***Short Research Article***

# Effect of Turmeric (Curcuma domestica) and Multi-Enzyme Supplementation on the Production Performance of Broiler Chickens

## ABSTRACT

|  |
| --- |
| **Aims:**This study aimed to evaluate the effect of turmeric (*Curcuma domestica* Val.) powder and multi-enzyme supplementation on the production performance of broiler chickens, particularly focusing on feed intake, body weight gain, feed conversion ratio, and production index.**Study Design:** The experiment was conducted using a Completely Randomized Design (CRD) with five dietary treatments and five replications for each treatment.**Place and Duration of Study:** The field trial was conducted in a closed-house poultry facility located in Kalipare District, Malang, Indonesia, over a 35-day rearing period.**Methodology:** This study employed a Completely Randomized Design (CRD) with five treatments and five replications. A total of 300 day-old Lohmann MB202 P broiler chickens were randomly allocated into five dietary treatment groups: P0 (Control): without feed additive supplementation, P1: 0.3% turmeric powder + 0.01% multienzyme, P2: 0.6% turmeric powder + 0.01% multienzyme, P3: 0.9% turmeric powder + 0.01% multienzyme, and P4: 1.2% turmeric powder + 0.01% multienzyme. Each experimental unit consisted of 12 birds housed in a closed-house pen, resulting in a total of 60 birds per treatment group. All birds were reared for 35 days under standard commercial management practices with ad libitum access to feed and water. The basal diet was formulated to meet the nutritional requirements of broilers based on standards. Parameters measured included feed intake (g/bird), body weight gain (g/bird), feed conversion ratio (FCR), and production index (PI). Data were analyzed using one-way analysis of variance (ANOVA), and if significant differences were found (P<0.05) Duncan’s Multiple Range Test was used as a post hoc comparison.**Results:** The supplementation of turmeric and multi-enzyme did not significantly affect feed intake (P>0.05), which ranged from 3772.37 g (P4) to 3916.53 g (P0). However, highly significant effects (P<0.01) were observed on BWG, FCR, and PI. The best performance was recorded in P4, with the highest BWG (2491.99 g), the most efficient FCR (1.49), and the highest PI (488.18). In contrast, the control group (P0) showed the lowest values in all parameters: BWG (2151.85 g), FCR (1.79), and PI (347.31).**Conclusion:** The combination of 1.2% turmeric powder and 0.01% multi-enzyme significantly enhanced broiler production efficiency, particularly in terms of growth rate, feed conversion, and production index, despite not increasing feed intake significantly. These findings suggest that this combination is a safe and effective alternative to antibiotic growth promoters (AGPs) and is recommended for practical application in sustainable poultry production systems. |

*Keywords: Turmeric flour; multienzyme; villus height; villus surface area; villus number; broiler chicken; gut morphology.*

## 1. INTRODUCTION

Chicken meat stands as the most widely consumed source of animal protein among the Indonesian population. Consumers favor chicken meat due to its consistent availability in both traditional and modern markets, its relatively affordable price across socioeconomic groups, and its rich nutritional content. Chicken meat offers high-quality protein, B-complex vitamins, and essential minerals such as iron and phosphorus. Its sensory qualities, including a savory aroma, bright meat color, and tender texture, make it a popular choice across all age groups and cultural backgrounds. Data from the Directorate General of Livestock and Animal Health Services reported that chicken meat contributed 79.59% of the total national meat production. This figure far exceeds the contribution of beef and buffalo (11.16%), pork (5.74%), goat and sheep (2.43%), and other meats (1.07%) (Ditjen PKH, 2021). These numbers highlight the crucial role of the broiler poultry sector in maintaining national food security and a stable domestic supply of animal protein.

Broiler chickens represent a fast-growing meat-type poultry breed selectively developed for high production efficiency. Farmers rely on broilers due to their short production cycle and superior feed conversion capabilities. Within 28 to 45 days, a broiler can reach a market weight of 1.2 to 1.9 kg, which offers economic advantages through faster turnover and lower production costs per cycle. These traits position broilers as the backbone of Indonesia’s poultry industry (Akbar et al., 2022). Although intensive farming systems promote higher productivity, they also create environmental challenges. Crowded housing, poor ventilation, fluctuating temperatures, and high humidity levels impose physiological stress on broilers. These conditions impair feed intake, slow down body weight gain, increase feed conversion ratio (FCR), and reduce the production index (IP) (Zhao et al., 2024). Nutrition strategies that are adaptive, cost-effective, and based on natural ingredients are essential to maintain production performance under such conditions.

Four primary parameters are commonly used to evaluate broiler production performance: feed intake, body weight gain (BWG), feed conversion ratio (FCR), and production index (PI). Feed intake reflects appetite and physiological health, while BWG indicates the effectiveness of nutrient utilization for growth. FCR is a direct measure of production efficiency, as it calculates the amount of feed required to gain one kilogram of body mass. The production index is a composite indicator that considers BWG, FCR, and survival rate, serving as a summary of overall production efficiency. These four variables are interconnected. A disturbance in one parameter often causes a chain reaction affecting the others, ultimately reducing profitability. Farmers must manage all four components optimally to sustain productivity, improve margins, and maintain economic viability in commercial broiler operations.

