Research Article

Effect of Dietary Supplementation of *Curcuma longa* and *Syzygium aromaticum* on Growth Performance, Antioxidant Enzymes, and Chemical Composition of Broiler Meat (Ross 308)

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Abstract | Poultry meat stands as one of the key protein sources worldwide, with the industry expanding at an impressive pace. This study evaluated the effects of dietary turmeric powder (TP), clove powder (CP), and their combination on growth performance, antioxidant capacity, and breast muscle composition in broiler chickens. A total of 144 one-day-old unsexed Ross 308 chicks were randomly assigned to four groups (three replicates of 12 birds each). The treatments included: a control diet (T1), 1% TP (T2), 1% CP (T3), and a mix of 1% TP + 1% CP (T4). Compared to the control, all supplemented groups showed significant improvements ($P \leq 0.05$) in body weight, weight gain, and feed conversion ratio, while feed intake significantly decreased ($P \leq 0.05$). Antioxidant markers, including serum glutathione peroxidase (GPX), superoxide dismutase (SOD) and protein content in breast muscle were also significantly elevated ($P \leq 0.05$) in all treated groups, with no significant changes in ash, fibre and starch content. Overall, TP, CP, and their combination positively affected broiler performance, antioxidant status, and breast meat quality. In conclusions, the results indicate that supplementation with clove powder, turmeric powder, and their combination significantly enhances broiler chickens' productive performance, serum antioxidant status, and protein content of meat, thus may be adopted as natural in-feed growth promoting agents.

Keywords | Antioxidant status, Clove powder, Performance, Turmeric powder, Chicks

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INTRODUCTION

Poultry meat stands as one of the key protein sources worldwide, with the industry expanding at an impressive pace. Since 2006, increasing concerns about antibiotic residues in meat and the rise of antibiotic-resistant bacteria have driven efforts to reduce or eliminate antibiotic growth promoters from poultry production systems (Rafeeq *et al*., 2022). Similarly, the increasing rejection of synthetic additives among consumers has spurred greater demand for natural feed alternatives, fostering significant interest and research in this area (Rehman *et al*., 2020).

Among various bioactive substances, medicinal spices such as clove (*Syzygium aromaticum*) and turmeric *(Curcuma longa)* have drawn considerable attention due to their therapeutic potential. Clove, belonging to the *Myrtaceae* family, has been a staple in traditional medicine, primarily for its abundance of essential oils, especially eugenol, which exhibits notable antimicrobial and antioxidant

effects (Kuete, 2017; El-Maati *et al*., 2016). Research indicates that clove supplementation can enhance broiler immunity, digestion, and growth performance by promoting gut microbiota health and improving nutrient absorption (Mohammadi *et al*., 2014; Nahed *et al*., 2022; Kunnumakkara *et al*., 2018). Furthermore, cloves are both cost-efficient and widely accessible, making them a practical option for small-scale poultry farming (El-Shall *et al*.,2019).

Turmeric, a plant within the *Zingiberaceae* family, is rich in curcumin and associated curcuminoids, which deliver significant antioxidant and anti-inflammatory benefits (Kumar *et al*., 2017; Chattopadhyay *et al*., 2004; Al-Sultan, 2003; Hewlings and Kalman, 2017). Studies have demonstrated that turmeric supplementation can boost digestive enzyme activity and enhance nutrient absorption, ultimately improving growth rates and feed conversion efficiency (Plate and Srinivasan, 2000; Daramola, 2020). Additionally, it contributes to intestinal health by promoting better villus structure and epithelial cell proliferation in the small intestine (Salah *et al*., 2021). Thus, the objective of this research was to examine the effects of dietary supplementation with clove and turmeric powders both individually and in combination on growth performance, antioxidant capacity, and breast muscle quality in broiler chickens.

MATERIALS AND METHODS

Birds and treatment

This study was conducted at the Poultry Research Unit, Department of Animal Production, College of Agriculture, University of Basrah, Iraq. The study was approved by the Institutional Animal Care and Use Committee (IACUC). A total of 144 one-day-old Ross 308 broiler chicks were randomly divided into four dietary groups, each with three replicates of 12 birds (6 males and 6 females). Birds were housed in floor pens within a well-ventilated, temperature-controlled room. Newcastle disease vaccines were administered via drinking water on days 1, 10, and 21, while the Gumboro vaccine was applied via eye drops on day 14. Chicks were fed a two-phase diet: A starter diet from days 1–21 and a grower diet from days 22–35. All diets were formulated to meet NRC (1994) recommendations and analysed according to AOAC (2016) standards. The ingredient and nutrient composition of starter and finisher diets is presented Table 1. The birds were reared under standard conditions. The treatment groups were as follows: T1 (control, no supplement), T2 (1% (10g turmeric powder/kg diet), T3 (1% clove powder), and T4 (1% turmeric + 1% clove). Supplements were sourced from local markets in Basrah.

