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Phytogenic Turmeric–Ginger Blend Enhances Nutrient Digestibility and Enzyme Activity in Broiler Chickens

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Abstract. This study examined the effects of turmeric–ginger flour supplementation on the digestive enzyme activity of broiler chickens as a natural substitute for synthetic feed additives. The research was motivated by two major challenges in poultry production: the high cost of feed, which contributes to about 60–70% of total expenses, and the growing concern over antibiotic resistance. One hundred one-day-old Lohmann MB Platinum broilers were randomly divided into five groups, each with four replications, receiving 0%, 0.2%, 0.4%, 0.6%, and 0.8% supplementation levels. The birds were raised for 35 days in open cages with free access to feed and water. At the end of the trial, intestinal digesta from the duodenum to the ileum were collected, frozen at −70 °C, and analyzed using spectrophotometric methods to measure amylase, protease, and lipase activities with substrates including 4-nitrophenyl-α-D-glucopyranoside, azocasein, and Tris buffer systems. Results showed a significant dose-dependent increase ($P < 0.01$) in enzyme activity. The 0.8% treatment yielded the highest values: 105.90 ± 1.05 U/g for amylase, 421.42 ± 6.96 U/g for protease, and 260.70 ± 5.71 U/g for lipase, indicating enhanced digestive performance and nutrient utilization in broilers.

Keywords: Broiler, enzyme activity, ginger, mixture, nutrient digestibility, turmeric

Abstrak. Penelitian ini meneliti dampak pemberian tepung kunyit-jahe pada ayam broiler terhadap fungsi enzim pencernaannya, sebagai respons atas kebutuhan mendesak akan substitusi aditif pakan alami. Biaya pakan yang tinggi (mencapai 60–70% dari total biaya produksi peternakan ayam) dan kekhawatiran yang meningkat mengenai resistensi antibiotik menjadi pendorong dilakukannya studi ini. Sebanyak 100 ekor ayam broiler Lohmann MB Platinum berumur satu hari digunakan dalam desain acak. Mereka dibagi menjadi lima kelompok perlakuan, masing-masing dengan empat replikasi: suplementasi 0%, 0,2%, 0,4%, 0,6%, dan 0,8%. Ayam-ayam tersebut dipelihara dalam kandang terbuka dengan akses pakan dan air minum tidak terbatas selama masa percobaan 35 hari. Hasil penelitian, di mana digesta usus dikumpulkan dari duodenum hingga ileum, segera dibekukan pada suhu -70 °C dan dianalisis menggunakan metode spektrofotometri untuk mengukur aktivitas amilase, protease, dan lipase. Prosedur biokimia standar melibatkan 4-nitrophenyl-α-D-glucopyranoside untuk amilase, azocasein untuk protease, dan sistem buffer Tris untuk lipase. Hasilnya menunjukkan peningkatan signifikan ($P<0,01$) pada semua aktivitas enzim seiring dengan kenaikan dosis. Pada kelompok suplementasi 0,8%, kadar enzim mencapai puncaknya: Amilase: 105,90±1,05 U/g, Protease: 421,42±6,96 U/g, Lipase: 260,70±5,71 U/g. Peningkatan kecernaan juga terjadi pada level pemberian 0,8 % tepung campuran kunyit dan jahe pada pakan ayam broiler.

Kata kunci: Aktivitas enzim, ayam pedaging, jahe, kunyit, campuran, kecernaan nutrient

Introduction

Feed in the livestock business is generally costly, amounting to around 60-70% of the total production cost. The key to optimizing production cost is through feed efficiency, which can be achieved by optimizing digestive tract functions and eventually increasing the livestock's productivity. With this in mind, it is crucial to develop feeding methods that are not only cost-effective but also supportive of the poultry digestive system. Recent studies have shown that increasing digestive enzyme activity can significantly increase feed conversion in broiler chickens by up to 15% (Nursiam et al., 2022; Li et al., 2021). However, problems arise because Indonesia's tropical climate is an ideal environment for the growth of various enteric pathogens (Kpomasse et al., 2021). It also poses a significant threat to gut health and livestock performance.

