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Effects of Ginger, Turmeric, Teak Leaf Extracts Combined with a Probiotic on Broiler Chicken Performance

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ABSTRACT

In poultry production, the transition to antibiotic-free systems has resulted in an increased demand for effective natural growth promoters. The present study aimed to evaluate the effectiveness of a mash-form feed additive made from microwave-extracted ginger, turmeric, and teak leaf phytobiotics, combined with a multi-strain bacterium as a probiotic, administered at graded inclusion levels in broiler chickens. A 35-day feeding experiment was conducted with 300 broiler chickens, arranged in a completely randomized design with five dietary treatments and five replicates per treatment. In the first group, chickens received only the basal diet and served as the control (T0). The treatment groups received the basal feed top-dressed with the phytobiotic and probiotic additive at inclusion levels of 0.2% (T1), 0.4% (T2), 0.6% (T3), and 0.8% (T4). Measurements of performance, including body weight gain (BWG), feed conversion ratio (FCR), performance index, and income over feed cost (IOFC), were collected and analyzed. High-performance liquid chromatography confirmed the presence of key bioactive compounds, such as curcumin and 6-gingerol. The inclusion of 0.2% bacterium as a probiotic additive resulted in optimal BWG, FCR, and the highest IOFC, indicating that this level was biologically effective and economically efficient. In contrast, higher inclusion levels of bacteria as probiotics led to reduced performance, likely due to polyphenol-induced mineral binding and issues with feed palatability. The co-administration of probiotics may enhance the bioavailability of curcumin and promote a healthier gut environment. The present findings highlighted the potential of phytobiotic-probiotic combinations as alternatives to antibiotic growth promoters when used at optimal dose levels.

Keywords: Antibiotic-free, Ginger, Performance, Probiotic, Teak leaf, Turmeric

INTRODUCTION

The global poultry industry, particularly in Asia, has experienced consistent growth, driven by increasing consumer demand, urbanization, and a shift towards protein-rich diets. Broiler meat has become a key protein source in countries such as China, Indonesia, Bangladesh, and India, significantly contributing to food security in developing economies (Haque et al., 2020). However, AGPs have raised concerns over food safety, antimicrobial resistance, and sustainability, leading to the implementation of bans on AGPs, including legislative actions such as Law No. 18/2009 and Law No. 41/2014 in Indonesia.

Phytobiotics, plant-based compounds such as flavonoids and essential oils, have emerged as promising alternatives to AGPs due to their antimicrobial and immunomodulatory properties. Botanicals, such as ginger and turmeric, enhance gut health and carcass quality, aligning with consumer preferences for antibiotic-free meat (Griggs and Jacob, 2021). Advanced techniques, such as microwave-assisted extraction (MAE) and nano-emulsions, can enhance bioavailability, although practical limitations exist (Agustina and Setyaningsih, 2024).

Ginger, turmeric, and teak leaves offer synergistic bioactivities, including antioxidants, anti-inflammatory properties, and antibacterial effects, which enhance broiler health and performance (Hermanto et al., 2022). Combining these herbs with probiotics, such as *Lactobacillus* and *Bacillus*, may further promote the production of short-chain fatty acids and gut integrity (Zhang et al., 2025). Dietary components, such as hemicellulose, divalent minerals, and feeds high in viscosity and protein content, may negatively impact the bio-accessibility of polyphenols. In contrast, digestible carbohydrates, dietary fats, particularly in the case of hydrophobic polyphenols such as curcumin, and the presence of additional antioxidants can help improve the bioavailability of these compounds (Bohn, 2014). The physiological

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response to polyphenol intake often follows a bell-shaped dose-response curve, highlighting the importance of well-powered trials with sufficient replication (Alhefny et al., 2022).

The present study aimed to evaluate the efficacy of a mash-form feed additive made from microwave-extracted ginger, turmeric, and teak leaf phytobiotics, combined with a multi-strain bacterium as a probiotic, on broiler chickens, providing insights into the minimal effective dose that optimizes performance and economic viability, supporting sustainable antibiotic-free poultry production.

