0.25 % inclusion levels as feed additives on growth performance of broiler chickens.

Parameters (g)	Experimental Diets				P-value	SEM
	T1	T2	T3	T4		
AIW	37.92	39.44	37.89	37.89	0.12	0.28
AFBW	1194	1277	1243	1222	0.91	38.48
ADWG	16.52	17.69	17.22	16.92	0.92	0.55
ADFI	43.67	45.86	44.67	44.95	0.84	0.78
FCR	2.69	2.61	2.61	2.70	0.98	0.10

Note: AIW = average initial weight; AFW = average final weight; ADWG = average daily weight gain; ADFI = average daily feed intake; FCR = feed conversion ratio; SEM = standard error of mean.

Table 3. The effects of dietary turmeric and ginger powder on apparent coefficient digestibility of broiler finisher chickens.

Parameters	Experimental Diets				SEM	P-value
	T_1	T_2	T_3	T_4		
DM	77.57^{a}	68.55^{b}	74.06^{ab}	71.87^{b}	1.20	0.02
CP	70.31	67.62	70.52	64.96	1.41	0.51
CF	76.27	73.81	71.06	73.72	1.08	0.46
EE	68.20	68.24	65.75	72.40	1.92	0.73
NFE	85.86^{a}	75.25^{b}	81.15^{ab}	79.57^{ab}	1.40	0.02

^{ab}Means within each row with different superscripts are significantly different ($p< 0.05$). ns – not Significantly different ($p>0.05$); * Significantly different ($p<0.05$). DM = Dry Matter; CP = Crude protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen Free Extract; SEM = standard error of mean; * = significant; T1 = Control diet; T2 = 0.25 % turmeric; T3 = 0.25 % ginger; T4 = 0.25 % ginger and turmeric mixture meal.

Table 4. Effect of turmeric, ginger and their mixture at 0.25 % on haematological parameters of finisher broiler chickens.

Parameters	Experimental diets				SEM	P-value
	T1	T2	T3	T4		
PCV (%)	23.50	24.50	23.50	24.00	0.29	0.64
RBC x $10^{12/L}$	2.25^{ab}	2.35^{a}	2.10^{b}	2.25^{ab}	0.04	0.11
WBC x $10^{9/L}$	7.00^{a}	7.00^{a}	6.40^{ab}	5.90^{b}	0.19	0.07
Hb (g/dL)	7.83	8.17	7.84	8.00	0.10	0.65
MCV (fL)	102.28	104.26	102.18	106.52	1.03	0.45
MCH (pg)	34.09	34.74	34.06	35.51	0.34	0.45
MCHC (g/dL)	33.34	33.33	33.34	33.33	0.00	0.27
Lymphocytes (%)	44.00	47.00	44.50	45.00	0.66	0.20
Heterophil (%)	48.00	47.00	48.00	46.50	0.40	0.52
Eosinophil (%)	1.00^{c}	2.00^{b}	3.00^{a}	2.00^{b}	0.21	<000
Basophil (%)	0.50	0.50	0.50	0.50	0.12	1.00
Monocytes (%)	2.25^{c}	3.50^{bc}	4.50^{b}	6.00^{a}	0.42	0.00

^{ab}Means within each row with different superscripts are significantly different ($P< 0.05$). ns – not Significantly different ($P>0.05$); * Significantly different ($P<0.05$). PCV – Pack cell volume; RBC – Red blood cells; WBC – White blood cells; Hb – Haemoglobin; MCV – Mean corpuscular volume; MCH – Mean corpuscular haemoglobin; MCHC - MCH – Mean corpuscular haemoglobin MCHC – Mean corpuscular haemoglobin concentration; SEM = standard error of mean; * = significant; T_1 = Control diet; T2 = 0.25 % turmeric; T3 = 0.25 % ginger; T4 = 0.25 % turmeric-ginger combination.

Similarly, MCV, MCH, and MCHC values showed minor fluctuations, with MCV spanning 102.18 fL (T3) to 106.52 fL (T4), MCH from 34.06 pg (T3) to 35.51 pg (T4), and MCHC virtually unchanged (33.33–33.34 g/dL). Lymphocyte and heterophil counts also did not differ significantly. However, eosinophil and monocyte percentages exhibited significant differences ($p<0.05$), with eosinophils ranging from 1.00% in T1 to 3.00% in T3, and monocytes increasing progressively from 2.25% in T1 to 6.00% in T4.

Table 5. Effect of turmeric, ginger and their mixture at 0.25 % on serum biochemical of finisher broiler chickens.