Indonesia is a tropical country with an environment and weather that support the

growth of pathogenic microorganisms, which can reduce livestock production (Kurnia et al. 2019). In general, farmers use feed additives, both natural and synthetic, to mitigate disease and optimize the digestive tract of livestock (Kurnia et al., 2024). However, synthetic feed additives have become less preferred due to the adverse effects when consumed excessively. Therefore, farmers consider using natural feed additives (Fonseca et al., 2024), such as turmeric and ginger.

The use of turmeric flour (*Curcuma longa*) and ginger (*Zingiber officinale*) as natural feed additives aligns with the global trend toward reducing AGP use in broilers (Purwanti et al., 2015). Studies have shown that both ingredients can improve performance, gut health, and metabolic status, but the effects depend strongly on the dose, form (flour vs. extract), and administration method (as is or combined). Studies have reported that the dose of turmeric flour generally ranges from 0.5 to 1% in rations to induce benefits, including increased body weight, daily weight gain, and lower FCR. Some studies conclude that a 0.5–0.75% dosage is most biologically and economically beneficial (Kafi et al., 2017; Bouchama et al., 2024; Joshi et al., 2021). Other research reports that supplementing 0.5–1% powdered ginger into feed can lower triglycerides, cholesterol, and liver enzymes and improve intestinal morphology and microbiota composition, although not as consistently as those of turmeric extract (Bouchama et al., 2024; Joshi et al., 2021; Jarić et al., 2025). The combination of turmeric and ginger powder (e.g., 0.5% + 0.5% or 0.75% + 0.75%) tends to result in performance equivalent to or slightly below that of a single turmeric but maintains meat protein conversion and gastrointestinal health (Kafi et al., 2017; Bouchama et al., 2024; Widjastuti et al., 2020).

Accordingly, the dosage of 0.5–1% turmeric flour and 1% of the turmeric-ginger mixture appears to be the proper percentage to substitute AGP, with continued focus on bioactivity stability during feed manufacturing and on the release of active compounds in the small intestine. The mechanism includes the antioxidant and anti-inflammatory activity of curcumin and 6-gingerol and stimulation of the secretion of digestive and bile enzymes, as well as modulation of the intestinal microbiota and intestinal barrier integrity (Kacena, 2025; Kouvedaki et al., 2024; X. Chen et al., 2022; Chen et al., 2024; Yadav et al., 2020; Xu et al., 2024). Essential oils and their phenolic compounds inhibit pathogenic bacteria, improve villi height and villi: crypt ratios, and increase the expression of nutrient transporter and tight junction genes, thereby supporting absorption efficiency (Chavira et al., 2024; Kouvedaki et al., 2024; Jarić et al., 2025; Yadav et al., 2020; Xu et al., 2024). However, excessive doses or concentrated phytobiotic–probiotic mixtures can reduce palatability and bind minerals, thereby reducing performance (Tasya et al., 2025).

Materials and Methods

Location and Time of the Study

This research was conducted at UD. Puncak Jaya, Bareng District, Jombang Regency. The research was conducted for one month, from October 2024 to November 2024. Temperature: 26 – 30°C and humidity: 75 – 83%.

Research Materials

In this study, 100 DOC strain Loghman MB platinum broiler chickens were used, and they were produced by PT. Multibreeder Adhiramareared 1-35 days in an open cage house. Feed and drinking water were supplied. Other equipment and materials were a 1,200-g O'Haus scale with a precision of 0.05 grams, a hygrometer, a digital scale, and plastic bags. Hygiene equipment included brooms, rags, and buckets. The tools for proximate analysis of feed materials were 4-nitrophenyl-α-D-glucopyranoside, phosphate buffer pH 7, glucose oxidase-peroxidase aminoantipyrine,

peroxidase, phosphate buffer saline, phosphate buffer, glucose oxidase, Na-bicarbonate, azocasein, $NaHCO_3$ 1% (pH 8.3), Aquadest, azocasein sulfanilamide reagent, fat-free casein, $NaHCO_3$, sulfanilamide, NaOH 5 N, $NaNO_2$, HCl 5 N, Buffer-Tris (pH 8.8), sodium dodecyl sulfate, eserine salicylate, albumin, Triton X-100, and hydrochloric acid.