MATERIALS AND METHODS

Ethical approval

All experimental procedures were conducted in accordance with the institutional animal-care guidelines of Brawijaya University No. 91/EC/KEPK/04/2025. Chickens were handled by trained personnel, and humane endpoints were strictly observed. Housing, feeding, and health-management practices complied with national welfare regulations for poultry research.

Maceration

Dried ginger rhizome, turmeric rhizome, and teak leaves were milled to pass a 60-mesh screen. Each botanical flour was macerated separately in ethanol 70% at a 1:5 (w/v) ratio for 24 hours in sealed glass tubes, following the protocol of Kambuno et al. (2024). The use of ethanol 70% was selected due to its proven efficacy in extracting a wide range of polyphenols and other bioactive compounds, as it offered an optimal balance between polarity and solubility. To prevent oxidative degradation, the macerates were protected from light using aluminum foil.

Microwave-assisted extraction

The combined filtrates, which were the pooled maceration extracts of ginger rhizome, turmeric rhizome, and teak leaves, with a total volume of 200 mL, were concentrated using MAE. Maceration liquor was transferred to a Kjeldahl flask to half capacity and irradiated using a pulsed microwave at a 450 W power output mode under reflux condensation at 50-60°C for 15 minutes. The flask was then cooled to ambient temperature, filtered, and re-irradiated for a further 10 minutes. The filtrates obtained from the first and second irradiation steps were combined and pooled to produce an extract with a final solvent-to-solid ratio of 5:1, as described by Pinelo et al. (2005).

Ultrasonic homogenization

To enhance dispersion and reduce particle size, the crude extract was subjected to probe sonication in a 100 mL borosilicate glass vessel using an ultrasonic homogenizer sonicator (UCD-250, 250 W, 220 V, 50 Hz, BIOBASE, China) equipped with a 13 mm titanium alloy probe operating at 20 kHz. Sonication was conducted for a total of 30 minutes at 50-60°C, with 10-minute sonication cycles followed by 5-minute passive cooling intervals at room temperature to prevent overheating (Pinelo et al., 2005). A water bath was used to stabilize the temperature during sonication, and real-time monitoring was performed using a digital thermocouple inserted into the vessel. This ultrasonic homogenization protocol, adapted from Rad et al. (2023), yielded a stable nano-suspension suitable for dry-mixing with carriers. Particle size analysis performed with scanning electron microscopy.

Mash formulation

One hundred mL volumes of ginger, turmeric, and teak extracts were blended at 2200 rpm until visually homogeneous; the mixture was then combined in a 1:1 (w/w) ratio with sun-dried cassava pulp as a carrier. After drying the cassava pulp, the final product exhibited a moisture content of 10.4% (wet basis), determined by oven-drying at 105°C for four hours. The slurry was spread 1-2 cm thick on aluminum trays and oven-dried at 60°C for 24 hours. Subsequently, the sheet was ground into a powder to produce a phytobiotic product suitable for inclusion in poultry feed. The final product was stored in opaque, airtight containers until it was utilized in feed formulation. A commercial multistrain probiotic (Lactoped®, containing viable Lactobacillus spp. and Bacillus spp.) was selected as the microbial component. Preliminary enumeration confirmed a viable count of 1×10^8 CFU/g at the time of mixing, with more than an 85% survival rate in the feed throughout the trial period.

Experimental design and housing

The *in vivo* trial was carried out for 35 consecutive days in Kambingan village, Tumpang district, Malang, East Java, Indonesia. A total of 300 Lohmann-strain day-old chickens with an initial body weight of 42.62 ± 3.52 g (coefficient of variation 8.25%) were obtained from a single commercial hatchery (PT Japfa Comfeed, production code MB 202) to reduce genetic variation. The chickens were brooded for seven days in floor pens with constant lighting, then moved to raised slatted cages measuring 1.0 m × 0.8 m × 0.5 m, equipped with nipple drinkers and tube feeders. The stocking density was maintained at twelve chickens per cage, providing 0.067 m^2 per chicken. The ambient temperature was maintained at 34 ± 1°C during the brooding phase and gradually reduced to 29 ± 1°C by day 14, thereafter following the daily room temperature. Feed and water were supplied *ad libitum* throughout the starter (0-14 days) and the finisher (15-35 days) phases.

