



Dietary Supplementation of Turmeric Rhizome Promotes the Growth Performance, Serum Lipid Profile and Intestinal Microflora of Broilers

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Abstract

The injudicious use of antibiotics as growth promoters in poultry rations has caused great concern around the world. Scientists are currently trying to replace broad-spectrum antibiotics in animal diets with alternative natural feed additives. The current study aimed to investigate the dietary effect of turmeric rhizome powder (TP) on the growth performance, serum lipid profiles, and intestinal microflora of broiler chickens. A total of 75 Cobb-15 broiler chicks (15-day-old) were randomly distributed into five groups offered with five experimental rations designated as T₀ (control diet, without TP), T₁ (1 g TP/kg feed), T₂ (2.5 g TP/kg feed), T₃ (5 g TP/kg feed), and T₄ (7.5 g TP/kg feed). Parameters such as body weight gain, total feed intake, and feed conversion ratio (FCR) were used to assess the response of broiler chickens to feed turmeric powder. Supplementation with 5 g TP/kg feed (T₃) resulted in the highest increase in body weight with a relatively lower FCR. Serum levels of cholesterol, triacylglycerol, and LDL-cholesterol decreased significantly when supplemented with 5 g TP/kg feed. The bacteriological investigation revealed that a turmeric-supplemented diet significantly lowered the total *Salmonella* spp. count. The antioxidant property of turmeric rhizome may alleviate stress in broiler chickens. Taken together, these findings indicate that supplementing broiler ration with 5 g TP/kg feed improved growth performance, lipid profiles, and intestinal microflora of broiler chickens, suggesting that turmeric rhizome can be a potential alternative feed additive to synthetic antibiotics for safe and organic poultry meat production.

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Introduction

Subtherapeutic use of antimicrobial growth promoters in livestock and poultry to improve performance is a common practice in veterinary medicine (Brown *et al.*, 2017). However, injudicious use of these antimicrobials, mostly broad-spectrum antibiotics, in farm animals can lead to the development of antibiotic-resistant bacterial strains that cause serious health consequences in humans (Rahman and Hollis, 2023). The European Union (EU) has prohibited the

use of antibiotics as growth promoters in animal nutrition since January 2006. Due to this ban in the EU and growing pressure on livestock producers in other parts of the world, alternative strategies for animal growth promotion and disease prevention are herbal products classified as 'phytogenic', which have received increased attention as a viable alternative since they are natural in origin, with expected pharmacological activities suitable to tackle microbial threats and to promote intestinal health, thereby optimizing growth performance and profitability in livestock (Murugesan *et al.*, 2015).

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Medicinal herbs are frequently incorporated into the poultry rations. The most commonly used herbal ingredient is turmeric rhizome (*Curcuma longa*), a widely used spice, food preservative, and coloring agent that has enormous biological activities, including hypolipidaemic (Dehzad *et al.*, 2023a), immunomodulatory (Yuandani *et al.*, 2021), and anti-inflammatory (Dehzad *et al.*, 2023b). Curcumin is the principal active component of turmeric, which is primarily responsible for its biological activities. Curcumin shows antioxidant activities (Ghareghomi *et al.*, 2021) by neutralizing reactive oxygen species and elevating the level of antioxidant enzymes such as superoxide dismutase, glutathione peroxidase, and catalase in the blood (Ramírez-Mendoza *et al.*, 2022). Curcumin also improves liver functions and reduces serum triacylglycerol, low density lipoprotein (LDL) cholesterol, and blood glucose levels (Tian *et al.*, 2022; Emadi and Kermanshahi, 2007; Seo *et al.*, 2008). Turmeric oil possesses antioxidant, antibacterial, antiviral, antifungal, hypolipidemic, and wound healing properties (Liju *et al.*, 2011). Turmeric is also used in gastrointestinal and respiratory disorders (Gilani *et al.*, 2005) and shows protective effects against aflatoxin-induced mutagenicity and hepatocarcinogenicity (Yarru *et al.*, 2009). Dietary turmeric powder lowers the serum LDL cholesterol level of triglycerides and total cholesterol in layers and broilers (Kermanshahi and Riasi, 2006). Broiler chickens show increased weight gain and improved feed conversion ratio (FCR) (Al-Muhammadawi and Jassim Hammoudi, 2022; Oke, 2018) with dietary supplementation of turmeric. However, the simultaneous effect of turmeric-supplemented ration on the growth performance, serum lipid profile, and intestinal microflora of broiler chickens is yet to be investigated. The current research was designed to analyze the antioxidant property of turmeric rhizome and to evaluate the effect of turmeric rhizome-supplemented feed on growth performances, serum lipid profiles, and intestinal microflora in broiler chickens.

