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# INFLUENCE OF TURMERIC *(Curcuma longa* L.) POWDER ON GROWTH PERFORMANCE AND INTESTINAL HISTOMORPHOMETRY IN BROILERS

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***Abstract***

*Natural herbal products are increasingly recognized as potent and cost-efficient alternatives to antibiotic growth promoters, improving growth performance and disease resistance in livestock and poultry. The main compound-curcumin is a lipophilic polyphenol derived from the rhizomes of Curcuma longa, has been highlighted for its beneficial effects, making it a promising feed additive. This study evaluated the effects of dietary turmeric supplementation on growth performance in broilers, as well as selected histomorphometric parameters, including intestinal villus height, width, surface area, and villus crypt depth. A total of 24 male Ross 308 broilers were assigned to two treatments over 42 days: a control group receiving a basal diet and an experimental group fed the same diet supplemented with 1% turmeric powder. The results showed that turmeric supplementation notably increased villus height, width, and surface area ($p<0.001$). These structural changes enhanced the absorptive capacity of the intestinal mucosa and improved nutrient transport, leading to significant ($p<0.05$) increases in body weight (BW), feed intake (FI), and feed conversion ratio (FCR).Overall, our findings indicate that turmeric can be applied as a natural alternative to conventional growth promoters in broiler production.*

***Key words****: chicken meat, growth promoters, intestinal morphology, turmeric.*

## INTRODUCTION

In recent decades, antibiotics have been used, on a large scale, in the prevention and treatment of many diseases in humans and animals. Their use, continuously and repeatedly, determines drug resistance by disrupting the balance of the intestinal microbiota, a process manifested by changes in nutrient metabolism, the loss of integrity in intestinal mucosa, invasion of pathogens, and the disruption of immunity (Gomaa, 2020; Ramirez et al., 2020).

In addition, antibiotics triggers various secondary effects on body (i.e., dysbiosis, allergies, liver and kidney toxicity, emesis, and diarrhea) (Bercik et al., 2014; Mostafa et al., 2014; Kesavelu et al., 2023). Following the adoption of Regulation (EC) No 1831/2003, the European Union progressively phased out antibiotic growth promoters, with the definitive ban entering into force on 1 January 2006. This regulatory measure stimulated increasing interest in the identification and evaluation of alternative feed additives, particularly phytochemicals and other plant-derived bioactive compounds. Phytochemicals are promising alternatives to antibiotic growth promoters, improving animal performance, nutrient availability, gut microbiota balance, immunity, and feed conversion ratio (FCR) efficiency. (Lillehoj et al., 2012; Gadde et al., 2017; Rahman et al., 2022). Phytochemicals can be used in solid, dry, and ground form or as extracts (crude or concentrated) and can also be classified according to the process used to obtain the active ingredients in essential oils (EOs)-which are lipophilic substances obtained by cold extraction or steam/alcohol distillation) and oleoresins (extracts derived from non-aqueous solvents) (Gadde et al., 2017). The main bioactive phytochemicals are polyphenols, whose composition and concentration vary with

