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Dietary Green Banana Powder Improves Feed Efficiency, Watery Droppings Indicators, and Litter Condition in H'Mong Chickens under Tropical Farm Conditions

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A B S T R A C T

Green banana powder is a functional feed ingredient rich in resistant starch and dietary fiber, with potential applications in poultry nutrition. However, information regarding its use in indigenous Vietnamese chicken breeds under practical tropical rearing conditions remains limited. This study evaluated the effects of dietary green banana powder supplementation on growth performance, feed efficiency, watery droppings incidence, and litter quality in H'Mong chickens from 1 to 56 days of age. A total of 120 one-day-old H'Mong chickens were randomly assigned to four dietary treatments containing 0%, 1%, 2%, or 3% green banana powder, with three replicates of 10 chickens per treatment. Dietary supplementation significantly affected final body weight, average daily gain, feed conversion ratio, incidence of watery droppings, wet-dropping days, litter moisture, litter quality score, and odor score ($p<0.05$). Chickens receiving 2% green banana powder showed the best productivity and litter-related responses. Feed intake and survival rate were not significantly influenced by dietary treatment ($p>0.05$). Under the conditions of the present study, supplementation with 2% green banana powder improved feed efficiency, productive performance, indicators of watery droppings, and litter condition in H'Mong chickens raised under practical tropical farm conditions.

Keywords: *Green Banana Powder, H'Mong Chickens, Functional Feed Ingredient, Watery Droppings Incidence, Litter Moisture, Smallholder Poultry.*

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1 Introduction

The poultry industry is considered one of the most important sectors of global agriculture because of its major contribution to animal protein supply, food security, and employment generation (Hajiabadi et al., 2026). Conversely, poultry production in tropical regions is frequently challenged by digestive instability and poor litter conditions, both of which can negatively affect growth performance, feed efficiency, flock welfare, and housing environment. Importantly, in small-scale poultry systems, watery droppings and wet litter are particularly problematic because they accelerate litter deterioration, increase microbial pressure within the rearing environment, and reduce production efficiency. These problems are especially critical during the early growth phase, when feed intake plays a central role in stimulating gastrointestinal development and functional maturation (Longo et al., 2007). Diets with high digestibility and adequate protein content during the first days of life are therefore essential for supporting gastrointestinal development and early growth in chickens, and early nutritional management has been regarded as an investment rather than merely a production cost (Lilburn, 1998). Correspondingly, feed intake in young chickens is closely associated with intestinal development and the ability to meet nutrient requirements during the post-hatch period (Uni et al., 1999). Consequently, practical nutritional strategies that support productive performance while improving field indicators of fecal consistency and litter condition remain of considerable interest in poultry production.

Proper feed management remains an important factor for achieving efficient growth and improved feed conversion in chickens (Putra et al., 2023). In this context, agro-industrial by-products and locally available feed resources have received increasing attention as alternative feed ingredients to improve resource utilization and reduce production costs. These materials are commonly processed into meal or powder form and incorporated into poultry diets at different production stages. Among them, green banana powder has attracted interest as a functional feed ingredient derived from unripe bananas harvested at the green stage or during the early ripening phase. In many banana-producing regions, large quantities of unmarketable green bananas are discarded, and their poor utilization may contribute to environmental problems (Padam et al., 2014). Therefore, converting unmarketable green bananas into poultry feed ingredients may provide both nutritional and environmental benefits, particularly in tropical regions where banana resources are abundant.

The functional potential of green banana powder is mainly associated with its resistant starch content and bioactive composition. Tribess et al. (2009) reported that green banana flour produced from fruits at the first stage of ripening contained high resistant starch levels ranging from 40.9±0.4 to 58.5±5.4 g/100 g dry basis (Tribess et al., 2009). Menezes et al. (2011) further showed that resistant starch represents the major fraction of green banana flour, accounting for approximately 48.99±0.04 g/100 g dry weight, while the largely intact starch granules contribute to low energy availability and moderate antioxidant capacity (Menezes et al., 2011). Green banana-derived materials also contain dietary fiber together with nutrients such as vitamin C, vitamin B6, provitamin A, and minerals including zinc, magnesium, potassium, and phosphorus (Falcomer et al., 2019; Lii et al., 1982). Resistant starch escapes enzymatic digestion in the upper gastrointestinal tract and can subsequently be fermented in the hindgut, potentially contributing to short-chain fatty acid production and microbial balance. In unripe bananas, resistant starch is predominantly present in the RS2 form in both dessert and plantain varieties (Cordoba et al., 2018; Langkilde et al., 2002; Yee et al., 2021). Depending on processing conditions, banana starch may also be transformed into other resistant starch forms, including RS3, RS4, and RS5, through physical, chemical, or enzymatic modification, indicating that processing methods may influence its functional properties (Almanza-Benitez et al., 2015; Cordoba et al., 2018; Tian et al., 2020).