Oxidative stress emerges as one of the key internal factors limiting broiler performance. Broilers have a naturally high metabolic rate that results in excessive production of reactive oxygen species (ROS) and reactive nitrogen species (RNS). These free radicals damage cellular membranes, proteins, and DNA, leading to reduced nutrient efficiency, impaired growth, and suppressed immune function (Fathi et al., 2024). Farmers must address oxidative stress through dietary interventions that enhance the body’s antioxidant defense system. Proper supplementation can help stabilize feed intake and BWG, reduce FCR, and improve the production index during the entire rearing period.

Antibiotic Growth Promoters (AGPs) were previously relied upon to stabilize intestinal microflora, improve feed efficiency, and boost growth performance. The Indonesian government officially banned the use of AGPs through Regulation No. 14/2017 in response to rising concerns over antimicrobial resistance and food safety. This policy shift forced producers to seek effective natural alternatives that deliver comparable performance without adverse long-term effects. Phytobiotics, or plant-derived feed additives, have gained popularity due to their antioxidant, antimicrobial, and anti-inflammatory properties. Turmeric (*Curcuma domestica* Val.) is one of the most promising local phytobiotics in Indonesia. This herbal plant contains curcumin, a bioactive compound with multiple physiological benefits. Curcumin plays a role in neutralizing free radicals and improving metabolic efficiency in broilers (El-Saadony et al., 2020). Feed supplementation with curcumin has also been shown to support growth rate and improve nutrient utilization efficiency (Samy et al., 2023).

Curcumin, however, suffers from low bioavailability in poultry digestive systems. Its lipophilic nature, combined with rapid metabolism in the liver and intestines, limits its absorption into the bloodstream. Most curcumin remains trapped within plant cell walls or bound to insoluble fibers that cannot be digested effectively by poultry (Hashem et al., 2022). Technological solutions like nanoencapsulation or lipid-based carriers may improve curcumin absorption, but they remain costly and impractical at the commercial farm level. Farmers require a more economical and applicable strategy to enhance the utilization of curcumin in broiler diets.

Digestive enzymes present a viable and affordable option for increasing the release and absorption of curcumin. Enzymes such as lipase, cellulase, and β-glucanase each play a specific role in improving digestion and enhancing the bioavailability of phytogenic compounds. Lipase promotes lipid breakdown, allowing curcumin to dissolve more effectively in the digestive tract. Cellulase breaks down plant cell walls, freeing curcumin from cellulose-rich matrices. β-glucanase hydrolyzes anti-nutritional polysaccharides that interfere with nutrient absorption (Selionova et al., 2025). The combination of these enzymes helps create an optimal intestinal environment for both curcumin absorption and overall nutrient digestion. This synergy is expected to support feed intake, accelerate body weight gain, reduce FCR, and improve PI under AGP-free conditions.

This study was designed to evaluate the effects of turmeric powder combined with a multi-enzyme blend on broiler production performance. The research focuses on four key parameters: feed intake, body weight gain, feed conversion ratio, and production index. The findings are expected to provide practical, natural alternatives to AGPs and contribute to the development of safer, more sustainable poultry nutrition strategies (Basiouni et al., 2023). The outcomes may also offer insights for future feed formulation practices that aim to balance productivity, efficiency, and animal health in modern broiler production systems (Chodkowska et al., 2024).

2. material and methods

**2.1 Study Design and Experimental Animals**

This experiment was arranged using a Completely Randomized Design (CRD) involving five dietary treatments and five replicates per treatment. A total of 300 Lohmann MB202 P broiler chicks aged one day were used. Each replicate consisted of 12 birds housed in a pen measuring 1 m × 1 m × 1 m, resulting in 60 birds per treatment group. All broilers were raised under closed house conditions following standard management practices. Feed and fresh water were provided ad libitum. A continuous 24-hour lighting program was applied during the first week to stimulate early feed intake. The birds were reared for a period of 35 days, from day 1 until day 35.

**2.2 Feed Preparation and Treatment Groups**

**2.2.1 Turmeric flour preparation**

Fresh turmeric rhizomes (Curcuma domestica Val.) were purchased from local markets in East Java. The rhizomes were cleaned, peeled, and sliced into thin pieces of approximately 2–3 mm thickness. The slices were dried in a hot-air oven at 60°C for 48 hours to reduce moisture content to about 10%. After drying, the turmeric was ground using a hammer mill and passed through a 60-mesh sieve to produce fine turmeric flour. The curcumin content was measured using High-Performance Liquid Chromatography (HPLC) and found to contain 3.2% curcumin.