Parameters	Experimental diets				SEM	P-value
	T_1	T_2	T_3	T_4		
Total protein (g/dl)	4.60[a]	3.56[b]	4.51[a]	3.74[b]	0.14	<000
Albumin (g/dl)	2.97[a]	2.30[b]	2.91[a]	2.42[b]	0.09	<000
AST (U/L)	157.00[c]	210.43[a]	199.69[a]	175.47[b]	6.63	<000
ALT (U/L)	31.80	40.21	34.07	33.19	1.46	0.18
ALP (U/L)	45.40[bc]	38.80[c]	75.40[ab]	69.40[ab]	5.72	0.03
Glucose (mg/dL)	56.19[b]	85.58[a]	58.66[b]	58.90[b]	4.23	0.01
Cholesterol (mg/dL)	123.69[b]	187.37[a]	128.20[b]	128.95[b]	9.34	0.01
Creatinine (mg/dL)	0.68[a]	0.49[b]	0.56[b]	0.46[b]	0.03	0.01

[abc]Means within each row with different superscripts are significantly different (P< 0.05). ns – not Significantly different (P>0.05); * Significantly different (P<0.05). SEM = standard error of mean; * = significant; aspartate amino transferase (AST), alanine aminotransferase (ALT) and alkaline phosphatase (ALP); T1 = Control diet; T2 = 0.25 % turmeric; T3 = 0.25 % ginger; T4 = 0.25 % ginger and turmeric mixture meal.

Table 6. Economics of production of starter broiler chicks fed dietary meals of turmeric, ginger and their mixture at 0.25 % inclusion levels.

Economic indices	Experimental diets				P-value	SEM
	T1	T2	T3	T4		
C of DOC	1500	1500	1500	1500	0.00	0.00
FC (₦/kg)	823.30[d]	839.60 [a]	838.30 [c]	838.90 [b]	<000	1.39
FC/WG (₦/kg)	2166[d]	2173[b]	2167[c]	2291[a]	<000	15.92
FC/bird (₦)	2535[d]	2695[b]	2624[c]	2704[a]	<000	20.47
OP CST (₦)	200	200	200	200	0.00	0.00
TCP (₦/chick)	4135[d]	4295[b]	4224[c]	4304[a]	<000	20.47
CS due spices	0.00[a]	-160.40[c]	-89.30[b]	-169.00[d]	<000	20.47
FC (% TCP)	61.30[d]	62.75[b]	62.12[c]	62.92[a]	<000	0.18

[abcd]Means within each row with different superscripts are significantly different (p<0.05). ns - not significantly different (P>0.05); * significantly different (P<0.05); FC = feed cost; CS = Cost savings; DOC = Day old chicks; C = Cost; TCP = Total cost of production; FC = Feed cost; OPC = Operational cost; T1 = Control diet; T2 = 0.25 % turmeric; T3 = 0.25 % ginger; T4 = 0.75 % ginger and turmeric mixture meal.

Effect of turmeric, ginger and their mixture at 0.25 % on serum biochemical of finisher broiler chickens

Serum biochemical profiles of broiler chickens were notably affected by the inclusion of turmeric, ginger and their combinations (Table 5). Significant reductions in total protein and albumin were observed in T2 (3.56 g/dL and 2.30 g/dL, respectively) compared to the control group T1 (4.60 g/dL and 2.97 g/dL). AST levels were markedly elevated in T2 (210.43 U/L) and T3 (199.69 U/L), while the control group maintained the lowest value (157.00 U/L). ALT levels showed no significant differences across treatments, ranging from 31.80 U/L in T1 to 40.21 U/L in T2. ALP activity varied significantly, peaking at 75.40 U/L in T3 and dropping to 38.80 U/L in T2. Glucose levels were highest in T2 (85.58 mg/dL), while T1 recorded the lowest (56.19 mg/dL). Similarly, cholesterol concentrations rose significantly in T2 (187.37 mg/dL) compared to T1 (123.69 mg/dL). In contrast, creatinine levels declined significantly in all supplemented groups, with values ranging from 0.68 mg/dL in T1 to 0.46 mg/dL in T4.

Economics of production of starter broiler chicks fed dietary meals of turmeric, ginger and their mixture at 0.25 % inclusion levels

Conversely, the dietary supplementation of turmeric, ginger, and their combination had a significant impact on most of the economic indices evaluated, excluding the fixed costs for day-old chicks (₦1500) and operational expenses (₦200), which remained constant (Table 6). Total feed cost (FC) spanned from ₦823.30 in the control diet (T1) to ₦839.60 in the turmeric group (T2). The cost per unit weight gain (FC/WG) was least in T1 (₦2166) and highest in T4 (₦2291), mirroring the trend in feed cost per bird, which ranged from ₦2535 (T1) to ₦2704 (T4). The total production cost (TCP) followed a similar pattern,

being lowest in the control group (₦4135) and highest in T4 (₦4304). Notably, all supplemented treatments resulted in negative cost savings, ranging from -₦89.30 in the ginger group (T3) to -₦169.00 in the combined turmeric-ginger group (T4). Additionally, feed cost as a percentage of total production cost varied significantly, increasing from 61.30% in T1 to 62.92% in T4.