Several previous studies have evaluated banana-derived ingredients in poultry diets, particularly in commercial broiler chickens. Dumorné et al. (2020) investigated banana flour mainly as an alternative energy source in broiler diets (Dumorné et al., 2020), whereas Rahmawati et al. (2023) evaluated unripe banana flour as a functional feed ingredient in relation to growth performance, internal organ relative weight, and carcass traits (Rahmawati et al., 2023). Sugiharto et al. (2023) further examined the effects of unripe banana flour on blood profile, serum biochemical traits, and intestinal indices in broilers (Sugiharto et al., 2023). More recently, Mnisi et al. (2025) reviewed resistant starch from green bananas as a potential prebiotic for poultry diets and discussed its mechanisms, limitations, and future prospects (Mnisi et al., 2025). Collectively, these studies provide scientific support for the application of banana-derived ingredients in poultry nutrition. Nevertheless, most available evidence has been generated in commercial broilers under relatively controlled experimental conditions, whereas information regarding indigenous Vietnamese chicken breeds raised under practical tropical farm systems remains limited.

The present study was conducted to address this gap by evaluating the effects of low-level dietary supplementation with green banana powder in H’Mong chickens, an indigenous Vietnamese chicken breed commonly raised under tropical smallholder conditions. Compared with previous studies, the present work differs in three important aspects. First, it focuses on a local genetic resource rather than commercial broiler strains. Second, it evaluates relatively low supplementation levels of green banana powder (1–3%), which may be more practical and economically feasible under farm conditions than high dietary replacement levels. Third, the study combines productive performance with field-observed watery droppings indicators, wet-dropping days, litter moisture, litter quality score, and odor score, thereby linking feed efficiency with practical indicators related to digestive stability and the rearing microenvironment. Accordingly, the aim of this study was to evaluate the effects of dietary green banana powder supplementation on growth performance, feed efficiency, watery droppings indicators, and litter quality in H’Mong chickens from 1 to 56 days of age.

2 Material and Methods

2.1 Study Animals

A total of 120 H’Mong chickens at one day of age were used in this study. The chickens were clinically healthy and had similar initial body weights at the beginning of the experiment. Chickens were randomly allocated to four dietary treatments with three replicates per treatment and 10 chickens per replicate. The experiment was conducted at Dong Loi Farm, Dong Phuoc commune, Can Tho city, Vietnam, from July to September 2025. During the experimental period, all chickens were raised under similar environmental and management conditions. The ambient temperature during the study ranged from 28 to 32°C, with relative humidity between 75 and 85%, typical of the Mekong Delta region.

2.2 Feed and Feeding

Green banana powder was prepared from unripe bananas (*Musa* spp.) harvested at the fully green stage. The fruits were washed, peeled, sliced into thin pieces, and dried at 60–65°C until constant weight. The dried slices were then ground into powder and stored in airtight containers until use.

Chickens were fed experimental diets formulated for the 1–56 day growing period. The basal diet contained approximately 3,000 kcal/kg metabolizable energy and at least 21% crude protein. The main feed ingredients were maize, broken rice, rice bran, fish meal, soybean meal, and other locally available feedstuffs. Calculated calcium and phosphorus contents ranged from 0.9 to 1.2% and 0.3 to 0.5%, respectively. Green banana powder was incorporated at 0%, 1%, 2%, and 3% in the treatments, partially replacing maize on a weight basis. The diets were formulated to remain approximately isoenergetic and isonitrogenous across treatments, and all ingredients were thoroughly mixed to ensure uniform distribution of green banana powder. Feed and fresh drinking water were provided ad libitum throughout the experimental period.

2.3 Experimental design

The experiment was arranged in a completely randomized design to evaluate the effects of dietary green banana powder supplementation on feed efficiency, indicators of watery droppings, and litter quality in H’Mong chickens from 1 to 56 days of age.

A total of 120 one-day-old H’Mong chickens were randomly allocated to four dietary treatments, with three replicate pens per treatment and 10 chickens per pen. The experimental treatments were as follows: control diet without green banana powder (0% GBP), control diet supplemented with 1% GBP, control diet supplemented with 2% GBP, and control diet supplemented with 3% GBP.