**2.2.2 Multienzyme supplement**

The multienzyme used in this study consisted of lipase, cellulase, and β-glucanase, selected for their complementary functions in improving feed digestibility and enhancing the absorption of curcumin. Lipase facilitates the breakdown of triglycerides into free fatty acids and glycerol, supporting the solubilization and uptake of lipophilic compounds such as curcumin. Cellulase hydrolyzes cellulose in plant cell walls, enabling the release of curcumin that may be trapped within fibrous turmeric matrices. β-glucanase reduces intestinal viscosity by degrading β-glucan, a non-starch polysaccharide that can impair nutrient absorption. The enzyme blend was included not only to improve nutrient utilization but also to enhance the bioavailability of curcumin, thereby optimizing the functional impact of the turmeric–enzyme combination in broiler diets.

**2.2.3 Treatment groups**

* The broilers were divided into the following five dietary groups:
* P0 (Control): Basal diet without additives
* P1: Basal diet + 0.3% turmeric flour + 0.01% multienzyme
* P2: Basal diet + 0.6% turmeric flour + 0.01% multienzyme
* P3: Basal diet + 0.9% turmeric flour + 0.01% multienzyme
* P4: Basal diet + 1.2% turmeric flour + 0.01% multienzyme

The basal diet was formulated to meet or exceed the nutritional requirements of broiler chickens, according to the standards set by NRC (1994). In the starter phase (0–21 days), the feed contained 21% crude protein and 3,000 kcal/kg of metabolizable energy (ME), while the finisher phase (22–35 days) contained 19% crude protein and 3,100 kcal/kg ME. All diets were mixed thoroughly to ensure uniform distribution of turmeric and enzyme additives.

**2.3 Production Performance Observation**

Production performance assessment was conducted at the end of the 35-day rearing period. All birds were individually weighed on day 1 and again on day 35 to determine body weight gain. Feed intake was measured by calculating the difference between the total feed offered and the remaining feed in each pen, recorded daily for each replicate. Feed was provided ad libitum, and refusals were collected and weighed before each morning feeding. In cases of mortality, feed intake and weight gain were adjusted accordingly by accounting for the number of birds lost and their corresponding feed consumption. The experimental unit used for all calculations was the replicate pen (n = 5 per treatment), and data were expressed as averages per bird.

This evaluation focused on four key variables: feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), and production index (PI). These parameters were selected for their critical role in measuring broiler growth performance, nutrient efficiency, and economic productivity. Feed intake reflects feeding behavior and consumption ability, while body weight gain indicates growth potential under dietary treatments. FCR is a standard indicator of feed efficiency, and PI integrates all factors—including survival rate and age—to provide a comprehensive productivity score. All variables were calculated using standard equations to ensure comparability across treatments and replicates.

**2.4 Parameters Observed**

The following variables were assessed to determine the production performance of broiler chickens:

* **Feed Intake (g/bird)**: Feed intake was measured by subtracting the leftover feed from the total feed offered during the 35-day period. The result was divided by the number of birds in each replicate to obtain the average intake per bird (g/bird). Calculate using the formula:

Feed Intake = Feed Offered – Feed Refused

* **Body Weight Gain (g/bird)**: Measured Body weight gain was obtained by subtracting the initial weight on day 1 from the final weight on day 35. The average per bird was calculated for each replicate. Calculate using the formula:

Body Weight Gain = Final Body Weight – Initial Body Weight

* **Feed Conversion Ratio:** FCR was calculated by dividing the total feed intake by the total body weight gain. This ratio indicates feed efficiency, with lower values representing better conversion. Calculate using the formula:

FCR = Total Feed Intake (g/bird) / Body Weight Gain (g/bird)

* **Production Index (PI):** PI was determined by multiplying final body weight by survival rate, dividing it by the product of FCR and rearing age, and then multiplying by 100. This index reflects overall productivity, considering growth, survival, and feed use. Calculate using the formula:

PI = (Body Weight × % Survival) / (Feed Convertion × Rearing Period) × 100%

**2.5 Statistical Analysis**

All collected data were statistically analyzed using one-way Analysis of Variance (ANOVA) with SPSS version 25.0. The Shapiro-Wilk test was used to assess the normality of data distribution, while the Levene’s test evaluated variance homogeneity. If a significant difference was found (P < 0.05), post-hoc analysis was carried out using Duncan’s Multiple Range Test (DMRT). Results were presented as mean ± standard error of the mean (SEM).

3. results and discussion

**3.1 Feed Intake (FI)**

The data regarding the effect of turmeric and multienzyme supplementation on broiler feed intake are presented in Table 1. Feed intake during the rearing period showed variation among treatment groups. The average feed intake, ranked from lowest to highest, was as follows: P4 (3772.37 ± 130.55 g), P3 (3811.00 ± 145.62 g), P1 (3881.98 ± 168.21 g), P2 (3900.23 ± 172.80 g), and P0 (3916.53 ± 184.43 g). The analysis of variance (ANOVA) showed that the dietary combination of turmeric and multienzymes had no significant effect on feed intake (P > 0.05). The calculated F-value (1.757) was lower than both the 5% (2.87) and 1% (4.43) critical values. The control group (P0) had the highest feed intake, while the group receiving the highest combination of turmeric and enzyme supplementation (P4) had the lowest. Although not statistically significant, these differences may reflect a physiological response to feed characteristics. It is possible that unmodified feed (without additives) was more readily accepted due to its higher palatability. Birds may also require a period of adaptation when consuming feed containing additives, potentially reducing feed intake slightly during adjustment.