Research Design

This research used an experimental method. Data were analyzed using ANOVA. If there were differences in treatment, they were analyzed using the Duncan multiple range test with 5 treatments and 4 replicates *of the* treatments in the study, which are as follows:

P1: Basal feed without flour addition (turmeric - ginger)
P2: Basal feed + flour (turmeric - ginger mixture) 0.2 %
P3: Basal feed + flour (turmeric - ginger mixture) 0.4 %
P4: Basal feed + flour (turmeric - ginger mixture) 0.6 %
P5: Basal feed + flour (turmeric - ginger mixture) 0.8 %

Research Procedure

Feed Additives

We used natural feed additives made of turmeric-ginger powder in the Figure 1 process. The turmeric and ginger were washed in running water and let dry in a covered area out of direct sunlight for 48 hours. After that, the ingredients were pulverized using a grinder to 100–125 µm. The ratio of turmeric and ginger was 1:1.

Research Feed

This study used basal feed and natural feed additives, with basal feed adjusted to the needs of broilers in each phase. The feed was given at 120 gr/day and drinking water was provided ad libitum. The composition of broiler basal feed for the starter and finisher periods is presented in Table 1. The nutrient content of basal feed based on 100% dry matter can be seen in Table 2, while the content of bioactive compounds mixed with turmeric and ginger is illustrated in Table 3.

Procedure for taking chyme from broiler chickens (Bisswanger, 2014).

The chickens in each pen of each treatment were selected and slaughtered based on an average of relatively similar body weight. The total number of chickens slaughtered was 20. Intestinal digesta (chyme) from each replication of each treatment was taken to analyze the activity of all enzymes, including amylase, protease, and lipase. The intestinal contents were taken from the small intestine, from the duodenum to the ileum. Digesta samples were stored directly at -70°C until use.

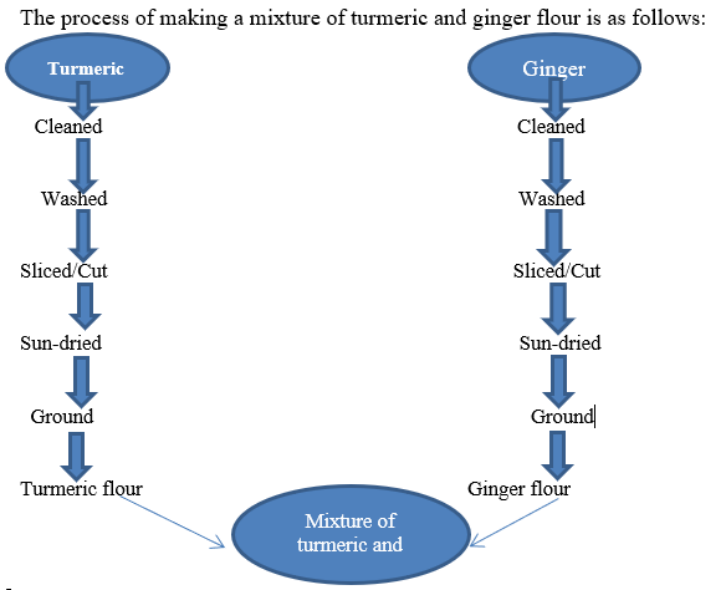


Figure 1. The process of making a mixture of turmeric and ginger flour

Table 1. Composition of starter and finisher basal feed

Feed Ingredients	Starter (%)	Finisher (%)
Corn	60.00	60.00
Concentrate 36	40.00	30.00
Bran	-	10.00

Table 2. Nutrient content of basal feed based on 100% dry matter

Nutrient content	Starter (%)	Finisher (%)
Metabolic energy (Kcal/kg)	3,022	3,058
Crude protein (%)	24.05	19.79
Crude fat (%)	4.77	5.63
Crude Fiber (%)	3.91	4.11
Ash (%)	7.27	5.34

Remarks: Based on the results of a proximate analysis from the Nutrition and Animal Feed Laboratory, University of Brawijaya, Malang (2009)