Dietary treatments and experimental design

A completely randomised design was adopted with five dietary treatments and five replicates per treatment. Each replicate corresponded to one cage of twelve chickens, resulting in a total of 25 experimental units. All chickens received a nutritionally adequate commercial basal diet formulated for fast-growing broilers. The basal diet was divided into three phases, including pre-starter (days 0-7), starter (days 8-21), and finisher (days 22-35), with nutrient specifications detailed in Table 1. In the first group, chickens received only the basal diet and served as the control (T0). The treatment groups received the basal feed top-dressed with the phytobiotic and probiotic additive at inclusion levels of 0.2% (T1), 0.4% (T2), 0.6% (T3), and 0.8% (T4). The additive was incorporated into the basal feed manually using the scoop-and-pour method in clean plastic tubs. Each batch (5 kg) was mixed for 10 minutes using circular and folding motions to ensure uniform distribution. Homogeneity was assured by visual consistency of color and texture across the batch, and mixing was repeated in small quantities to minimize variation.

Table 1. Nutrient content of broiler chickens in the present study

Nutrient content	Pre starter (1-7 days)	Starter (8-21 days)	Finisher (22-35 days)
Water content (%)	12.8	11.5	11.3
Crude protein (%)	22.2	21.6	19.4
Ether extract (%)	5.2	5.5	5.6
Crude fiber (%)	4.7	5.2	5.4
Ash (%)	7.1	7.3	7.2
Calcium (%)	1.1	1.1	1.1
Phosphor (%)	0.5	0.5	0.4
ME (Kcal/kg)	2.900	3.000	3.100
Aflatoxin (µg/Kg)	40.8	50.2	50.1

Note: Proximate analysis data from the Animal Nutrition Laboratory at the Brawijaya University, Malang, Indonesia. ME: Metabolizable energy

Performance measurements

Feed intake was recorded daily as the difference between feed offered and orts. Broiler chickens were weighed collectively at placement and every seven days thereafter; body weight gain (BWG) for each replicate was calculated by subtracting the initial weight from the subsequent weight. Feed conversion ratio (FCR) was expressed as cumulative feed intake divided by cumulative BWG. Mortality was monitored twice daily, and the mass of deceased chickens was used to adjust performance data. The European production efficiency factor, designated locally as performance index (PI), is calculated in accordance with Gonzales et al. (2023).

PI = (final live weight [g] × survival [%]) ÷ (age × FCR) × 100

Economic performance was evaluated solely based on feed-related profitability, calculated as income over feed cost (IOFC). This metric was calculated by subtracting the total feed cost per chicken from the revenue generated by its live body weight at the current farm gate price. The selling price of live chickens was set at 17,500 IDR per kilogram. Feed costs were determined based on the phase-specific prices. Pre-starter and starter feeds were priced at 9,340 IDR per kilogram, while finisher feed was priced at 9,000 IDR per kilogram. The data was calculated using Microsoft Excel.

Statistical analysis

All variables were tabulated in SPSS Statistics and subjected to one-way analysis of variance (ANOVA) using the general linear model procedure. The statistical model, $Y_{ij} = \mu + T_i + \varepsilon_{ij}$, included the fixed effect of dietary treatment (T_i) and the residual error term (ε_{ij}). The significant results were separated with Duncan's multiple-range test to characterize dose-response patterns ($p < 0.05$). Before analysis, data were checked for homogeneity of variance and normality; arcsine transformation was applied to survival percentages where necessary. Statistical software assumptions were met in all cases, and transformed data were returned to the original scale for presentation.

RESULT AND DISCUSSION

The present results of the experimental treatments included the quantified concentrations of key active phytochemicals, measured broiler growth performance indicators, economic efficiency based on income over feed cost, and an interpretation of biological trends with additive dosage. The present data highlighted measurable effects of the dietary treatments on broiler productivity and profitability, with particular emphasis on identifying optimal inclusion levels for practical application.