Overall, the results suggest that broilers were capable of consuming modified diets without experiencing a significant decline in intake. Individual variation in feed intake was relatively high, especially in the control group, with a standard deviation of ±184.43 g. This variation indicates that non-nutritional factors such as environmental conditions, health status, and individual feeding behavior also influenced daily intake. These findings align with Eko et al. (2020), who noted that broilers possess a strong physiological adaptability to changes in feed composition. According to Khatun et al. (2023), feed intake fluctuations are often not statistically significant but may still reflect responses to environmental factors such as temperature or adaptation-related stress during the early stages of rearing. Broilers are known to be highly sensitive to environmental changes, meaning external factors can play a crucial role in feed intake even when feed formulation remains constant.

Feed intake is influenced by feed palatability, metabolic activity, and gut health. The inclusion of turmeric, which contains active compounds such as curcumin, can alter the color and aroma of feed. These changes may lower the feed’s acceptability, especially if they are too pronounced. Hashem et al. (2022) reported that unfamiliar organoleptic properties can reduce sensory response to new feed formulations. On the other hand, multienzyme supplementation aims to improve nutrient digestion efficiency. The effectiveness of enzyme use depends on the compatibility between enzyme types and available feed substrates. Ceylan et al. (2024) emphasized that if a broiler’s digestive system is already sufficiently efficient, enzyme supplementation may not significantly affect feed intake.

The interaction between phytobiotics and enzymes is another critical factor in feed formulation. Tavangar et al. (2021) stated that the success of such combinations depends heavily on precise proportions and dosing. Improper combinations may cause antagonistic effects that negatively impact feed intake performance. These results are consistent with the findings of Chodkowska et al. (2022), who observed that feed intake remains stable when there are no drastic changes in the physical form or basic nutrient composition of the feed. Moniruzzaman et al. (2023) also highlighted that the effects of additive supplementation are more often observed in feed efficiency parameters (such as FCR) than in feed intake itself. Broilers are generally more responsive to the efficiency of nutrient utilization than to the total quantity of feed consumed.

In conclusion, feed intake data from this study suggest that broilers have a high adaptive capacity to changes in dietary composition. The relatively stable intake across all treatments indicates that the inclusion of turmeric and multienzymes did not significantly impair feed acceptability. Sari et al. (2023) noted that substantial changes in feed intake typically occur only when there are noticeable disruptions in physical feed appearance or the presence of substances that interfere with gastrointestinal function.

**3.2 Body Weight Gain (BWG)**

The research findings on the effect of turmeric and multienzyme supplementation in broiler diets on body weight gain (BWG) are presented in Table 1. The average BWG, ranked from lowest to highest, was as follows: P0 (2151.85 ± 137.84 g), P1 (2373.81 ± 96.68 g), P2 (2372.72 ± 49.38 g), P3 (2422.46 ± 70.14 g), and P4 (2491.99 ± 130.09 g). The analysis of variance (ANOVA) revealed that the F-calculated value of 7.72 exceeded the critical F-values at both the 5% (2.87) and 1% (4.43) significance levels. Thus, it can be concluded that the combination of turmeric and multienzymes had a highly significant effect (P < 0.01) on broiler BWG. The addition of turmeric and enzymes significantly enhanced broiler growth compared to the control group.

This improvement is likely attributed to several factors, including the curcumin and enzyme content in the feed, which improved metabolic efficiency and nutrient absorption, as well as antioxidant activity that suppressed oxidative stress, and enhanced physiological and immunological responses. The significant increase in BWG observed in the treatment groups demonstrates the synergistic role of phytobiotics and enzymes in supporting digestive function, improving intestinal morphology, and enhancing nutrient conversion into body mass. Favorable environmental conditions and the birds' ability to adapt to the feed formulation may have also contributed to optimal growth in the treated groups. Kilany and Mahmoud (2014) stated that the combination of curcumin and exogenous enzymes can enhance poultry growth performance by improving metabolic efficiency and stimulating immune responses. The BWG improvements in the treatment groups suggest that the synergistic interaction between curcumin’s antioxidant activity and enzyme effectiveness in increasing nutrient bioavailability directly contributed to broiler growth optimization during the rearing period.

Descriptive results indicate that treatment P4 produced the highest average BWG, reaching 2491.99 grams with a standard deviation of 130.09 grams. Treatments P3, P2, and P1 also showed high BWG values and belonged to the same statistical group based on Duncan’s multiple range test. These results confirm the consistent positive effect of feed additives on broiler growth. The control group (P0) recorded the lowest BWG (2151.85 grams) and was significantly different from all other treatment groups. Duncan’s test grouped P1 through P4 as statistical group “a,” while P0 was placed in group “b,” confirming a statistically significant difference. These findings are in agreement with Ruan et al. (2019), who reported that improvements in poultry BWG are closely related to enhanced nutrient absorption and increased detoxification and antioxidant gene activity. The current study supports this perspective, as the treated groups demonstrated superior physiological capacity to convert feed into body mass compared to the control.