Table 1: Ingredient and nutrient composition of starter and finisher diets.

Ingredient (%)	Starter diet (1-21 days)	Finisher diet (21- 35 days)
Yellow corn	56	60
Wheat barn	9	0
Wheat	0	12
Soybean (44% protein)	24	22
Concentrated protein	10	5
Limestone	0.50	0.50
Premix	0.25	0.25
Common salt	0.25	0.25
Total	100	100
Calculated chemical analysis		
ME (Kcal/Kg diet)	2952	3119
Crude protein%	22.40	19.34
Calorie: protein ratio	131.80	161.30
Ca %	1.10	0.84
Available phosphorus %	0.52	0.41
Lysine %	1.24	1.16
Methionine + cysteine %	0.92	0.78

ME: metabolizable energy.

Study parameters

Performance parameters measured included final body weight (FBW), feed intake, and feed conversion ratio (FCR), following the study of Lambert *et al*. (1936). On day 35, one bird per replicate (three per group) was slaughtered humanely, and breast muscle samples were collected, labelled, and stored at 4°C for analysis of protein, starch, fibre and ash contents (Tashla *et al*., 2019).

Blood samples were collected from the brachial vein of one bird per replicate and centrifuged at 3000g/10 minutes at 4°C. Serum was stored at –20°C and later analyzed for antioxidant enzymes viz., glutathione peroxidase (GPX) and superoxide dismutase (SOD) using commercial ELISA kits (SzaKits, Albasheer Scientific Bureau) based on the methods of Flohé and Günzler (1984), and Misra and Fridovich (1972), respectively. Meat quality analysis of breast meat were carried out following standard proximate analysis procedures. Ash was measured by incineration at 550 °C, crude fiber by sequential acid–alkali digestion; starch by enzymatic hydrolysis using α-amylase and amyloglucosidase; and crude protein by the Kjeldahl method (N × 6.25).

Statistical analysis

The results were analyzed using one-way ANOVA for a completely randomized design. Treatment means were compared using Duncan's multiple range test in SPSS

(2002), and significant differences were determined at the 5% level.

RESULTS AND DISCUSSION

Data from Table 2 show that supplementing broiler diets with turmeric powder (T2), clove powder (T3), or their combination (T4) significantly increased body weight at weeks 3, 4, and 5 ($P < 0.05$) compared with the control (T1). Among the treatments, T3 resulted in the highest overall body weight.

This raise in weight could be due to altered gut morphology and microflora level particularly improved level of lactobacillus as reported by Namagirilakshmi *et al*. (2010). Similar results were observed by Mashhadani (2015) and Sethy *et al*. (2016). However, Tariq *et al*. (2015) reported no significant effects of clove supplementation, and some earlier studies by Mehala and Moorthy (2008) and Nouzarian *et al*. (2011) also reported that turmeric did not affect body weight, indicating that outcomes may vary based on dosage, diet composition, and bird age.

As shown in Table 3, weekly body weight gain in the turmeric-supplemented group (T2) was not significantly different from the control in weeks 1, 2, and 4. However, significant improvements ($P < 0.05$) were observed in weeks 3 and 5, consistent with the trends seen in clove (T3) and combined (T4) treatments. These enhancements may result from turmeric's ability to extend intestinal villi length and lower intestinal pH, creating a favourable environment for nutrient absorption (Sieo *et al*., 2005). Additionally, turmeric appears to reduce harmful gut microbes while promoting beneficial Lactobacillus species (Namagirilakshmi *et al*., 2010; Faghani *et al*., 2014). Improved digestive enzyme secretion further supports nutrient uptake and growth performance (Arslan *et al*., 2017; Sharma *et al*., 2015).

In the T3 group, clove supplementation produced the highest body weight during weeks 3 to 5, with notable gains in weeks 3 and 5. This effect may be attributed to the antimicrobial and digestive-stimulating properties of clove essential oil (Kamel, 2001). However, these findings contrast with Mohammadi *et al*. (2014), who observed reduced growth and feed intake at higher clove oil concentrations, suggesting that dosage plays a critical role in outcomes.

Table 4 highlights the impact of dietary treatments on feed intake. A significant reduction ($P < 0.05$) was observed in week 5 in all treatments group compared to the control. This reduction may be linked to turmeric's antioxidant properties, which enhance protein synthesis through enzymatic activity (Osawa *et al*., 1995). Similar outcomes were reported by Arslan *et al*. (2017), while other studies (Sharma *et al*., 2015; Hady *et al*., 2016) noted inconsistent effects.

Table 2: Effects of clove powder, turmeric powder, and their mixed supplementation on body weight (g) of broiler chickens (mean± SD).