Feed intake

The current findings indicated that supplementing broiler diets with a phytobiotic-probiotic mix consisting of ginger, turmeric, teak leaf extracts, and probiotics had no statistically significant effects on feed intake ($p > 0.05$). The average cumulative feed intake per chicken ranged from 3,334.98 g to 3,362.72 g across the treatment groups. The highest intake was recorded in Group T3 (3362.72 ± 64.58 g/head), while the control group consumed slightly less (3334.98 ± 0.41 g/head). These narrow variations indicated that the observed BWG improvements were not due to increased intake, but rather to improved nutrient utilization. The present result was consistent with the findings of Ardiansyah et al. (2024), who observed that incorporating fermented feed additives composed of ginger, turmeric, and teak leaf extracts in nanoparticle form did not significantly influence feed intake in broilers. The absence of significant differences in feed intake among treatment groups in the present study aligned with the findings of Ardiansyah et al. (2024), who reported that phytobiotic feed additives composed of ginger, turmeric, and teak leaf nanoparticles did not adversely affect broiler consumption traits. However, direct comparison was limited as feed intake was not quantitatively assessed in that study.

Similarly, Sunmola et al. (2024) indicated that the effects of using 0.3% of ginger and turmeric did not differ significantly in terms of feed consumption, indicating that the addition of these herbs up to a level of 0.30% did not negatively impact palatability or feed acceptance. The present data demonstrated that variables, including the form of administration (drinking water or feed), levels, and fermentation methods, significantly influence the efficacy of feed additives on feed consumption. In contrast with the results of the current study, Al-Mahdawi and Al-Hassani (2023) reported that supplementing broiler chicken feed with 0.5% or 1% of ginger powder significantly reduces feed consumption and weight gain compared to the control group at 35 days of age. This finding suggested that the type of probiotic and the method of administering feed additives play an important role in determining the consumption response of broiler chickens.

Body weight gain

As shown in Table 2, chickens in Group T1 achieved the highest mean BWG (2163.43 ± 31.18 g/head), followed by Group T2 (2133.70 ± 100.55 g/head). In groups T3 and T4, BWG declined to 2076.19 ± 108.79 g/head and 2030.58 ± 112.54 g/head, respectively. Although the differences were not statistically significant ($p > 0.05$), the numerical trend exhibited optimal performance within the inclusion range of 0.2% (T1) to 0.4% (T2). The current findings align with prior evidence that curcumin has dose-dependent effects, with moderate levels promoting microbial balance and nutrient absorption, while high doses may lead to metabolic stress or decrease palatability in laying hens (Nawab et al., 2019). Nuningtyas et al. (2024) reported that the addition of feed additives in the form of liquid nano extracts of ginger, turmeric, teak leaves, and probiotics at levels of 0.4 - 0.8% can increase the percentage of carcass and physical quality of broiler chicken meat, although it does not directly increase BWG significantly. Supplementation of probiotic fermentation with a mixture of turmeric in broiler drinking water can significantly increase ration consumption, BWG, and PI at certain doses. Aderemi and Alabi (2023) highlighted that the inclusion of probiotics did not increase BWG in broiler chickens, emphasizing that the effectiveness of probiotics can be species-dependent and potentially affected by other dietary factor components. The combination of probiotics and herbs in commercial feed additives such as Promix^{TM} had synergistic effects and beneficial roles in improving the growth performance of broiler chickens, including increasing BWG, body weight, and decreasing FCR value; therefore, it can replace AGP as a feed additive in broiler chickens (Nahak et al., 2021). The present findings demonstrated that supplementation with a combination of curcumin, gingerol, and teak leaf extract with probiotics did not directly increase BWG ($p > 0.05$), which was in line with the findings of Martinez et al. (2022), who performed a commercial meta-analysis on phytogenic feed additives and reported improvements in feed conversion efficiency but observed no significant effect on the final body weight of broiler chickens.