All chickens were raised in floor pens under similar housing, environmental, feeding, and management conditions. Each pen was considered the experimental unit for feed intake, feed conversion ratio, indicators related to watery droppings, and litter quality parameters. The only planned difference among treatments was the inclusion level of green banana powder in the diet. Growth performance and feed efficiency were evaluated using body weight, average daily gain, feed intake, feed conversion ratio, and survival rate, whereas digestive stability and housing conditions were assessed using watery droppings incidence, number of days with wet droppings, litter moisture, litter quality score, and odor score. The overall experimental layout is illustrated in Figure 1.

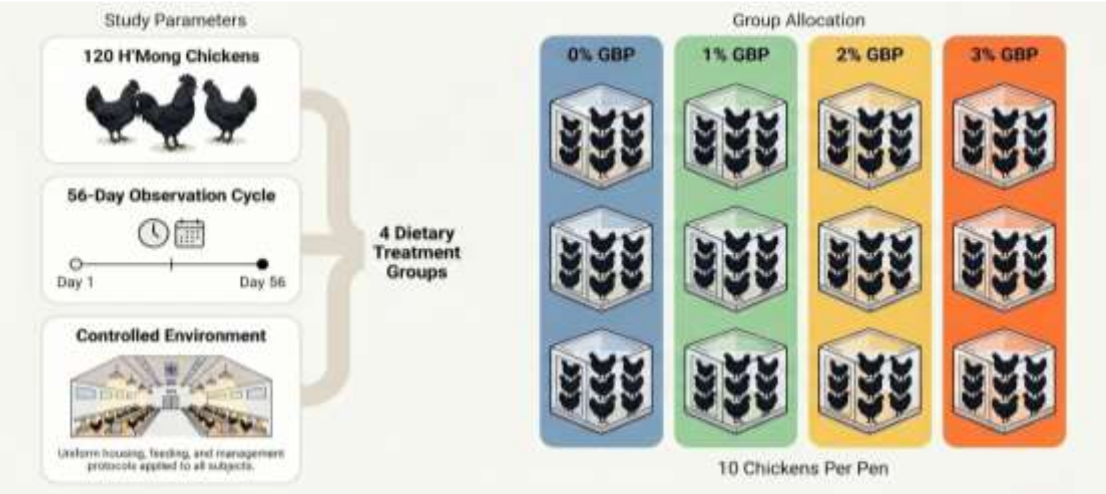

Figure 1. Experimental layout of dietary green banana powder supplementation in H'Mong chickens from 1 to 56 days of age.

2.4 Measurements

2.4.1 Growth performance & feed efficiency

Chickens were individually weighed at the beginning (day 1) and at the end of the experiment (day 56) using a 40-kg digital scale (AWS, Japan). Body weight gain was determined as the difference between the final and initial body weight.

Feed intake was recorded daily for each pen by subtracting the amount of feed remaining from the amount of feed offered. Total feed intake per pen during the experimental period was calculated accordingly.

Average daily gain (ADG) was calculated as:

$$\text{ADG (g/bird/day)} = \frac{Final\ body\ weight - Initial\ body\ weight}{Number\ of\ experimental\ days}$$

Feed conversion ratio (FCR) was calculated based on pen-level data as:

$$\text{FCR} = \frac{Total\ feed\ intake\ (g)}{Total\ body\ weight\ gain\ (g)}$$

$$\text{Survival rate (\%)} = \frac{Number\ of\ chickens\ remaining\ at\ the\ end\ of\ the\ experiment}{Initial\ number\ of\ chickens} \times 100$$

2.4.2 Watery droppings and litter quality

Watery droppings and litter quality were monitored throughout the experimental period as practical, field-based indicators of digestive stability and housing conditions. Observations were conducted daily at the pen level at the same time each morning by two trained observers using predefined visual criteria. The observers were not blinded to treatment allocation because dietary treatments were visually distinguishable during feed preparation and distribution; however, the same scoring criteria were consistently applied across all pens throughout the study. Inter-observer agreement was not formally evaluated.

Chickens were considered to exhibit watery droppings when freshly voided feces were watery, unformed, and clearly different from normal fecal consistency. Wet droppings were recorded when soft or watery fecal material was visibly present on the litter surface within a pen. No microbiological, parasitological, molecular, or clinical diagnostic examinations were performed during the study. Therefore, coccidiosis, bacterial enteritis, parasitic infection, or other infectious causes were not specifically confirmed. No medication or therapeutic treatment was administered during the experimental period. Consequently, watery droppings in the present study were interpreted as field-based indicators of digestive stability rather than confirmed disease outcomes.