Treatment	Weeks				
	1	2	3	4	5
T1	168.6 ±11.15	355.83±8.02	720.33±25.84^{c}	1352.6±12.19^{b}	1946.6±11.79^{c}
T2	170.6 ±13.44	388.93±27.76	801.39±19.89^{a}	1414.3±30.55^{ab}	2148.6±17.94^{ab}
T3	176.5 ±10.13	366.63±20.03	812.32±8.45^{a}	1428.3±32.37^{a}	2197.0±21.15^{a}
T4	174.03±10.99	388.90±27.75	799.70±13.96^{b}	1427.6±37.72^{a}	2151.6±27.26^{ab}
Significance	N. S	N. S	*	*	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. N.S: non-significant effect; *: significant effect (P<0.05).

Table 3: Effects of clove powder, turmeric powder, and their mixed supplementation on body weight gain (g) of broiler chickens (mean±SD).

Treatment	Weeks				
	1	2	3	4	5
T1	123.66±1.15	187.23±7.11^{b}	364.51 ±8.42^{c}	632.27 ±30.74	594.31 ±80.75^{b}
T2	127.66±3.44	218.33±24.44^{a}	412.46 ±14.16^{b}	612.91 ±30.66	734.30 ±17.94^{a}
T3	133.56±6.13	190.13±20.12^{b}	445.69 ±29.05^{a}	615.98 ±52.15	768.70 ±34.47^{a}
T4	125.03±5.07	214.87 ±22.68^{a}	410.82 ±14.17^{b}	626.93 ±59.84	724.43±44.04^{a}
Significance	N. S	*	*	N. S	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. N.S: non-significant effect; *: significant effect (P<0.05).

Table 4: Effects of clove powder, turmeric powder, and their mixed supplementation on broiler chickens' feed intake (g) (mean±SD).

Treatment	Weeks				
	1	2	3	4	5
T1	426.16±3.32	419.56±6.64	820.0 ±10.01	940.33 ±3.41	903.33±6.00[a]
T2	377.22±10.82	381.94±7.73	812.48 ±2.41	812.46 ±2.39	780.55±19.44[b]
T3	374.99±8.75	341.66±8.64	752.77 ±2.77	900.76 ±2.76	726.51±25.78[b]
T4	406.66±5.29	403.33±3.75	791.38 ±3.81	901.21 ±3.85	764.72±53.36[b]
significance	N. S	N. S	N. S	N. S	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. N.S: non-significant effect; *: significant effect (P<0.05).

Table 5: Effects of clove powder, turmeric powder and their mixed supplementation on feed conversion rate (FCR) of broiler chickens (mean± SD).

Treatment	Weeks				
	1	2	3	4	5
T1	3.44 ±0.05	2.24±0.09[a]	2.25±0.11[a]	1.48±0.12	1.52±0.32[a]
T2	2.95 ±0.08	1.74±0.18[c]	1.96±0.07[b]	1.32±0.06	1.06±0.07[b]
T3	2.80 ±0.06	1.79±0.03[c]	1.68±0.03[c]	1.46±0.10	1.00±0.05[b]
T4	3.25 ±0.10	1.87±0.19[b]	1.92±0.11[b]	1.43±0.09	1.05±0.14[b]
Significance	N. S	*	*	N. S	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. N.S: non-significant effect; *: significant effect (P<0.05).

Likewise, feed intake decreased in both the clove (T3) and combination (T4) groups. Mustafa (2016) found comparable results, suggesting that higher clove levels may reduce consumption by enhancing nutrient utilization. As birds meet energy needs more efficiently, intake may naturally decline. This efficiency could be linked to improved nutrient absorption and increased epithelial cell development in the gut (Ferket and Gernat, 2006; Batool *et al*., 2021).

Table 5 presents the feed conversion ratio (FCR) data for broilers supplemented with turmeric (T2), clove (T3), and their combination (T4). All supplemented groups showed improved FCR compared to the control, with the turmeric group displaying the most efficient nutrient utilization.

The enhanced FCR in the turmeric-supplemented group may be attributed to the phytogenic properties of turmeric, which promote better nutrient absorption and microbial balance in the gut. Turmeric's antimicrobial compounds, particularly in ethanol extracts, have been shown to inhibit pathogenic bacteria in poultry and shrimp (Ong-ard *et al*., 2010). This antibacterial effect likely contributes to improved digestion and feed efficiency, similar to antibiotic growth promoters. Supporting this, Durrani *et al*. (2006) found that broilers fed 5 g/kg of turmeric had better FCR than those given lower or higher doses. Additionally, the reduced feed intake observed in T3 and T4 may be linked to the high phenolic content in clove, which enhances nutrient bioavailability, allowing birds to meet their energy needs with less feed (Diego *et al*., 2014).

Table 6: Effects of clove powder, turmeric powder, and their mixed supplementation on broiler chickens' production index (mean±SD).