Table 3. The content of bioactive compounds mixed with turmeric and ginger

Flour	Level				
	0 %	0.20 %	0.40 %	0.60 %	0.80 %
Essential oils	0 %	0.03 %	0.06 %	0.08 %	0.11 %
Curcumin	0 %	0.23 %	0.46 %	0.68 %	0.91 %
Oleoresin	0 %	0.04 %	0.09 %	0.13%	0.18%

Source: Soewignyo (2009)

The sample was weighed ± 1 g, and 8 mL of Phosphate Buffer Saline (PBS) was added, homogenized, and left for 1 hour at 4°C. The next step was centrifugation at 3,000 rpm for 10 minutes (using a centrifuge at -4°C), and the supernatant was removed for analysis. The supernatant obtained was the crude extract of enzymes that would be used in the analysis of amylase, protease, and lipase enzyme activities. The small intestine sample was in the solid form, so we converted the results from units/dl to units/g in all analyses of enzyme activities.

The activity of amylase enzymes was analyzed in two steps

1. Reagent 1 (R1), consisting of 20 mM 4-nitrophenyl-α-D-glucopyranoside, was mixed with 1.0 ml of 0.1 M phosphate buffer (pH 7), and then the mixture was heated at 37°C for 5 minutes. Reagent 2 (R2) consisted of phosphate buffer (pH 7) 250 mmol/l, glucose oxidase 10 ku/l, phenol 5 mmol/l, peroxidase 10 ku/l, and 4-aminoantipyrine 0.5 mmol/l.
2. Then, 1:1 ml of reagent R1 was added to 0.5 ml of the broiler small intestine chyme sample. The reaction was carried out at 37°C for 30 minutes, then 0.25 ml of R2 was incorporated, the mixture was homogenized, and it was left at room temperature for 20 minutes. Its absorbance was determined by measuring the color change until the spectrophotometer reading at 400 nm reached 1.0 in units/dl.
3. After analyzing the amylase enzyme activity, we converted the result from units/dl to units/g with the formula below:

$$Amylase\ activity\ = \frac{Amylase\ activity\ \left(\frac{Units}{dL}\right) \times 2\ ml}{sample\ weight} x100$$

The protease enzyme activity test is conducted in two stages

1. We used substrate solution (R1) reagent, which contained 25 mg of azocasein and 5 mg of Na-bicarbonate per ml. The reagent was prepared by dissolving 2.5 g of azocasein in 50 ml of 1% $NaHCO_3$ solution (pH 8.3), stirring it at 60°C, and diluting it with water until the volume was 100 ml. The substrate was then stored at 0°C. The sulfanilamide azocasein

(R2) reagent consisted of Reagent A and Reagent B with a ratio of 1:1, where Reagent A, containing 50 g of fat-free casein, was dissolved in 1 liter of aqueous solution and 10 g of $NaHCO_3$. Reagent B contained 5 g of sulfanilamide in 200 mL of aqueous solution and 6 mL of 5 N NaOH and 2.2 g of $NaNO_2$. After stirring, 18 mL of 5 N HCl was added.

2. In the next stage, 1 mL of substrate solution (R1) and 100 microliters of chyme samples were added, homogenized, and incubated for 30 minutes at 37°C. Then, 250 microliters of R2 reagent was added, the solution was homogenized, and it was let sit for 5 minutes. Subsequently, the purple color at 546 nm was measured using a spectrophotometer.
3. After that, the protease enzyme activity in units/L was converted to units/g in the formula as follows:

$$\text{Protease activity} = \frac{Protease\ activity\ (units/dL) \times Volume}{\text{Sample mass}} \times 100$$

The lipase enzyme activity test procedure was carried out in the following stages

1. Reagent 1 (R1) consisted of a mixture of Buffer - Tris (pH 8.8) with 0.12 Molar Sodium Dodecyl Sulfate, 2 mM (millimolar), Eserine Salicylate 0.03 mM, and albumin 7.0 mg/ml. Reagent 2 (R2) consisted of 0.6 – 0.8% Triton X-100 in 16.5 mM hydrochloric acid.
2. In the first procedure, 1 milliliter of R1 was added to 20 microliters of the sample and incubated at 37°C for 20–30 minutes. The reaction was stopped with 0.2 mL of R2, and the absorbance was measured at 367 nm
3. After testing the activity of the lipase enzyme in units/l, we converted it to units/g in the following calculations:

$$\text{Lipase activity: } \frac{Lipase\ activity\ (unit/L) \times Volume\ extract}{\text{Sample mass}}\ x\ 1000$$