Feed conversion ratio

The present findings indicated that supplementing broiler diets with a combination of ginger, turmeric, teak leaf extracts, and probiotics had no statistically significant impact on FCR ($p > 0.05$). The trend in FCR presented the pattern observed in BWG. The highest feed efficiency, as indicated by the lowest FCR, was observed in Group T1 (1.55), followed by Group T2 (1.57), whereas the control group recorded an FCR of 1.61. Feed conversion ratio values increased at higher inclusion levels, reaching 1.62 and 1.65 for groups T3 and T4, respectively. The current results were consistent with meta-analytical evidence indicating that ginger-based additives can improve feed conversion efficiency, particularly when administered at optimal dosages (Khalil et al., 2022).

The mechanisms behind these improvements are probably multifaceted, involving proper digestion, reduced pathogen levels, and enhanced gut structure effects previously linked to the antimicrobial and pro-digestive properties of gingerol and curcumin (Ferdous et al., 2022). The present results aligned with a study conducted by Windisch et al. (2008), which evaluated the use of red ginger flour as a phytobiotic supplement in broiler chicken feed. The findings revealed that supplementing broiler diets up to 0.4% of red ginger flour did not significantly alter feed conversion ratios in broiler chickens compared to the control group ($p > 0.05$). However, improvements were observed in BWG alongside a reduction in feed intake. These outcomes suggested that herbal additives, such as red ginger, may enhance broiler growth performance without significantly affecting feed conversion efficiency.

Table 2. Growth performance of Lohmann broiler chickens receiving diets supplemented with different levels of phytobiotic and probiotic additives over 35 days

Variables / Treatment	T0	T1	T2	T3	T4	P-value
Feed intake (g/chicken)	3334.98 ± 0.41[a]	3345.46 ± 26.40[a]	3350.46 ± 26.41[a]	3362.72 ± 64.58[a]	3335.27 ± 0.22[a]	0.67
BWG (g/chicken)	2077.42 ± 124.46[a]	2163.43 ± 31.18[a]	2133.70 ± 100.55[a]	2076.19 ± 108.79[a]	2030.58 ± 112.54[a]	0.84
FCR	1.61 ± 0.1[a]	1.55 ± 0.02[a]	1.57 ± 0.07[a]	1.62 ± 0.07[a]	1.65 ± 0.09[a]	0.26
PI	353.21 ± 49.41[a]	371.66 ± 68.02[a]	369.05 ± 27.64[a]	325.55 ±75.40[a]	354.09 ± 39.03[a]	0.80
IOFC (Rp/chicken)	13884.31 ± 2177.8[a]	15397.13 ± 544.2[a]	14922.89 ± 1758.9[a]	13723.16 ± 1703.5[a]	13053.81 ± 1968.7[a]	0.24

Note: Data are presented as mean ± Standard deviation. T0: Basal diet, T1: Phytobiotic plus probiotic 0.2%, T2: Phytobiotic plus probiotic 0.4%, T3: Phytobiotic plus probiotic 0.6%, T4: Phytobiotic plus probiotic 0.8%. BWG: Body weight gain, FCR: Feed conversion ratio, PI: Performance index, IOFC: Income over feed cost. $P > 0.05$ indicates that no significant differences were observed among the treatment groups.

Performance index

The PI is a comprehensive indicator that integrates growth rate, feed efficiency, and livability to evaluate overall broiler production efficiency. Although numerical differences were observed among treatments during the present study, statistical analysis indicated that the differences in PI among groups were not significant ($p > 0.05$). The highest numerical PI value was recorded in Group T1 (371.66 ± 68.02), followed by Group T2 (369.05 ± 27.64), Group T4 (354.09 ± 39.03), and the control group (353.21 ± 49.41), with the lowest in Group T3 (325.55 ± 75.40). Although the results were not statistically significant, Group T1 exhibited the most favorable overall trend. The enhanced PI in T2 corresponds with the improvement of BWG and the relatively efficient FCR observed at this stage level. The present findings were supported by the study of Urban et al. (2023), which indicated that phytogenic additives, particularly those rich in curcumin and gingerols, can improve the growth performance of broiler chickens and feed conversion by modulating gut microbiota and enhancing nutrient absorption.