plant source, origin, environmental conditions, storage, and processing. In recent years, phytochemicals have been used as natural growth promoters in ruminants, pigs, and poultry. A wide variety of herbs and spices (e.g., turmeric, thyme, oregano, rosemary, marjoram, garlic, ginger, green tea, black cumin, coriander, and cinnamon) have been used in poultry as alternatives to antibiotic growth promoters (AGPs) (Gadde et al., 2017; Stratakos et al., 2017). In addition to herbs and spices, various EOs (e.g., thymol, carvacrol, cinnamaldehyde, eugenol, coriander, star anise, ginger, garlic, rosemary, turmeric, basil, cumin, lemon, and sage) have been used individually or in the form of blends to strengthen animal health and performance (Gadde et al., 2017). A few studies have been reported the use of EOs in poultry diets. Thus, the use of thymol and star anise EOs improved FCR. Also, the use of turmeric alone or mixed with capsicum (bell pepper) (Lee et al., 2013; Kim et al., 2013; Moharreri et al., 2022) has led to an increase in the resistance of birds to enteric diseases such as coccidiosis and necrotic enteritis. A mixture of phytonutrients based on carvacrol, cinnamaldehyde, and Capsicum oleoresin has been shown to enhance innate immunity and reduce the adverse effects of enteric pathogens (Lee et al., 2010; Kim et al., 2019), being approved for the first time in the EU as a botanical feed additive to improve the growth performance of broiler chickens. It resulted in increased body weight (BW) and decreased FCR and mortality (Bravo et al., 2008; Kim et al., 2019). The beneficial promoting effects of phytochemicals are attributed to their antimicrobial and antioxidant properties. Additionally, their inclusion in the diet leads to the stabilization of the intestinal microbiota and the reduction of toxic microbial metabolites in the intestine due to their direct antimicrobial properties on various pathogenic bacteria, which leads to the relief of intestinal problems and immune stress, consequently improving growth performance (Kim et al., 2015). Another significant advantage of dietary phytochemical supplementation is its capacity to attenuate oxidative stress while enhancing antioxidant defense mechanisms in different tissues, thereby contributing to improved overall health status (Settle et al., 2014). In addition, phytochemicals exert notable immunomodulatory effects by stimulating the proliferation of immune cells, regulating cytokine responses, and promoting higher antibody titers (Lee et al., 2010; Lee et al., 2017). Recent meta-analytic evidence further strengthens these observations, demonstrating that curcumin supplementation significantly increases daily weight gain (DWG) and improves FCR, without affecting feed intake (FI), highlighting its role as an efficient natural growth promoter. Moreover, curcumin has been shown to enhance antioxidant defenses by increasing enzymatic activity and lessening lipid peroxidation markers (e.g., malondialdehyde and hydroperoxides), thereby mitigating oxidative stress in broilers (Hernández-García et al., 2025). Administration of mixtures of phytochemicals has been evidenced to exert synergistic effects in reducing the negative consequences of enteric infections.

For example, supplementing broiler chicken diets with a mixture of *Curcuma longa*, *Caspicum annuum* (pepper), and *Lentinus edodes* improved BW gain and increased serum profilin antibody titer, as well as decreased fecal excretion of oocysts of *E. acervulina*, compared to control chicks fed only a basal diet or a basal diet supplemented only with Capsicum plus Lentinus (Lee et al., 2010). In addition, a number of bioactive compounds of curcumin in turmeric, such as demethoxycurcumin, bisdemethoxycurcumin, and tetrahydrocurcuminoids (Kiuchi et al., 1993; Sadeghi et al., 2012; El-Saadony et al., 2023), have antioxidant, anti-inflammatory, and nematocidal activities (Alia et al., 2006), protective effects against mutagenicity and hepatocarcinogenicity induced by aflatoxins (Ahmadi, 2010; Dai et al., 2022), and against coccidiosis (Lee et al., 2010; Yadav et al., 2020). Although turmeric and curcumin have shown beneficial effects in humans and animals, their impact on intestinal morphology, metabolism, and nutrient absorption in broilers remains insufficiently explored.

Starting from these considerations, the objective of the present study was to evaluate the effects of supplementing the diet of broilers with turmeric powder on the morphology of the intestine, with the final aim of clarifying a new perspective on the possible mechanisms through which curcumin exerts its effects as a potential

promoter of their growth. In approaching this topic, we have considered the many advantages of using solid forms of plants, such as availability, easy and practical application, and lower costs compared to different EOs formulas.

## MATERIALS AND METHODS

### Experimental design and biological material

The experiment was carried out on 24 one-day-old male Ross 308 broiler chicks obtained from a local commercial hatchery. Upon arrival, the birds were randomly distributed into two experimental groups: a control group (LC) and a treated group (LTu). Each group consisted of 12 birds, arranged in two replicates of six chicks each. The broilers were maintained under controlled environmental conditions, with temperature, humidity, ventilation, and general management practices adjusted according to standard broiler-rearing requirements. The birds received a basal compound feed, while feed and drinking water were provided ad libitum throughout the experimental period. A continuous 24-hour lighting program was applied.