DISCUSSION

The results of this study reveal that the dietary addition of turmeric, ginger, and their combination at a 0.25% inclusion level had no significant effect on the growth performance of broiler chickens. This finding differs from previous reports where phytogenic additives led to improved performance indices. For example, Al-Sultan (2003) reported increased weight gain in birds fed turmeric-based diets. Durrani *et al.* (2006) also observed notable improvements in feed efficiency and weight gain with ginger supplementation. Furthermore, research by Ademola *et al.* (2009) and Al-Kassie (2009) supported the beneficial role of herbal additives in promoting better nutrient utilisation and feed consumption. The absence of significant improvements in the current trial may suggest that the 0.25% inclusion level was insufficient to trigger notable growth responses.

The economic analysis indicates a clear impact of turmeric, ginger, and their combination on cost-related parameters of broiler production. While phytogenic feed additives are often praised for enhancing efficiency and animal health, their financial implications are equally vital. Previous studies, such as Sunmola *et al.* (2022), pointed out that while beneficial to health, herbal additives could raise feed costs. Onu (2010) emphasised that such additives need to be cost-effective to justify their use. On the other hand, Ali *et al.* (2008) reported that ginger-enhanced diets contributed to better profitability through improved growth and reduced disease incidence.

In terms of haematological responses, the generally stable values across treatments indicate that 0.25% supplementation with turmeric, ginger, or their combination does not adversely affect the blood health of broilers. This aligns with the work of Sunmola and Tuleun (2023a), who reported no disruptions in haematological indices with white ginger inclusion. Barazesh *et al.* (2011) also confirmed that herbal additives like ginger help sustain normal blood parameters. The significant increases in eosinophils and monocytes observed in this study may reflect immune modulation, a view supported by Emadi and Kermanshahi (2007), who found that turmeric boosted monocyte activity. Ghasemi and Taherpour (2015) also suggested that plant-based additives influence immune-related cell populations. Additionally, Sunmola and Tuleun (2023b) noted that normal haemoglobin and red blood cell levels in birds fed phytogenic-based diets (white ginger) reflect a non-toxic nature. These outcomes collectively indicate that turmeric and ginger at the tested levels are physiologically safe and may support immune function without compromising general blood health.

The observed variations in serum biochemical parameters underscore the metabolic effects of turmeric and ginger supplementation. Notably, reductions in total protein and albumin, particularly in T2 and T4, suggest potential influences on protein metabolism or utilisation, consistent with the observations of Sunmola *et al.* (2023). Elevated AST values in turmeric- and ginger-fed birds align with earlier studies by Durrani *et al.* (2006) and Al-Sultan (2003), which linked such increases to hepatic responses. Although ALT did not differ significantly, ALP levels varied across treatments, suggesting fluctuations in liver or bone activity, as reported by Ademola *et al.* (2009). The spike in glucose concentration in T2 corroborates findings by Oleforuh-Okoleh *et al.* (2014), who associated turmeric with altered carbohydrate metabolism. Similarly, increased cholesterol in T2 echoes Herve *et al.* (2021), who noted phytogenic-induced changes in lipid profiles. Lower creatinine levels in all supplemented groups support the renal-protective effects of these additives, as discussed by Sunmola *et al.* (2023) and Mirbod *et al.* (2017). Prior research by Ali *et al.* (2008) and Dalkılıç *et al.* (2017) also highlights the hepatoprotective and hypolipidemic properties of these herbs, suggesting their potential to enhance metabolic function in poultry. These findings collectively reinforce the role of herbal additives in modulating biochemical parameters, though optimal dosing is necessary to ensure metabolic stability.

Regarding digestibility, the reduction in dry matter and nitrogen-free extract digestibility among birds fed turmeric- and ginger-supplemented diets indicates that these additives may influence the efficiency of nutrient utilisation. Durrani *et al.* (2006) reported that turmeric and ginger can affect digestibility by altering gut flora and digestive enzyme activity. Sunmola and Tuleun (2024) and Onu (2010) emphasised the variability of such effects based on inclusion levels and additive types. Ademola *et al*. (2009) also suggested that turmeric may reduce carbohydrate digestibility due to its fibrous composition. In contrast, Ali *et al.* (2008) reported improved digestibility with ginger due to increased bile secretion. Olupona *et al*. (2021) observed mixed outcomes when turmeric and ginger were used in combination, indicating the importance of diet formulation and bird age. Windisch *et al.* (2008) pointed out that the mechanisms of phytogenic additives are multifactorial, involving antioxidant properties, microbiome shifts, and gut motility changes. Similarly, Oleforuh-Okoleh *et al*. (2014) stressed the need for balanced dosage to enhance digestibility without impairing energy uptake. Overall, while turmeric and ginger show promise in digestive support, their effective use requires precision in formulation.

Conclusion

Herbal additives (turmeric, ginger, and their combination) had little effect on broiler growth but impacted production

costs, nutrient digestibility, and blood profiles at 0.25 % inclusion level. Their value may lie in health support rather than growth. Further studies should explore optimal inclusion levels, immune responses, and long-term impacts to clarify their role in sustainable poultry production.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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