Determination of Apparent digestibility

Apparent digestibility of dry matter, crude protein, crude fat, and organic matter was determined using the total collection method during the last three days of the trial. Feed offered and excreta were weighed, oven-dried, and analyzed for proximate composition using AOAC (2005) procedures.

$$\text{Digestibility (\%): } \frac{Nutrient\ intake - Nutrient\ excreted}{Nutrient\ intake}\ x\ 100$$

Results and Discussion

Based on the data in Table 4, statistical analysis shows that the administration of the turmeric and ginger mixture significantly increased ($P < 0.01$) the activity of amylase, protease, and lipase enzymes in the small intestine of broiler chickens. In general, the average values of these enzymes continued to increase with the treatment levels from P1 to P5. These are expressed in the superscript letters (a, b, c, d, e) in each column, indicating statistically significant differences between treatment groups with a confidence level of 99%.

For the amylase enzyme, the highest activity was achieved by treatment P5 (105.90 ± 1.05 Units/g), although it was not significantly different from that of P3 and P4 statistically. For protease enzymes, each treatment level provided a very consistent and significantly different increase, with P5 producing the most optimal enzyme activity (421.42 ± 6.96 Units/g). Meanwhile, in lipase enzymes, a significant increase occurred up to level P4, but no significant difference was found between P4 and P5 (both with superscript d), indicating that lipase activity began to stabilize at that high dose. Overall, these data prove that the essential oil, curcumin, and oleoresin content in turmeric and ginger effectively stimulate digestive enzyme secretion in chickens.

The results indicated that the higher the level of use of the turmeric and ginger mixture, the higher the activity of the amylase enzyme. This effect was attributed to the increasing content of essential oils, curcumin, and oleoresins as the levels increase.

Table 4. Enzyme activity of amylase, protease, and lipase in the small intestine of broilers

Treatment	Variables: Enzyme activity		
	Amylase (unit/g)	Protease (unit/g)	Lipase (unit/g)
P1	40.22± 0.68[a]	199.21 ± 7.92[a]	145.51 ± 10.11[a]
P2	61.16 ± 1.15[b]	258.10 ± 7.47[b]	204.56 ± 7.84[b]
P3	82.36 ± 1.34[c]	297.14 ± 9.17[c]	229.85 ± 3.95[c]
P4	87.70 ± 25.13[c]	384.21 ± 8.33[d]	247.30 ± 1.99[d]
P5	105.90 ± 1.05[d]	421.42 ± 6.96[e]	260.70 ± 5.71[d]

Remarks: Different superscripts (a-e) on the same columns show a highly significant effect (P<0.01)

Other studies also support that the addition of turmeric and ginger to chicken feed increases the activity of digestive enzymes (amylase, protease, lipase). Besides containing essential oils, ginger also contains two important digestive enzymes: protease and lipase. Protease breaks down protein, while lipase breaks down fat (Natsir et al., 2016; Harmoko et al., 2020; Irwani et al., 2021).

Activity of the amylase enzyme

Based on Table 4, the inclusion of a turmeric and ginger flour mixture exerts a highly significant effect (P<0.01) on amylase enzyme activity in the small intestine of broilers, with activity levels increasing in direct correlation with the dosage of the herbal supplement. The highest amylase enzyme activity in the treatment with the use of a mixture of turmeric and ginger flour was P4 (105.90 ± 1.05 units/g), followed by P3 (87.70 ± 25.13 units/g), P2 (82.36 ± 1.34 units/g), P1 (61.16 ± 1.15 units/g), and P0 (40.22 ± 0.68 units/g), which was the lowest in the treatment without the use of a mixture of turmeric and ginger flour. These results show that the higher the level of use of a mixture of turmeric flour and ginger, the higher the activity of the amylase enzyme in the small intestine of broilers. This is consistent with the findings of Winarshih (2002), which showed that adding turmeric powder (*Curcuma domestica*) to the feed of two- to six-week-old Arab roosters at levels of 0.8%, 1%, and 1.2% increased the activity of lipase, amylase, and protease enzymes (Septiana et al., 2023). According to Natsir et al. (2016), adding ginger powder (*Zingiber officinale*) to the feed of young roosters at different concentrations of 3%, 6%, and 9% increased amylase enzyme activity. When considering the use of herbal supplements in poultry diets, it is important to note that results may vary depending on breed and environment, which may influence how effectively dietary interventions work (Solichaedi, 2001).