Materials and Methods

Chicks and Experimental Design

A total of 75 day-old broiler chicks (Cobb-15) were purchased from a local hatchery. Chicks were

provided with feed and drinking water *ad libitum*. They were fed a starter diet from 1 to 13 days, a grower diet from 14 to 24 days, and a finisher diet from 25 to 30 days of age. The compositions of the starter, grower, and finisher rations are presented in Table 1. Fifteen day-old chicks were randomly split into 5 dietary treatment groups, each with 10 chicks, following a complete randomized block design. Treatment groups include T₀ (control diet, without TP), T₁ (1 g TP/kg feed), T₂ (2.5 g TP/kg feed), T₃ (5 g TP/kg feed), and T₄ (7.5 g TP/kg feed).

Preparation of Experimental Diets and Turmeric Supplementation

The fresh turmeric rhizome was collected from a farmer's field, chopped and air-dried at room temperature, and then finely powdered in the mill. Experimental feed was formulated using the data of the proximate composition of turmeric rhizome and other commercial feed ingredients on a dry matter basis. All diets were formulated manually to meet the nutrient requirements of broilers. The ingredients and chemical composition of the control diet are given in Table 1.

Growth Performance Monitoring

Body weight was recorded at the commencement of the experiment and was repeated at the beginning of the week at the same time. Live weight gain was calculated by subtracting the live body weight at the beginning of the week from the live body weight of the next week. Feed conversion ratio (FCR) was calculated every week at the amount of feed consumption per unit of body weight gain: {average weekly feed consumption (g)/average weekly gain (g)}.

Bacteriological Study

Caecal samples were collected directly from the caecum of each bird (three from each group) with the help of sterilized surgical instruments after slaughter. Microbial populations were determined by serial dilution of caecal samples. Plate count agar, eosin methylene blue agar, and salmonella-shigella agar media were used to determine total viable bacteria, *Eschericia coli* and *Salmonella* spp., respectively.

Table 1. Formulated turmeric powder-supplemented diets

Items	Dietary level of turmeric rhizome powder (g/Kg feed)									
	14 to 24 days (Grower diet)					25 to 30 days (Finisher diet)				
	T ₀	T ₁	T ₂	T ₃	T ₄	T ₀	T ₁	T ₂	T ₃	T ₄
Feed ingredients (%)										
Maize	51.90	53.15	52.90	53.65	53.65	54.95	56.21	53.99	54.69	54.69
Soybean meal	22.50	21.57	20.87	20.02	20.00	20.90	19.90	20.87	20.02	20.00
Rice polish	10.00	10.00	10.00	10.00	10.00	7.98	7.98	7.98	7.98	7.98
Meat and bone meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Protein concentrate	5.80	5.50	5.20	4.90	4.60	6.00	5.80	5.80	5.60	5.60
Soyabean oil	3.27	3.00	3.00	3.00	3.00	3.30	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.80	0.80	0.80	0.80	0.80
Di-calcium phosphate	1.00	1.00	1.00	1.10	1.10	1.00	1.00	1.00	1.10	1.10
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.10	0.10	0.10	0.10	0.10	0.08	0.08	0.08	0.08	0.08
Broiler premix	0.25	0.25	0.25	0.25	0.25	0.32	0.32	0.32	0.32	0.32
Toxin binder	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Coccidiostats	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-
Lysine	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Enzyme	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Turmeric rhizome powder (g/Kg feed)	00	1.00	2.50	5.00	7.50	00	1.00	2.50	5.00	7.50
Calculated composition										
MJ/Kg	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Crude protein (g/Kg)	210	212	213	214	214	205	207	208	209	214
Crude fiber (g/Kg)	45.00	46.30	47.70	49.10	49.10	4.40	4.52	4.65	4.72	49.10
Calcium (g/Kg)	11.90	11.80	11.70	11.90	11.90	1.30	1.30	1.30	1.31	11.90
Phosphorus (g/Kg)	4.00	3.90	3.80	3.90	3.90	0.38	0.38	0.37	0.38	3.90
Methionine (g/Kg)	4.70	4.70	4.70	4.70	4.70	0.45	0.45	0.45	0.45	4.70
Lysine (g/Kg)	9.90	10.20	10.50	10.80	10.80	0.95	0.98	1.01	1.02	10.80