Broiler BWG is strongly influenced by digestive efficiency, nutrient availability, environmental conditions, and the birds’ physiological and immune status. Abd El-Hack et al. (2021) explained that curcumin possesses potent antioxidant properties capable of enhancing metabolic activity and reducing oxidative stress in broiler tissues. Pan et al. (2022) added that digestive enzymes such as lipase, cellulase, and β-glucanase help break down complex compounds in feed into simpler, more absorbable forms, thereby increasing nutrient absorption in the intestines. Hernández-García et al. (2025) emphasized that the synergistic effects of phytobiotics and enzymes can improve the digestive system's efficiency, accelerate nutrient conversion, and reduce energy loss during metabolism. These physiological improvements, driven by additive supplementation, were likely the key factors behind the higher BWG observed in the treated birds.

This study is consistent with various previous reports highlighting the effectiveness of natural feed additives in supporting broiler growth. Yadav et al. (2020) noted that combinations of phytobiotics and antioxidants offer protection against oxidative stress and improve the physiological condition of poultry, thereby supporting tissue development. Li et al. (2023) reported that curcumin can enhance intestinal morphology by increasing villus height and surface area while also stimulating digestive enzyme activity. Hafez et al. (2022) further confirmed that curcumin is a safe and sustainable alternative to antibiotic growth promoters (AGPs) in modern poultry production systems.

**Table 1. Effect of turmeric flour and multienzyme supplementation on intestinal villus morphology in broiler chickens**

|  |
| --- |
| **Observation Variables** |
| **Treatment** | **Feed Intake (FI)** | **Body Weight Gain (BWG)** | **Feed Conversion Ratio (FCR)** | **Production Index (PI)** |
|  | **(gram/bird)** | **(gram/bird)** |  |  |
| P0 | 3916,53 ± 184,43 | 2151.85 ± 137.84b | 1.79 ± 0.15b | 347.31 ± 47.21c |
| P1 | 3900,23 ± 93,95 | 2373.81 ± 96.68a | 1.61 ± 0.08a | 431.49 ± 21.99b |
| P2 | 3881,98 ± 69,88 | 2372.72 ± 49.38a | 1.61 ± 0.06a | 428.01 ± 11.65b |
| P3 | 3811,00 ± 74,49 | 2422.46 ± 70.14a | 1.55 ± 0.06a | 447.05 ± 18.23ab |
| P4 | 3772,37 ± 34,47 | 2491.99 ± 130.09a | 1.49 ± 0.07a | 488.18 ± 49.79a |

**3.3 Feed Conversion Ratio (FCR)**

The research data regarding the effect of turmeric and multienzyme supplementation in the diet on the Feed Conversion Ratio (FCR) of broilers are presented in Table 1. The average FCR values of broilers, ranked from highest to lowest, were as follows: P0 (1.79 ± 0.15), P1 (1.61 ± 0.08), P2 (1.61 ± 0.06), P3 (1.55 ± 0.06), and P4 (1.49 ± 0.07). The results of the analysis of variance (ANOVA) showed that the dietary combination of turmeric and multienzymes had a highly significant effect (P < 0.01) on broiler FCR. The calculated F-value of 7.89 was greater than the F-table values at both the 5% significance level (2.87) and the 1% level (4.43). The broiler FCR values in this study were influenced by improvements in metabolic efficiency, digestibility, and nutrient utilization due to the addition of the turmeric–multienzyme combination in the feed. Curcumin functioned as an antioxidant and immunostimulant that supports physiological function, while the multienzymes assisted in breaking down complex feed compounds, thereby increasing the availability of energy and protein. The synergy between the two components significantly reduced FCR values, indicating improved feed conversion into body mass. Enhanced gut microflora, better mucosal integrity, and reduced digesta viscosity further supported digestion efficiency. Additionally, favorable environmental conditions and the birds' adaptability to the diet were also important contributing factors to the decreased FCR in the treatment groups.

The reduction in FCR among the treatment groups indicated improved physiological efficiency in converting feed into body weight. The lower FCR value in the P4 group suggested that the addition of turmeric and multienzymes effectively improved digestibility and nutrient utilization. The control group (P0) had the highest FCR value of 1.79 ± 0.15, indicating that broilers in this group required more feed to achieve the same weight gain. In contrast, the P4 group recorded the lowest FCR of 1.49 ± 0.07, reflecting the best feed conversion efficiency. This difference was confirmed by the results of Duncan's test, which showed that groups P1 to P4 belonged to the same statistical group, while P0 was significantly different. These findings demonstrate that the inclusion of turmeric and multienzyme combinations in feed had a positive effect on broiler growth performance through improved feed conversion efficiency.