The increasing activities of the amylase enzyme in the small intestine of broilers may be due to enzyme products added to the feed given to chickens and also the presence of essential oils in ginger that are efficacious in regulating the release of stomach acid so that it is not excessive and reducing the intestinal work that is too heavy in digesting food substances (Darwis et al., 1991).

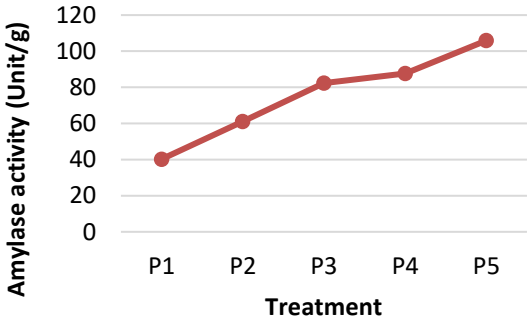


Figure 2. Graph of the effect of using a mixture of turmeric and ginger in the form of flour on the activity of the amylase enzyme

The essential oils in turmeric and ginger can help regulate stomach acid levels, preventing overproduction and insufficient stomach acid. This causes the contents of the stomach to be less acidic, so when the contents of the stomach enter the duodenum, the pancreas is stimulated to secrete to the duodenum to lower the acidity of the chyme faster and change it to a suitable pH state to be forwarded to the small intestine

for absorption (Praseno et al., 1992). Priyanti (2006) stated that a decrease in the pH of the digestive tract will stimulate the production of endogenous enzymes and increase the digestion of food substances such as carbohydrates, proteins, and fats. The intestinal and pancreatic mucosa produce endogenous enzymes, which are essential for converting food into absorbable components. For example, the breakdown of fats and carbohydrates depends on pancreatic lipase and amylase (Sitrin, 2014). Changes in pH within the digestive tract can trigger the synthesis of these enzymes, indicating the presence of a feedback mechanism that enhances digestive efficiency (Ksenofontov & Ksenofontova, 2022).

Protease enzyme activity

Based on Table 4, the inclusion of a turmeric and ginger flour mixture exerts a highly significant effect ($P < 0.01$) on protease enzyme activity, showing a clear linear increase as the dosage levels rise. The highest protease activity was recorded in the P4 treatment (421.42 ± 6.96 units/g) at a 0.8% inclusion level, while the lowest activity occurred in the P0 control group (199.21 ± 7.92 units/g). This positive correlation, further visualized in Figure 3, demonstrates that higher levels of the herbal mixture effectively stimulate protease secretion, thereby potentially enhancing protein degradation and nutrient absorption in the small intestine of broilers.

Based on Figure 3. The activity of protease enzymes increases with the dosage of turmeric-ginger flour. This is because the bioactive substances in the treatment of turmeric and ginger mixtures increase for each level, such as curcumin or essential oil oleoresin. The percentage of active substance content will increase with the dosage. The highest protease enzyme activity in the treatment of the turmeric and ginger flour mixture was in the P4 treatment (421.42 units/g), followed by P3 (384.21 units/g), P2 (297.14 units/g), P1 (258.10 units/g), and P0 (199.21 units/g), as can be seen in Table 4. This is due to the presence of chyme as a mechanical stimulant for the digestive system, directly related to the synthesis and secretion of enzymes.