Blood Sample Collection and Serum Lipid Profiling

The blood was collected from experimental and control chicks at 35th days by using a sterilized disposable syringe and needle by wing vein puncture without using any anticoagulant. Each of the syringes with blood samples was kept at normal temperature in an inclined position. After 20 minutes, the serum was collected and centrifuged for 15 minutes at 2500 rpm. After centrifugation, the supernatant was carefully collected by a micropipette and preserved in Eppendorf vials. The collected serum samples were stored at -15 °C until used for determination of total cholesterol, high density lipoprotein (HDL)-cholesterol, and triglycerides. The serum lipid profile was analyzed by standard protocol according to the manufacturer's instructions (Human, GmbH, Germany).

2,2-diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Assay

The antioxidant activity of the turmeric rhizome extract was determined on the basis of the scavenging effect on the stable DPPH free radical as described previously (Braca *et al.*, 2002, Afrin *et al.*, 2022).

Statistical Analyses

The data were analyzed by using the statistical package SPSS Statistics 17.0 (one-way ANOVA). Differences among treatments, when significant, were ordered using Duncan's multiple range test. Statements of statistical significance were based on $P \leq 0.05$ or $P \leq 0.01$.

Results and Discussion

Dietary supplementation of turmeric rhizome at varying levels improved the growth performance of broiler. A slight but significant variation in feed intake and body weight in different dietary groups was observed (Tables 2 and 3). However, on a weekly basis, the treatment group T₃ showed the highest body weight (Table 2). On the other hand, the T₃ group consumed a comparatively lower amount of feed (Table 2). T₃ also gained the highest body weight while consuming a relatively lower amount of feed (Table 3). The feed conversion ratio (FCR) was calculated to measure the efficiency of broilers to utilize feed for growth

performance. It was observed that FCR was the lowest in T₃ (1.68) and highest in T₀ (2.05). Our findings are in line with the previous report which states that the inclusion of turmeric at 5g/kg significantly increased body weight of broiler (Namagirilakshmi, 2005). The reason for the growth-promoting effect of turmeric might be attributed to the antioxidant, anti-inflammatory, antimicrobial, and gastroprotective effect of curcumin and other bioactives of turmeric rhizome (Liju *et al.*, 2011). The high FCR of broilers given diets enriched with turmeric powder suggests that the effects of growth promoters, including phytochemicals, on performance may be linked to increased nutrient use, which raises FCR.

Table 2. Effect of different levels of turmeric powder on average body weight and feed intake of broilers fed with experimental diets (g/bird/week)

Parameters	Treatments				
	Control T ₀	1 g TP/kg feed (T ₁)	2.5 g TP/kg feed (T ₂)	5 g TP/kg feed (T ₃)	7.5 g TP/kg feed (T ₄)
Body weight* (g/bird/week)					
First week	658.2±11.8 ^a	491.0±17.0 ^b	657.1±23.7 ^a	648.4±18.5 ^a	655.2±32.1 ^a
Second week	1045.1±23.3 ^{ab}	1089.9±34.2 ^a	1107.4±18.4 ^a	1115.8±91.1 ^a	1051.8±47.2 ^{ab}
Third week	1330.0±24.2 ^c	1404.7±49.1 ^{bc}	1442.6±27.6 ^{ab}	1478.8±16.9 ^a	1427.2±38.2 ^b
Feed Intake* (g/bird/week)					
First week	565.4±9.5 ^b	581.3±22.4 ^a	567.0±13.8 ^b	559.9±8.7 ^b	596.6±12.4 ^a
Second week	655.6±22.4 ^a	639.1±19.7 ^{ab}	637.2±8.4 ^{ab}	592.9±71.3 ^b	601.2±12.4 ^b
Third week	669.0±33.2 ^a	657.3±14.1 ^{ab}	655.6±18.2 ^{ab}	611.7±27.9 ^b	644.8±22.8 ^{ab}

Values are expressed as Mean±SD (n=15); ^{abc}values with different superscript differed significantly ($P<0.05$). *Measurement was taken at 15 days of age when experimental feeding started; TP = Turmeric powder.