Hashem et al. (2022) stated that phytobiotics have the ability to improve metabolic efficiency and support modulation of the digestive system, which ultimately accelerates nutrient conversion into body tissues. Ceylan and Bortoluzzi (2024) reported that the use of phytogenic feed additives can enhance digestive function and improve growth performance in broilers without increasing feed intake. Moniruzzaman et al. (2023) explained that nano-formulated curcumin has strong potential to improve nutrient absorption and reduce oxidative stress, directly supporting feed efficiency. Ogbuewu et al. (2020) mentioned that phytobiotics such as turmeric influence the balance of gut microbiota and strengthen the integrity of the intestinal mucosa, positively affecting nutrient absorption. Gharahveysi and Rezaeipour (2021) stated that exogenous enzymes such as β-glucanase and cellulase function to reduce digesta viscosity and increase the availability of metabolizable energy. These mechanisms explain how the addition of turmeric and enzymes can improve broiler physiological performance and support feed efficiency.

Khatun et al. (2023) reported that phytobiotic-based feed significantly improves metabolic efficiency and carcass quality while reducing FCR. Ahmed et al. (2018) stated that the proper inclusion of turmeric can act as a natural antioxidant and growth promoter that supports production performance. Yesuf et al. (2023) demonstrated that combining several herbal plants, including turmeric, produces a strong synergistic effect in enhancing feed conversion efficiency and accelerating broiler growth rates. The present study supports and reinforces these findings, as the low FCR values in the treatment groups reflect the successful use of natural additives in poultry feeding systems. The use of turmeric and multienzymes as feed additives not only provides physiological benefits but also contributes to production efficiency and the implementation of a healthy, natural, and sustainable poultry farming system.

**3.4 Production Index (PI)**

The research data regarding the effect of turmeric and multienzyme supplementation on the Production Index (PI) of broilers are presented in Table 1. The average PI values, ranked from lowest to highest, were P0 (347.31 ± 47.21), P2 (428.01 ± 11.65), P1 (431.49 ± 21.99), P3 (447.05 ± 18.23), and P4 (488.18 ± 49.79). Analysis of variance (ANOVA) showed that the calculated F-value of 11.61 was greater than the F-table values at the 5% (2.87) and 1% (4.43) significance levels. Therefore, it can be concluded that the dietary combination of turmeric and multienzymes had a highly significant effect (P < 0.01) on the broiler PI.

The PI in this study was influenced by the synergistic effect between curcumin's antioxidant and immunostimulant activity and the role of multienzymes in enhancing digestive efficiency and nutrient absorption. Increases in PI were aligned with higher body weight gain, lower FCR, and stable mortality rates, reflecting improved metabolism and physiological health. The combination of turmeric and multienzymes was proven to enhance feed utilization, improve gut condition, and strengthen the birds’ immune response, thereby supporting overall productivity. These effects were reinforced by favorable environmental conditions and the birds’ adaptability to the new feed formulation, positioning PI as a reliable indicator of the success of dietary additive treatments in intensive and sustainable production systems. Prihatiningsih and Sofjan (2024) stated that the combined use of phytobiotics and acidifiers can improve feed efficiency, reduce metabolic stress, and suppress pathogenic microorganisms in the digestive tract.

Descriptive data showed that the highest PI value was obtained in treatment P4 (488.18 ± 49.79), followed by P3 (447.05 ± 18.23), P1 (431.49 ± 21.99), and P2 (428.01 ± 11.65). The control group P0 recorded the lowest PI (347.31 ± 47.21). The high PI values in the treatment groups were positively correlated with increased body weight and reduced FCR, directly indicating improved production efficiency. Aljumaah et al. (2020) reported that turmeric and Curcuma xanthorrhiza-based phytobiotics in poultry diets significantly improved growth performance and feed efficiency, ultimately increasing PI without raising mortality. These relationships among performance parameters confirm that PI is a comprehensive indicator that is sensitive to changes in feed quality and physiological performance in broilers.

Production index is a composite indicator that integrates several key performance metrics, such as final body weight, feed conversion ratio, and mortality, thus reflecting overall production efficiency. The increase in PI among the treatment groups not only indicates optimal growth but also reflects physiological stability during the rearing period. Chaundhari et al. (2020) explained that phytobiotics work by suppressing pathogenic microbes and supporting natural digestive enzyme activity, thereby improving nutrient utilization. Attia et al. (2023) stated that multienzyme supplementation helps break down complex polysaccharides, increases nutrient bioavailability, and improves energy and protein availability. Nim et al. (2022) added that curcumin in turmeric also has immunostimulant and anti-inflammatory effects that support gut health and accelerate tissue recovery. The combined mechanisms result in enhanced metabolic efficiency and overall broiler performance, which is directly reflected in higher PI values.