Treatment	Productive index	Rank
T1	586.67 ±28.65[c]	3
T2	655.48±51.40[b]	2
T3	714.87±92.75[a]	1
T4	741.89±77.47[a]	1
Significance	*	

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. *: significant effect (P<0.05).

Table 6 presents the effects of dietary treatments on the production index (PI) in broiler chickens compared to the control. Treatments with clove powder (T3), turmeric powder (T2), and a clove-turmeric mixture (T4) significantly (P < 0.05) improved production index (PI). These enhancements were attributed to greater body weight and improved feed conversion ratios observed throughout the trial. Similar improvements have been reported in previous studies by Yaghobfar *et al*. (2011), Basak (2015), and Attia *et al*. (2017).

The results presented in Table 7 exhibited antioxidant

effects of dietary treatments on broilers. This shows a significant increase in GPX and SOD enzyme activities in the T3 and T4 groups compared to the other groups. This improvement is likely due to curcumin, the active compound in turmeric, which enhances antioxidant status by directly scavenging free radicals and stimulating antioxidant enzymes such as GSH, catalase, and SOD, while inhibiting ROS-producing enzymes (Hewlings and Kalman, 2017). Curcumin, a natural polyphenol with medicinal properties, is known to reduce oxidative stress in both humans and animals (Sugiharto, 2020). Overall, turmeric boosts broiler antioxidant defences by increasing enzyme activity and reducing lipid peroxidation (Akhavan-Salamat and Ghasemi, 2016). These findings align with Mahrous *et al.* (2017), who demonstrated that dietary clove, particularly at 1 g/kg, significantly enhances broiler muscle antioxidant capacity and immunity in a dose-dependent manner.

Table 7: Effects of clove powder, turmeric powder, and their mixed supplementation on serum glutathione-peroxidase (GPX) and superoxide dismutase (SOD) enzymes of broiler chicken (mean± SD).

Treatment	SOD (U/mL)	GPX (U/mL)
T1	2.46 ±0.37^{b}	703.33±8.66^{c}
T2	3.60 ±0.62^{ab}	869.40±7.36^{b}
T3	4.51 ±0.28^{a}	925.39±28.49^{a}
T4	3.71±0.29^{ab}	885.46±6.82^{ab}
Significance	*	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. *: significant effect (P<0.05).

Table 8: Effects of clove powder, turmeric powder, and their mixed supplementation on ash, fibre, starch, and protein contents of broiler meat (mean±SD).

Treatments	Ash (%)	Fibre (%)	Starch (%)	Protein (%)
T1	1.18 ±0.03	0.50±0.05	0.52±0.006	21.66 ±0.98^{b}
T2	1. 11±0.06	0.33±0.08	0.53±0.008	24.16 ±0.16^{a}
T3	1.11±0.05	0.40±0.05	0.50±0.008	24.50 ±4.68^{a}
T4	1.12±0.5	0.36±0.08	0.52±0.02	24.46 ±0.09^{a}
Significance	N. S	N. S	N. S	*

T1: control treatment, T2: 1% turmeric mixed with the ration, T3: 1% clove mixed with the ration, T4: 1% turmeric + 1% clove mixed with the ration. N.S: non-significant effect; *: significant effect (P<0.05).

The results presented in Table 8 shows no significant differences (P > 0.05) in ash, fibre, or starch content across treatments. However, protein content significantly increased (P < 0.05) in supplemented groups compared to the control (T1). This rise may be attributed to phenolic compounds in turmeric and clove powders, indicating a positive effect of these dietary medicinal plants on the nutritional quality of chicken meat. Nutritional strategies to enhance meat quality are an emerging focus in animal and food research (Džinić *et al.*, 2015; Puvača *et al.*, 2016; Spasevski *et al.*, 2018). Our findings support Tashla *et al.* (2019), who reported significant improvements in the chemical composition of broiler meat following medicinal plant supplementation.

CONCLUSION

The results indicate that supplementation with clove, turmeric powder, and their combination significantly enhances broiler chickens' productive performance, serum antioxidant status, and protein content. However, no significant effects were observed on ash, fiber, or starch levels in broiler meat. Finally, we recommend further studies to evaluate the effects of turmeric and clove on the sensory qualities of poultry meat.

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NOVELTY STATEMENT

This study evaluates the effects of turmeric powder (TP), clove powder (CP), and their combination on broiler growth performance, antioxidant capacity, and breast muscle composition. Findings demonstrate that TP, CP, and their mixture improve production, antioxidant status in blood serum, and meat quality.

AUTHOR'S CONTRIBUTION

All authors equally contributed to the study's conception, design, data analysis, interpretation, and manuscript preparation.

Generative AI and AI-assisted technology statement

The authors declare that no generative AI or AI-assisted technologies were used in the preparation, writing, analysis, or interpretation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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