The growing period lasted for 42 days, divided into three phases: the starter phase from day 0 to 10, the grower phase from day 11 to 35, and the finisher phase from day 36 to 42.

Throughout the experimental period, feed and water were provided ad libitum. The birds received compound feed (CF) formulated according to the requirements of the main broiler growth phases. The starter feed contained 2850 kcal/kg metabolizable energy (ME) and 21.00% crude protein (CP), the grower feed contained 3050 kcal/kg ME and 19.00% CP, and the finisher feed contained 3080 kcal/kg ME and 17.20% CP.

From day 1 to day 42, the control group received the basal compound feed, whereas the experimental group was fed the same basal diet supplemented with 1% turmeric powder. Feed and water were provided ad libitum throughout the experimental period.

### Histomorphometric analysis of the intestine

At 42.5 days of age, the broilers were slaughtered following stunning, and small-intestine samples were collected immediately after evisceration. The tissue fragments were fixed in 10% neutral buffered formalin to preserve tissue architecture and prevent post-mortem degradation. Subsequently, the samples were processed according to standard histological protocols, embedded in paraffin, and sectioned at 5 µm using a Leica RM 2125 RT manual rotary microtome.

For the histological study, the sections were stained by the Mallory trichrome staining method (Bancroft, 1990). The mounting of the sections was done with Canada balsam (anhydrous medium). The histomorphometric analysis was carried out using an Olympus CX41 light microscope fitted with a 10× eyepiece and 10×, 40×, and 100× optically corrected objectives. Image acquisition and measurements were performed with Quick Photo Micro 2.2 software. The evaluated intestinal parameters were villus height, villus width, villus surface area, villus perimeter, and crypt depth. Villus height was defined as the linear distance between the villus apex and the villus–crypt junction. Villus width was measured at the central portion of the villus, whereas villus area and perimeter were obtained by tracing the villus contour. Crypt depth was determined as the distance from the crypt mouth to the muscularis mucosae.

### Statistical analysis

The statistical analysis of the results obtained by histomorphometry was carried out using the IBM SPSS 23 package (SPSS Inc., Chicago, IL, USA). All data was tested for normality using the Shapiro-Wilk test, and differences between the experimental variants were made with the Student test. Results were presented as the mean and standard error of the mean (mean±SEM), while the differences were considered to be statistically significant at $p<0.05$, respectively.

## RESULTS AND DISCUSSIONS

At the end of the growing period, the body weight of the chicks from the experimental group (LTu) was significantly higher at 2776.17±303.72 g (mean ± standard error of the mean) compared to that of the chicks from the control group (LC) at 2489.00±70.092 g, indicating a difference of approximately 10%. The broilers in the control group (LC) exhibited the lowest intake of combined feed throughout the experiment (4368.00±579.828 g), while the highest consumption of combined feed was

observed in the broilers in the experimental group (LTu) at 4726.00±14.14 g. In the experimental group (LTu), where the feed was supplemented with turmeric, a FCR of 1.72±0.009 was recorded, while the control batch registered a value of 1.81±0.447. The difference is 4.42%, with statistical significance ($p<0.05$) (Table 1).

In the control group (LC), broilers fed only the basal compound diet showed preserved intestinal mucosal architecture, with no apparent histological abnormalities or morphometric deviations observed in the examined sections (Figure 1 A, B).