The maximum amylase and protease enzyme activities were at pH 6–7. It is consistent with the characterization of digestive enzymes in several fish species and other animals, which show an amylase optimum pH of around pH 6–7.5 and alkaline protease around pH 8–10, i.e., in chyme conditions that are not too acidic so that digestive enzyme activity can be optimal (Champasri et al., 2021; Palomera et al., 2024. Essential oils are known to have various biological activities that affect the central and autonomic nervous systems, including antistress, anxiolytic, and analgesic properties; modulation of sympathetic-parasympathetic activity; and changes in heart rate, blood pressure, cortisol levels, and cognitive function through the olfactory and blood circulation pathways (Lizarraga-Valderrama, 2021; Soares et al., 2022; Dobetsberger and Buchbauer, 2011).

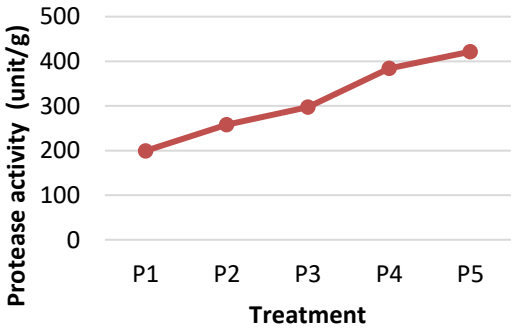


Figure 3. Graph of the effect of using a mixture of turmeric and ginger flour on protease enzyme activity

Several essential oils and their aromatic compounds have been shown to regulate appetite by increasing or decreasing feed intake through modulation of the hormone leptin, sympathetic/parasympathetic nerve activity, and mRNA expression of neuropeptide Y (NPY), AgRP, POMC, and CART in the hypothalamus so

that pleasant aromas can act as appetite stimulants (Nguyen et al., 2023).

Lipase enzyme activity

Figure 4 shows a graph of the effect of using a mixture of turmeric flour and ginger on the activity of lipase enzymes, where the higher the level of use of a mixture of turmeric and ginger flour, the higher the activity of lipase enzymes. This follows the observation of Samadi (2004) that the addition of essential oils and the like in animal feed can increase livestock productivity. The content of essential oils, curcumin, or oleoresins increases in amount with the increasing level of giving a mixture of turmeric and ginger flours. Benefits of Essential Oils and Livestock Productivity: Essential oils can increase the fatty acid content in milk and meat, resulting in higher-quality products.

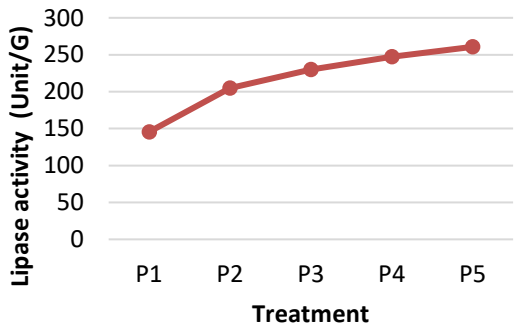


Figure 4. Graph of the effect of using a mixture of turmeric flour and ginger flour on the activity of lipase enzymes

They alter the fermentation process in the rumen, which affects the fatty acid composition of animal products (Khattab and Elgandy, 2024). Impact of Turmeric and Ginger: Research indicates that the inclusion of turmeric and ginger powder in livestock feed significantly influences immunological responses, enhances meat quality, and affects the slaughter weight of chickens (Suanta et al., 2021). According to research, meat quality and overall production increase with higher doses of supplementation. Impact on Livestock: Although there were no significant changes in weight gain, research conducted on Kaur cattle showed that adding ginger and turmeric to their feed can increase production (Zulpadly & Meitasari, 2024).

The percentage of bioactive substances in the mixture of turmeric and ginger flour for each level of treatment is presented in Table 3. The activity of lipase enzymes was the highest in the treatment with the use of a mixture of turmeric and ginger flour, namely in the P4 treatment (260.70 units/g), followed by P3 (247.30 units/g), P2 (204.56 units/g), and P1 (145.51 units/g), and the lowest was in the control treatment without turmeric flour and ginger, P0 (145.51 units/g). The increase in broiler production occurs through the creation of a suitable environment for the development of beneficial bacteria. A favorable environment for the growth of certain bacteria can activate and stimulate endogenous enzymes such as amylase, protease, and lipase enzymes that result in increasing the digestibility of nutrients and feed consumption for growth, production, and reproduction. The higher the level of turmeric and ginger powder in broiler chicken feed, the higher the activity of lipase enzymes in the broiler chicken's small intestine.