Table 3. Growth performances of broilers fed with different levels of turmeric powder for 20 days (15 to 35 days of age)

Parameters	Treatment Groups				
	Control (T ₀)	1 g TP/kg feed (T ₁)	2.5 g TP/kg feed (T ₂)	5 g TP/kg feed (T ₃)	7.5 g TP/kg feed (T ₄)
Initial BW at 15 days of age (g)	484.4±12.3	491.0±8.4	493.2±14.6	492.8±7.1	490.4±9.3
Final BW at 35 days of age (g)	1406.6±45.2	1468.8±32.8	1510.2±61.5	1528.8±38.0	1450.6±28.4
*BW gain (g)	922.2±29.3 ^b	977.8±21.5 ^{ab}	1017.0±17.5 ^a	1052.1±25.0 ^a	960.2±11.5 ^{ab}
Total feed intake (g)	1890.0±44.2 ^a	1877.7±28.8 ^a	1859.9±75.5 ^a	1764.7±26.4 ^b	1842.7±55.2 ^a
**FCR	2.05±0.1 ^c	1.92±0.1 ^b	1.83±0.1 ^b	1.68±0.1 ^a	1.92±0.0 ^b

Values are expressed as Mean±SD (n=15); ^{abc}values with different superscript letters differed significantly ($P<0.05$). BW = Body Weight, *BW gain (g) = Final body weight at 35 days of age (g) – Initial body weight at 15 days of age (g). **FCR (Feed Conversion Ratio) = Total feed intake (g)/Body weight gain (g). TP = Turmeric powder.

Poultry meat is comparatively low in lipid contents, but inclusion of a fat-rich diet may result in the deposition of fat in muscle, which is a concern for consumers. Accordingly, poultry rations supplemented with lipid-lowering additives are highly desirable (El-Bagir *et al.*, 2006). The present study demonstrated that serum biochemical parameters, including total cholesterol, triglycerides (TG), HDL- and LDL-cholesterol of experimental chicks, were significantly influenced by turmeric-supplemented diet (Figure 1). T₃ showed the highest cholesterol-lowering effect, followed by T₁, T₄ and T₂. Serum TG level was also lowest in T₃. However, T₁ showed a slightly higher TG level. LDL cholesterol levels were significantly declined in T₁ and T₃. On the other hand, there was a slight but insignificant declining effect on HDL observed in the treatment groups offered with turmeric-supplemented diet. The present study was in agreement with the previous reports. A line of evidence suggests that turmeric rhizome has shown hypolipidemic and hypocholesterolemic potentials in animal studies. Dietary supplementation of turmeric powder up to 7.5 g/kg feed lowers the serum levels of total cholesterol, TG, LDL- and VLDL-cholesterol while raising the HDL-cholesterol (Kermanshahi and Riasi, 2006).

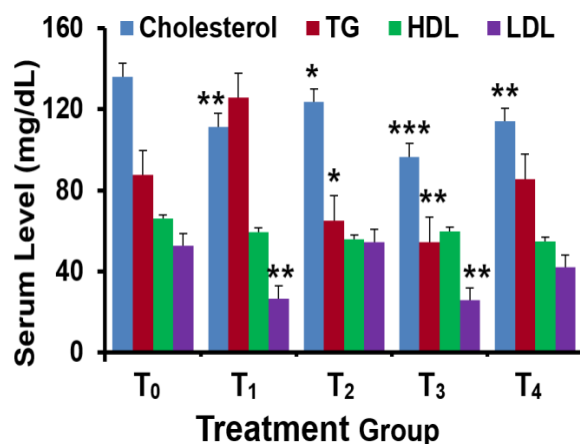


Figure 1. Serum lipid profiles of broiler chicks fed with control feed (T₀), 1 g TP/kg feed (T₁), 2.5 TP/kg feed (T₂), 5 TP/kg feed (T₃), 7.5 TP/kg feed (T₄) at 35 days of age. Bar represents the Mean±SD (n=15). Statistical significance compared to vehicle: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. TP = Turmeric powder.