Table 1. Effect of turmeric supplementation on BW, FI, and FCR in broiler chickens (mean ± standard error of the mean)

| Specification | LC | LTu | P values |
|---|---|---|---|
| BW (g) | 2489.89 ± 242.81[a] | 2776.17 ± 303.72[b] | p<0.05 |
| FI (g) | 4368.00 ± 579.83[a] | 4726.00 ± 14.14[b] | p<0.05 |
| FCR (kg CM/kg gain) | 1.81 ± 0.45[a] | 1.73 ± 0.01[b] | p<0.05 |

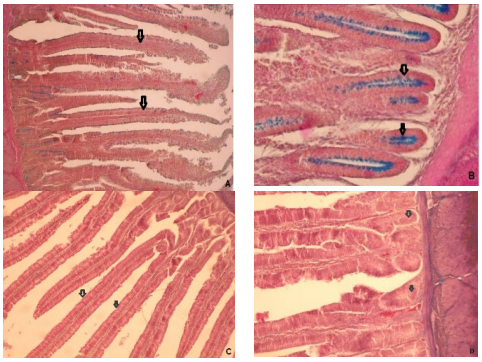


Figure 1. Intestinal mucosa: A, B - LC. intestinal villi (100x) and intestinal glands (200x) (arrows); C. D - LTu –intestinal villi (100x) and intestinal glands (200x) (arrows) (Mallory trichrome staining)

Intestinal villi resulted in an average height of 1245.82±152.08 µm, an average width of about 105.38±12.47 µm, a surface area of 108554.02±26761.47 µm$^2$, perimeter of 2642.97±254.92 µm and the average depth of the crypts was about 262.42±55.40 µm (Table 2). In individuals of the experimental group (LTu), supplementing the basic diet with 1% turmeric powder led to an increment of the intestinal villi (Figure 1C, D) and of the histomorphometric parameters, compared to the control group (LC). Thus, in LTu chickens, the height of the intestinal villi was 1794.21±315.52 µm, with an average surface of 242152.27±55309.69 µm$^2$ and a perimeter of 3624.32±644.82 µm, with significant differences between individuals from this group and the control group ($p<0.001$) (Table 2, Figure 2). The villi have a rectangular appearance; they have a much larger average width (150.64±20.04 µm), compared to the control group (LC), where the average width was 105.38 ± 12.47 µm. Between the two groups, the differences were significant ($p<0.001$) (Table2, Figure 2). Turmeric supplementation produced only a numerical increase in crypt depth, from 262.42 ± 55.40 µm in the control group to 278.97 ± 41.24 µm in the experimental group, without reaching statistical significance ($p>0.05$) (Table 2, Figure 3).

Table 2. Effect of turmeric dietary supplementation on height, area, perimeter, width of intestinal villus and crypts depth in 42-day-old broiler chickens (mean ± SD)

| Specification | N | LC 40 | LTu 40 | P values |
|---|---|---|---|---|
| Intestinal villus | Height (µm) | 1245.82 ±152.08[a] | 1794.21 ±315.52[b] | p<0.001 |
| | Area (µm$^2$) | 108554.02 ±26761.47[a] | 242152.27 ±55309.69[b] | p<0.001 |
| | Perimeter (µm) | 2642.97 ±254.92[a] | 3624.32 ±644.82[b] | p<0.001 |
| | Width (µm) | 105.38 ±12.47[a] | 150.64 ±20.04[b] | p<0.001 |
| Crypt depth (µm) | | 262.42 ±55.40[a] | 278.97 ±41.24[a] | p>0.05 |

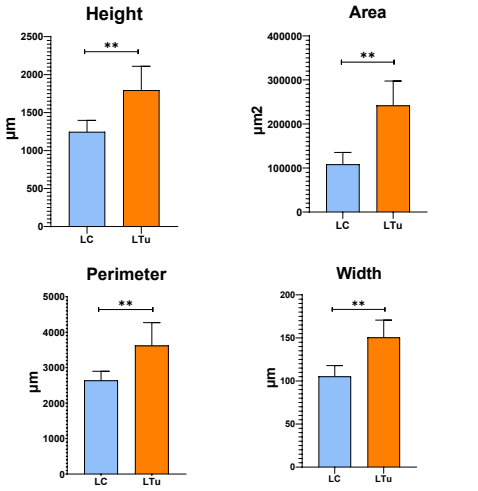



Figure 2. Graphic representation of the height, area, perimeter and width of intestinal villus at LC and LTu (**p<0.001)