The synergistic use of probiotics may contribute to improved intestinal health, immune modulation, and a reduced pathogenic load, all of which are crucial for maximizing performance outcomes (Gadde et al., 2017). The current result aligns with the findings of Amad et al. (2011), who suggested that excessive inclusion of plant-derived bioactives can impair nutrient utilization and palatability. The enhanced PI in broiler chickens at moderate levels, compared to higher levels, supported the present results, which indicated a negative response at high doses.

Income over feed cost

Income over feed cost is a critical economic indicator used to assess poultry production profitability, calculated by subtracting total feed expenses from the income generated per chicken (Pradana and Zuprizal, 2025). The highest IOFC was recorded in Group T1 (15,397.13 ± 544.2 IDR), followed by Group T2 (14,922.89 ± 1,758.9 IDR) and the control group (13,884.31 ± 2,177.8 IDR). Treatments T3 and T4 yielded lower IOFC values, indicating reduced economic returns despite similar feed intake. However, statistical analysis demonstrated no significant differences in IOFC among treatment groups ($p > 0.05$). The numerically superior IOFC in Group T1 suggested that the 0.2% inclusion level of the phytobiotic-probiotic mix may provide an economically efficient balance between feed cost and weight gain. This trend aligns with the findings of Aderemi and Alabi (2023), who reported that moderate supplementation with phytogenic additives can improve growth and feed efficiency in broiler chickens without markedly increasing production costs, thereby enhancing net income. Although Group T2 resulted in the highest PI, its slightly lower IOFC compared to Group T1 suggested that biological efficiency does not always correlate directly with economic efficiency, particularly as feed additive costs rise with inclusion level. Baurhoo et al. (2007) emphasized the importance of evaluating performance and cost parameters to make informed decisions about feed formulation, particularly in commercial production systems where profit margins are narrow. Interestingly, during the present study, high inclusion levels (0.6% and 0.8%) were associated with declining IOFC values, likely due to diminishing returns in BWG and exacerbating FCR. This trend supported the dose-response relationship described by Amad et al. (2011), where excessive inclusion of phytobiotic compounds may lead to anti-nutritional effects and reduced economic efficiency in broiler chickens.

CONCLUSION

The present study demonstrated that supplementing broiler diets with a feed additive containing ginger, turmeric, and teak leaf extracts combined with a multi-strain *Bacillus*/*Lactobacillus* probiotic offered beneficial effects at an optimal inclusion level of 0.2%. This dose consistently improved body weight gain, feed conversion ratio, performance index, and economic returns. The observed bell-shaped dose-response trend emphasized the importance of dose optimization, as higher inclusion levels (0.6%-0.8%) indicated decreasing returns, possibly due to excessive polyphenolic compounds having anti-nutritional effects. The present findings supported the potential of natural feed additives as effective alternatives to antibiotic growth promoters, particularly in tropical production environments. Future studies should focus on optimizing dosing strategies, evaluating the long-term health effects, and assessing the economic feasibility, including additional costs, to enhance the practical application of phytobiotic-probiotic combinations in broiler production.

DECLARATIONS

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Authors’ contributions

Silvi Annas Tasya conducted the laboratory and field research. Muhammad Halim Natsir served as the principal investigator and supervised the overall study framework. Adelina Ari Hamiyanti was responsible for the laboratory procedures and ensured methodological accuracy. Veronica Margareta Ani Nurgiartiningsih was responsible for formulating and extracting phytobiotics. Fajar Shodiq Permata contributed to data analysis and statistical interpretation. Muhammad Sasmito Djati supported scientific validation and data synthesis. Yuli Frita Nuningtyas coordinated field activities and contributed to manuscript review. All authors have read and approved the final edition of the manuscript.

Competing interests

The authors confirmed that there are no conflicts of interest associated with this publication.

Ethical considerations

All authors were actively involved in the development of this original manuscript. The authors reviewed the final version of the completed paper, assessed any necessary revisions and updates, and verified the article’s similarity index.

Availability of data and materials

The data to support the findings of the present study are available upon reasonable request from the corresponding author.

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