Watery droppings incidence was calculated as follows:

$$\text{Watery droppings incidence (\%)} = \frac{Number\ of\ chickens\ with\ watery\ or\ unformed\ feces}{Total\ number\ of\ chickens\ in\ the\ pen} \times 100$$

The number of days with wet droppings was recorded for each pen during daily observations.

Rice husk was used as bedding material at an initial litter depth of approximately 7 cm, and stocking density was maintained equally across all pens. Litter was not replaced during the experiment; however, visibly wet areas around drinkers were lightly stirred when necessary as part of routine farm management. Litter samples were collected weekly at the same time of day from at least three representative locations within each pen, including areas near the drinker, feeder, and resting zone, and then thoroughly mixed before analysis. Litter moisture content was determined by oven-drying samples at 105°C until constant weight and calculated as follows:

$$\text{Litter moisture (\%)} = \frac{Fresh\ weight - Dry\ weight}{Fresh\ weight} \times 100$$

Litter quality and odor were assessed weekly using subjective ordinal scoring scales. Litter quality was visually scored using a 4-point scale: 1=dry and loose, 2=slightly moist, 3=moderately wet with slight caking, and 4=wet and heavily caked. Odor was evaluated using a 4-point scale: 1=very slight, 2=slight, 3=moderate, and 4=strong. Ammonia concentration was not directly measured; therefore, odor score was interpreted only as a subjective sensory indicator of litter condition rather than a direct measure of ammonia emission.

2.5 Statistical Analysis

All data were analyzed using Minitab statistical software version 16.0. The pen was considered the experimental unit for all statistical analyses. For body weight and average daily gain, individual chicken data were first averaged within each pen before analysis. Feed intake, feed conversion ratio, survival rate, field-observed diarrhea-like droppings, wet-dropping days, litter moisture, litter quality score, and odor score were analyzed using pen-level values. Daily observations of diarrhea-like droppings were summarized as cumulative pen-level values over the 1–56-day experimental period. Weekly litter moisture measurements and litter scoring data were averaged within each pen before statistical analysis. Final summarized pen-level data were expressed as Mean±Standard Deviation (SD). Percentage data were arcsine-square-root-transformed before analysis when required to improve normality. The assumptions of normality and homogeneity of variance were evaluated using the Shapiro–Wilk and Levene's tests, respectively. Treatment effects were analyzed using one-way analysis of variance (ANOVA) under a completely randomized design. When significant differences were detected, means were separated using Tukey's honestly significant difference (HSD) test. Statistical significance was declared at $p<0.05$. The use of one-way ANOVA was retained because the analysis was based on final summarized pen-level outcomes rather than repeated daily or weekly measurements. The limited number of replicate pens per treatment should be considered a limitation of the study.

3 Results and Discussion

3.1 Growth performance & feed efficiency

As shown in Table 1, initial body weight did not differ among treatments ($p>0.05$), indicating that the experimental chickens were comparable at the beginning of the trial. This baseline uniformity suggests that subsequent differences in productive performance were mainly associated with dietary supplementation with green banana powder rather than with initial body weight variation.

Dietary supplementation with green banana powder significantly affected final body weight and average daily gain ($p<0.05$). Chickens receiving 2% green banana powder achieved the highest final body weight (781.5 g/chicken) and average daily gain (13.39 g/chicken/day), both of which were higher than those of the control group. Feed intake was not significantly influenced by treatment ($p>0.05$), indicating that the improved productive response was not associated with greater feed consumption. Instead, the response appeared to be related to feed utilization efficiency. This interpretation was supported by the FCR results, with the lowest value observed in the 2% group (2.47) compared with the control group (2.72) ($p<0.05$). Therefore, the primary productive response associated with green banana powder supplementation in the present study was improved feed efficiency, particularly at the 2% inclusion level.

Table 1. Effects of dietary green banana powder supplementation on growth performance and feed efficiency of H'Mong chickens from 1 to 56 days of age (Mean ± SD)

Parameter	Control (0%)	1% GBP	2% GBP	3% GBP	*P-value*
Initial body weight (g/bird)	31.82 ± 1.21	31.74 ± 1.11	31.92 ± 1.16	31.84 ± 1.21	0.984
Final body weight (g/bird)	728.4 ± 24.62^{b}	756.9 ± 22.85^{ab}	781.5 ± 21.74^{a}	765.2 ± 23.58^{ab}	0.012
Average daily gain (g/bird/day)	12.44 ± 0.43^{b}	12.95 ± 0.40^{ab}	13.39 ± 0.38^{a}	13.10 ± 0.41^{ab}	0.015
Feed intake (g/bird/day)	33.85 ± 0.92	33.42 ± 0.88	33.10 ± 0.84	33.36 ± 0.90	0.218
Feed conversion ratio (FCR)	2.72 ± 0.08^{a}	2.58 ± 0.07^{b}	2.47 ± 0.06^{c}	2.55 ± 0.07^{b}	0.004
Survival rate (%)	93.33 ± 5.77	96.67 ± 5.77	100.00 ± 0.00	96.67 ± 5.77	0.287

Means with different superscripts in the same row differ significantly ($P<0.05$). GBP: green banana powder.