Table 5. Effect of Turmeric–Ginger Flour Supplementation on Nutrient Digestibility in Broilers

Treatment	Dry Matter Digestibility (%)	Crude Protein Digestibility (%)	Crude Fat Digestibility (%)	Organic Matter Digestibility (%)
P1	71.25 ± 1.12^{a}	74.10 ± 0.98^{a}	77.65 ± 1.03^{a}	73.50 ± 0.84^{a}
P2	75.30 ± 1.04^{b}	77.45 ± 1.15^{b}	80.80 ± 0.91^{b}	76.40 ± 0.92^{b}
P3	77.85 ± 0.93^{c}	80.20 ± 1.10^{c}	82.60 ± 1.21^{c}	79.15 ± 1.04^{c}
P4	79.50 ± 1.18^{cd}	82.45 ± 1.08^{cd}	84.75 ± 0.89^{cd}	81.20 ± 0.95^{cd}
P5	82.10 ± 1.09^{d}	85.90 ± 1.02^{d}	87.65 ± 1.15^{d}	83.40 ± 1.11^{d}

Remarks: Different superscripts (a-e) on the same columns and shapes show very real different influences (P<0.01).

This is because the presence of lipase enzymes found in curcumin and oleoresin, as well as essential oils, will be properly broken down and work on the small intestine in greater amounts, with an increasing amount expected to be an additional enzyme for increasing the activity of lipase enzymes. Essential oils increase enzyme activity and digestive secretions but do not directly support claims regarding acidity reduction. The effects of organic acids and essential oils on growth performance and gut health in broiler chickens (Krishan and Narang 2014; Choi et al. 2022).

The lipase enzyme found in ginger rhizomes helps break down fats in feed. Turmeric improves digestive organ function in chickens by stimulating the production of bile from the gallbladder wall and pancreatic juice, which contains lipase, amylase, and protease enzymes. Essential oils can regulate stomach acid so that it is not too high or too low. In this way, when stomach contents enter the duodenum, pancreatic activity reduces the acidity of chyme more quickly and alters its pH so that it can be sent to the small intestine for absorption. Lipase enzymes, which are abundant in ginger rhizomes, are necessary for chickens to digest fats. Additionally, it stimulates the production of pancreatic enzymes needed for the breakdown of proteins and carbohydrates, including lipase, amylase, and protease (Krishan & Narang, 2014; Suciyati et al., 2024; Moniei et al., 2024).

Nutrient Digestibility of Turmeric–Ginger Flour Supplementation in Broilers

The results showed that supplementation with a mixture of turmeric and ginger powder had a significant effect ($P < 0.01$) on increasing the digestibility of dry matter, crude protein, crude fat, and organic matter in broiler chickens (Table 5). This improvement follows a dose-dependent pattern and peaks at a supplementation level of 0.8% (P5). The increase in amylase, protease, and lipase enzyme activity discussed earlier has been shown to facilitate more efficient breakdown of carbohydrates, proteins, and fats, which ultimately improves nutrient absorption and minimizes feed waste. Bioactive compounds such as curcumin, oleoresin, and essential oils work by stimulating bile and pancreatic secretion and optimizing intestinal pH to create an ideal digestive environment. At the optimal inclusion level (0.8%), broilers showed higher digestibility efficiency compared to the control. This is in line with the characteristics of turmeric and ginger as natural feed additives (phytogenic) that can improve nutrient utilization through the stimulation of digestive enzymes and improvement of intestinal microflora (Irwani et al., 2021; Fonseca et al., 2024).

Conclusions

This study shows that supplementation with a mixture of turmeric and ginger powder significantly increases digestive enzyme activity in broiler chickens in a dose-dependent manner. The optimal addition level of 0.8% resulted in the highest enzyme activity, with amylase (105.90±1.05 U/g), protease (421.42±6.96 U/g), and lipase (260.70±5.71 U/g). A dose of 0.8% turmeric and ginger flour showed an increase in digestibility of amylase (105.90 ± 1.05 U/g), protease (421.42 ± 6.96 U/g), and lipase (260.70 ± 5.71 U/g) in broilers.

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