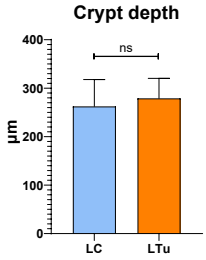


Figure 3. Graphic representation of the crypts depth at LC and LTu (ns – insignificant p>0.05)

Curcumin has been stated to have a number of biological activities, such as anti-inflammatory, antioxidant (Gandhi et al., 2011; Sharifi-Rad et al., 2020; Saadony et al., 2023) antimicrobial (Araujo and Leon, 2001; Sharifi-Rad et al., 2020; Saadony et al., 2023), anticoagulant, antidiabetic, and antiulcer (Kepinska-Pacelik et al., 2023).

Also, it could improve digestibility and metabolism, prevent biliary disorders and anorexia in humans and farm animals (Al-Sultan and Gameel, 2004; Chattopadhyay et al., 2004). Although various studies have been conducted on the use of turmeric and its active compounds, curcumin, as an antioxidant and immune enhancer in humans, animals, and broilers (Kumari et al., 2007; Gandhi et al., 2011; Sureshba et al., 2023), the effect of curcumin on intestinal morphology, as well as its association with metabolism and nutrient absorption, in broilers is a topic still being explored.

Numerous studies (Platel and Srinivasan, 2000; Durrani et al., 2006; Kumari et al., 2007; Hafez et al., 2022) showed that curcumin dietary supplementation has a significant positive effect on WG and feed efficiency at a marketable age (42 days), thus validating the positive effect of curcumin on broiler growth performance.

Recent studies have shown that curcumin supplementation enhances intestinal structure, improves gut barrier function, and modulates microbiota composition, thereby supporting nutrient absorption and immune response in poultry (Zhengyu Xu et al., 2024*)*.

These findings are consistent with recent evidence from the scientific literature, demonstrating that curcumin supplementation improves growth performance by increasing daily WG and reducing FCR ratio, while simultaneously enhancing intestinal morphology (↑ villus height and VH/CD ratio, ↓crypt depth) and antioxidant status (↑ SOD, CAT, GSH-Px; ↓ MDA), indicating improved nutrient absorption and reduced oxidative stress (Hernandez-Garcia et al., 2025*)*.

These findings are further supported by recent study indicating that curcumin acts as a multifactorial growth promoter by improving feed efficiency, modulating lipid metabolism, optimizing intestinal integrity, and exerting antioxidant, antimicrobial, and immunomodulatory effects, particularly under stress conditions (Fouad et al., 2025).

The results of our study show that supplementing the basic diet with 1% turmeric powder led to improvements in growth performance, FI, and FCR (kg NC/kg gain) in the individuals of the experimental group (LTu) related to the individuals of the control group (LC).

The efficiency on growth performance could be due to the larger surface area of intestinal villi (Raiput et al., 2013), and this positive effect is influenced by anti-inflammatory, antioxidant, and antibacterial activity (Chattopadhyay et al., 2004; Bondar et al., 2023) or the prebiotic-like effect of curcumin (Niamsa and Sittiwet, 2009). Also, Emadi and Kermanshahi (2007) reported that *Curcuma longa* improved FCR in broilers, and these beneficial effects could be due to augmented secretion of enzymes such as amylase, trypsin, chymotrypsin, and lipase (Platel and Srinivasan, 2000). Supplementation of the basic diet with curcumin causes a decrease in abdominal fat in a manner dependent on the concentration of curcumin, an aspect due to its influence on adipocyte apoptosis, or the withdrawal of glucose from the blood. De Beer (2008) believes that greater fat mobilization may be due to stimulation of the thyroid hormone T4. Dietary curcumin has been shown to lower cholesterol and stimulate fat digestion (Hong, 2022). Additionally, Gandhi et al. (2011) and Kumari et al. (2007) previously reported that curcumin significantly decreased total cholesterol, which could be due to inhibition of the active enzyme hepatic 3-hydroxyl-3-methylglutaryl CoA-reductase (HMGCR), which governs cholesterol synthesis in the liver (Galib et al., 2011). Thyroid hormones play an important role in the regulation of fat metabolism, and plasma concentrations of these hormones could be potential indicator of metabolic activity and physiological response in