The results of this study are consistent with several previous reports confirming the effectiveness of combining phytobiotics and enzymes in improving broiler production performance. Ehiedu et al. (2021) reported that supplementation with herbs such as turmeric and garlic significantly improved feed conversion efficiency and increased PI in broiler chickens. Galamatis et al. (2023) stated that combined phytobiotics significantly reduced physiological stress and enhanced nutrient absorption in the small intestine, contributing to higher poultry productivity. Sapsuha et al. (2022) emphasized that the use of functional nutrition strategies such as phytobiotics and enzymes is a sustainable and effective alternative to antibiotic growth promoters (AGPs) in modern poultry systems. The findings of this study support this approach by demonstrating that turmeric and multienzyme supplementation is not only safe but also effective in increasing broiler PI, making it a promising strategy for efficient and healthy intensive poultry farming.

## 4. CONCLUSION

This study concludes that the dietary inclusion of turmeric flour (*Curcuma domestica* Val.) combined with multienzyme supplementation had a highly significant effect on broiler production performance, particularly on body weight gain, feed conversion ratio (FCR), and production index (PI), while feed intake remained statistically unaffected. The improvement in growth performance was attributed to the synergistic action of curcumin as an antioxidant and the enzymatic breakdown of complex feed components, which enhanced nutrient absorption and metabolic efficiency. The treatment group receiving 1.2% turmeric flour and 0.01% multienzyme (P4) demonstrated the best performance, showing the highest body weight gain, the lowest FCR, and the highest production index, despite having the lowest feed intake. Therefore, it is recommended that this combination be used as a natural feed additive in broiler diets to replace antibiotic growth promoters, due to its proven effectiveness in improving production efficiency without compromising bird health, thus offering a sustainable solution for intensive poultry production systems.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that generative AI technologies have been used during the writing or editing of this manuscript.

**Details of AI usage:**

1. AI Technology Used: Claude Sonnet 4 (Anthropic) and ChatGPT (OpenAI)
2. Purpose: Assistance in discussion development and manuscript revision
3. Usage: Improvement of sentence structure, grammar, paragraph organization, and enhancement of scientific writing clarity

Statement: All scientific content, data, research results and conclusions remain the original intellectual work of the authors. AI was used solely for language improvement and structural editing, not for data analysis or research interpretation.

Ethical approval

This study does not involve human participants and thus ethical approval and informed consent are not applicable.