Turmeric has been reported to exhibit antimicrobial properties and its ethanol extract demonstrated high potential to inhibit some pathogenic bacteria in chicken (Gul and Bakht, 2015). Thus, through its antimicrobial potential, turmeric could control and limit the growth and colonization of numerous pathogenic and non-pathogenic species of bacteria in chicken's gut resulting in balanced gut microbial ecosystems that lead to better feed utilization reflected by the improved feed conversion ratio. Corresponding to our results on feed efficiency, Durrani *et al.* (2006) also reported that chickens receiving diets supplemented with 5 g/kg turmeric powder had better feed conversion ratio than 2.5 and 10 g/kg supplementation level. In addition, we observed a significant reduction ($P < 0.05$) in *Salmonella* count in broilers fed on diets supplemented with 2.5 g turmeric powder/kg feed (T₂) (Figure 2). The turmeric rhizome has also been reported to improve immunity because of its curcumin and other bioactive ingredients (El-Saadony *et al.*, 2022).

Moreover, Turmeric rhizome had shown potent antioxidant activity. Turmeric extract exhibited 88.89% inhibition for DPPH radical scavenging at 1.0 $\mu\text{g/mL}$ (Table 4). It showed moderate antioxidant activity with an IC₅₀ value of 107.12. Broilers with turmeric supplementation are expected to have higher antioxidant status and to withstand oxidative stress more efficiently than the control group, rendering proper growth performance of supplemented chicken. Our findings and previously described results suggest that herbal feed additives might be an effective alternative to synthetic antibiotics for the promotion of the health and performance of poultry.

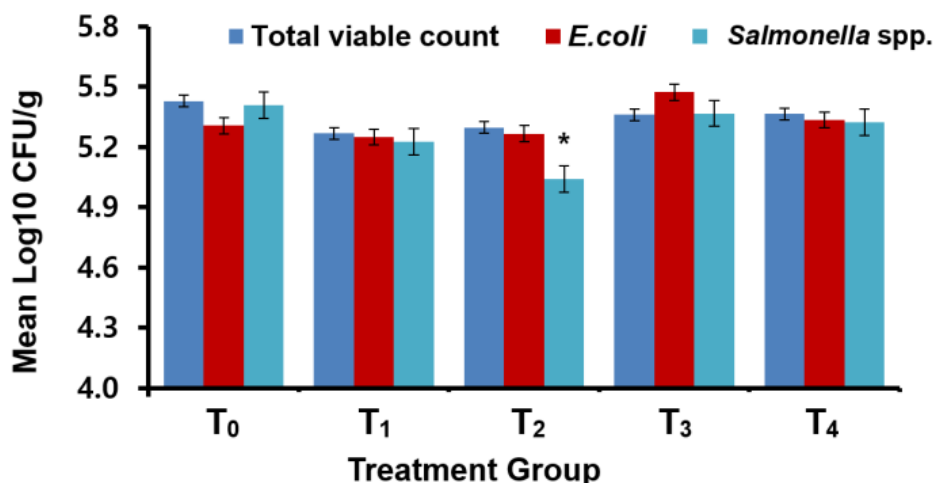


Figure 2. Bacterial count in caecal samples of broilers fed with control feed (T₀), 1 g TP/kg feed (T₁), 2.5 g TP/kg feed (T₂), 5 g TP/kg feed (T₃), 7.5 g TP/kg feed (T₄) at 35 days of age. The bar represents the Mean±SD (n=15). Statistical significance compared to vehicle: * $P < 0.05$. TP = Turmeric powder.

Table 4. Extract yield, % Inhibition and IC₅₀ values of turmeric rhizome for DPPH scavenging

Sample	Extract yield (%w/w)	% DPPH Inhibition				IC ₅₀ *
		0.01 µg/mL	0.1 µg/mL	0.5 µg/mL	1.0 µg/mL	
Turmeric rhizome	5.44	9.03±1.83	59.03±16.93	64.58±0.41	88.89±3.86	107.12±41.50
Vitamin C	-	52.17±0.53	93.09±0.44	93.86±0.19	94.11±0.71	7.45± 0.39

Values are expressed as Mean±SD (n=3); *IC₅₀ = the half maximal inhibitory concentration.

Conclusion

The current study demonstrated that dietary supplementation of turmeric rhizome improved growth performance, serum lipid profiles and intestinal microflora of broiler. Therefore, turmeric rhizome could be a sustainable alternative to synthetic antibiotics for the promotion of the health and performance of poultry.

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Declaration

The authors declare no conflict of interest.

Authors' Contribution

MAH conceptualized the idea; MAH also supervised resourced and validated the project; RS, AAMS and MTH are responsible for data curation, methodology, investigation and writing of original draft; RS and AAMS analyzed the data. The completed manuscript has been read and approved by all authors.

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