commercially farmed birds (Melesse et al., 2011). Raiput et al. (2013) demonstrate that curcumin supplementation in broiler chicken diets led to increased intestinal villi height and width, which may be due to increased epithelial cell turnover in all segments of the small intestine. Consequently, the increase in intestinal villi is associated with mitotic activation of stem cells in the intestinal mucosal epithelium (Samanya and Yamauchi, 2002; Bondar et al., 2023). Intestinal epithelial cells are initially originated in the crypts and migrates along the surface of the villi upwards towards their tips.

In the present study, supplementing the basic diet of broilers with turmeric 1% led to an increase in the height ($p<0.001$) and width of the villi ($p<0.001$), their surface area ($p<0.001$), as well as the depth of the crypts ($p>0.05$).

Many studies have confirmed that the intestine can react morphologically and adapt by increasing the length and/or by increasing the height or decreasing the villi in response to external factors related to dietary changes (Žikic et al., 2008; Peric et al., 2010). The increase in the height of the villi enhances the absorption capacity of the intestinal mucosa, a consequence of the increase in the absorption surface, the expression of microvilli at the apical pole of the absorbing epithelial cells, and, implicitly, the nutrient transport systems at their level (Pluske et al., 1996; Rajput et al., 2013).

Crypt depth reflects the proliferative activity of the intestinal epithelium and is often associated with the rate of mucosal renewal. Increased crypt depth may occur when epithelial replacement is intensified, particularly under conditions involving villus epithelial loss, inflammatory stimulation, or pathogen-derived toxins. However, in the present study, the increase observed in the turmeric-supplemented group was numerical and not statistically significant, indicating that 1% turmeric powder did not induce a marked alteration of crypt architecture. This finding should therefore be interpreted as a mild morphometric tendency rather than a clear biological effect. In contrast, Rajput et al. (2013) observed a reduction in crypt depth in curcumin-supplemented broilers, which may indicate improved mucosal stability and a reduced need for epithelial regeneration. The potential beneficial effects of turmeric may also be linked to its role in digestive physiology, as turmeric supplementation has been reported to stimulate bile acid secretion and enhance the activity of digestive enzymes such as lipase, amylase, and proteases, which are directly involved in nutrient digestion and metabolic efficiency (Hong et al., 2022).

Curcumin also improves liver function and reduces serum triglycerides, LDL, and blood glucose concentrations (Emadi and Kermanshahi, 2007; Gandhi et al., 2011). However, Desphpande et al. (1998) reported decreased BW accompanied by hepatotoxic effects, expressed by focal necrosis, in mice and rats fed turmeric or an ethanolic extract of turmeric at high doses and for prolonged periods of time. Similar aspects are also described by Kandarkar et al. (1998), who mention processes of coagulative necrosis, accompanied by parenchymal regeneration, using turmeric or turmeric extract in doses considered necessary for anticancer activity.

## CONCLUSIONS

Adding turmeric 1% to broiler chicken diets resulted in expanded BW, FI, FCR ($p<0.05$), height, width, villi area perimeter ($p<0.001$), and crypt depth ($p>0.05$) in the experimental group (LTu) compared to the control group (LC). Villi size increases the intestinal mucosa's absorption capacity due to the absorption surface, microvilli at the apical pole of the absorbing epithelial cells, and implicitly, nutrient transport systems at their level. Increased intestinal villi are linked to mitotic activation of intestinal mucosa epithelium stem cells, resulting in deeper intestinal crypts. The histological changes and histomorphometric analysis of this study's data suggest turmeric may promote growth in broiler feed.

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