References

1. Abd El-Hack, ME, Alaidaroos, BA, Farsi, RM, Abou-Kassem, DE, El-Saadony, MT, Saad, AM, ... & Ashour, EA (2021). Dampak suplementasi ransum ayam pedaging dengan kurkumin biologis, nanopartikel seng, dan Bacillus licheniformis terhadap pertumbuhan, sifat karkas, indeks darah, kualitas daging, dan beban mikroba sekum. Hewan , 11 (7), 1878.
2. Ceylan, N., Bortoluzzi, C., Gunturkun, O., & Perez-Calvo, E. (2024). Efek komparatif muramidase dan fitogenik pakan terhadap kinerja pertumbuhan dan fungsi gastrointestinal ayam pedaging. *Poultry Science* , *103* (10), 104147.
3. Li, S., Wu, F., Zhao, M., Chen, B., & Chen, X. (2023). Effect of curcumin on growth performance, apparent nutrient digestibility, intestinal morphology, digestive enzyme activity, and antioxidant capacity in meat rabbits. Italian Journal of Animal Science, 22(1), 222–229.
4. Chodkowska, K. A., Abramowicz-Pindor, P. A., & Tuśnio, A. (2022). Effect of phytobiotic composition on production parameters, oxidative stress markers and myokine levels in broilers. Animals, 12(19), 2625.
5. Eko, P. M., Afolabi, K. D., & Enyenihi, G. E. (2020). Growth performance, carcass quality, organ weights, and hematology of broilers fed dietary turmeric (Curcuma longa L.) powder at different inclusion levels as a feed additive. Environment, 8, Article 10.
6. Ruan, D., Zhu, YW, Fouad, AM, Yan, SJ, Chen, W., Zhang, YN, ... & Zheng, CT (2019). Feed curcumin enhances intestinal antioxidant capacity in ducklings through modulation of gene expression of antioxidant and key detoxification enzymes. Poultry Science , 98 (9), 3705-3714.
7. Tavangar, P., Gharahveysi, S., Rezaeipour, V., & Irani, M. (2021). The efficacy of phytobiotic feed additives and toxin binders, both individually and in combination, on growth performance, blood biochemical parameters, intestinal morphology, and microbial population in broiler chickens exposed to aflatoxin B1. Tropical Animal Health and Production, 53(3), 335.
8. Hernández-García, P.A., Granados-Rivera, L.D., Orzuna-Orzuna, J.F., Vázquez-Silva, G., Díaz-Galván, C., & Razo-Ortíz, P.B. (2025). Meta-analysis of curcumin supplementation in broiler feed: growth performance, antioxidant status, intestinal morphology, and meat quality. *Antioxidants*, 14(4), 460.
9. Hashem, Y. M., Abd El‑Hamid, M. I., Awad, N. F. S., Ibrahim, D., Elshater, N. S., El‑Malt, R. M. S., Hassan, W. H., Abo‑Shama, U. H., Nassan, M. A., El‑Bahy, S. M., Samy, O. M., El Sharkawy, R. B., Algabri, N., & Elnahriry, S. S. (2022). Insights into growth‑promoting, anti‑inflammatory, immunostimulant, and antibacterial activities of Toldin CRD as a novel phytobiotic in broiler chickens experimentally infected with Mycoplasma gallisepticum. Poultry Science, 101(11), 102154.
10. Khatun, A., Das, S. C., Ray, B. C., Ahmed, T., Hashem, M. A., Khairunnesa, M., & Roy, B. C. (2023). Effect of phytobiotic supplementation on growth performance, breast meat quality, blood biochemical indices, and liver enzymes in broiler chickens. European Poultry Science, 87, 1–13.
11. Kilany, O. E., & Mahmoud, M. M. (2014). Turmeric and exogenous enzyme supplementation enhance growth performance and immune status of Japanese quails. World Journal of Veterinary Medicine, 4(3), 20–29.
12. Moniruzzaman, M., Kim, D., Kim, H., & Kim, N. (2023). Evaluation of dietary curcumin nanospheres as phytobiotics on growth and feed intake in broiler chickens. Frontiers in Veterinary Science, 10, Article 1127309.
13. Ogbuewu, I. P., Okoro, V. M., & Mbajiorgu, C. A. (2020). Meta-analysis of the effects of phytobiotic (pepper) supplementation on broiler performance. Tropical Animal Health and Production, 52(1), 17–30.
14. Pan, S., Yan, J., Xu, X., et al. (2022). Plant-derived polyphenol curcumin as a novel feed additive in livestock and poultry. International Journal of Molecular Sciences, 23(19), 11905.
15. Yadav, S., Teng, P.-Y., Santos, T. S., Gould, R. L., Craig, S. W., Fuller, A. L., … Kim, W. K. (2020). The effects of different doses of curcumin compound on growth performance, antioxidant status, and gut health of broiler chickens challenged with Eimeria species. Poultry Science, 99(11), 5936–5945.
16. Ahmed, I., El-Rayes, T., & Ahmed, A. I. (2018). Evaluation of turmeric (Curcuma longa) supplementation as a phytobiotic on broiler performance and bacterial count. Egyptian Journal of Nutrition and Feeds, 21(2), 519–528.
17. Attia, Y. A., Al-Harthi, M. A., & El-Shafey, A. S. (2020). Effect of timing and frequency of multienzyme supplementation on broiler performance efficiency and selected metabolic indicators. Animals, 10(3), 450.
18. Nm, J., Joseph, A., Maliakel, B., & Im, K. (2018). Supplementation of standardized turmeric extract (TurmaFEED™) in feed enhances growth performance and carcass quality of broiler chickens. *Journal of Animal Science and Technology, 60*(1), 8.
19. Chaudhari, D. K., Gautam, S., Singh, V. K., Devi, R., Singh, K. D., Singh, S. P., ... & Rao, S. (2020). Effect of herbal mixture, exogenous enzymes, and butyric acid supplementation on nutrient digestibility, carcass traits, and economic value of broiler chickens. Journal of Entomology and Zoology Studies, 8(2), 55–59.
20. Prihatiningsih, P., & Sjofjan, O. (2024). Pengaruh Penambahan Ampas Herbal Fermentasi sebagai Aditif Pakan terhadap Kualitas Internal Telur Puyuh (Coturnix coturnix japonica). Dalam BIO Web of Conferences (Vol. 88, hlm. 00014). EDP Sciences.
21. Aljumaah, M. R., Suliman, G. M., Abdullatif, A. A., & Abudabos, A. M. (2020). Effect of phytobiotic feed additives on growth traits, blood biochemistry, and meat characteristics of broiler chickens challenged with Salmonella typhimurium. Poultry Science, 99(11), 5744–5751.
22. Galamatis, D., Panitsidis, I., Mantzios, T., Sioutas, G., Stylianaki, I., Papadopoulos, E., ... & Giannenas, I. (2025). Evaluation of a natural phytogenic blend as a feed additive for broiler chickens: A study on animal performance, gut health, and antioxidant status after experimental infection with Eimeria spp. Poultry, 4(1), 4.
23. Sapsuha, Y., Suprijatna, E., Kismiati, S., & Sugiharto, S. (2021). Combination of probiotics and phytobiotics as an alternative to antibiotic growth promoters for broiler chickens – a review. Livestock Research for Rural Development, 33, Article 49.
24. Ehiedu, B. N., Ari, M. M., Yakubu, A., Alhassan, I. D., & Owie, P. A. (2024). Effects of garlic and turmeric as additives on growth performance, nutrient digestibility, and production economics of starter broiler chickens. Nigerian Journal of Animal Production, 51(3), 1–7.
25. Sari, T. V., Ginting, E. E., Hamdan, & Trisna, A. (2023, June). The effect of Allium sativum and Curcuma xanthorriza meal supplementation as phytobiotics in broiler feed on performance and feed economic value. In Proceedings of the 4th International Conference on Animal Science and Technology (ICAST 2021) (Vol. 2628, No. 1, Article 030024). AIP Publishing LLC.