The present findings are generally consistent with previous reports showing that banana-derived ingredients can influence growth performance and feed utilization in poultry (Dumorné et al., 2020; Mandey et al., 2015; Rahmawati et al., 2023; Siyal et al., 2016). Rahmawati et al. (2023) reported that broilers receiving unripe banana flour-based diets showed lower FCR during the 8–38 and 22–38 day periods, especially when 5% unripe banana flour was combined with probiotics or multienzyme supplementation (Rahmawati et al., 2023). However, that study did not observe significant effects on body weight, body weight gain, or feed intake, and no dietary response was detected during the early 8–21-day period. Compared with the broiler findings, the present study suggests that H'Mong chickens may respond to low-level supplementation with green banana powder, evidenced by improved FCR and increased body weight gain, particularly at the 2% supplementation level. The positive response observed in the present study may be partly due to the nutritional and bioactive properties of green banana-derived ingredients. Green bananas have been described as sources of resistant starch, dietary fiber, vitamin C, vitamin B6, provitamin A, and minerals such as potassium, phosphorus, magnesium, and zinc. In addition, they contain bioactive compounds, particularly phenolic compounds, which may contribute to their functional properties (Borges et al., 2009; Chávez-Salazar et al., 2017; Hettiaratchi et al., 2011; Lii et al., 1982; Riquette et al., 2019; Suntharalingam & Ravindran, 1993; Wall, 2006). Owing to these characteristics, green bananas have been considered a functional food ingredient (Anyasi et al., 2013), and several studies have reported potential physiological benefits associated with their use (Bodinham et al., 2010; Choo & Aziz, 2010; Costa et al., 2017; Zandonadi et al., 2012). Previous poultry studies have also indicated that unripe banana flour contains fermentable carbohydrates, oligosaccharides, resistant starch, and dietary fiber that may contribute to digestive stability and nutrient utilization (Alvarado-Jasso et al., 2020; Chang et al., 2022; Dumorné et al., 2020; Powthong et al., 2020).

Previous studies further suggest that unripe banana flour may offer benefits beyond its role as an energy source. Resistant starch and soluble fiber fractions may function as prebiotic substrates, while antioxidant activity has also been reported in green banana-derived products (Chang et al., 2022; Munita et al., 2022; Padam et al., 2014; Powthong et al., 2020). Munita et al. (2022) reported that four Indonesian unripe banana flour cultivars contained more than 3,000 kcal/kg of energy, promoted the growth of probiotic bacteria such as *Lactobacillus casei*, and showed DPPH radical-scavenging activity (Munita et al., 2022). These mechanisms may partly explain the improved FCR observed in the present study; however, this interpretation should be treated cautiously because gut microbiota, short-chain fatty acid production, antioxidant status, and intestinal morphology were not directly measured.

The response may also be related to the fermentation of resistant starch in the hindgut. Resistant starch can escape digestion in the upper gastrointestinal tract and serve as a substrate for beneficial microbiota, leading to the production of short-chain fatty acids. These metabolites have been associated with intestinal integrity and nutrient absorption in previous studies, which may help explain the improved feed conversion observed in the present experiment. Nevertheless, this remains a literature-supported interpretation rather than a directly measured mechanism in the current study. Previous studies have shown that banana flour can be incorporated into broiler diets at up to 20% without adverse effects on growth performance (Dumorné et al., 2020). Similarly, banana peel meal has been reported to replace up to 10% of conventional ingredients such as maize without impairing productive performance, although excessive replacement levels may reduce efficiency (Abel et al., 2015).

Increasing green banana powder supplementation to 3% did not provide additional benefits compared with 2%. This response may indicate that excessive inclusion reduces the positive effect, possibly because higher dietary fiber levels can dilute nutrient density or reduce digestibility. Under the conditions of the present study, supplementation with 2% green banana powder appeared to be the most suitable level for improving feed efficiency in H'Mong chickens. The survival rate was not significantly affected by dietary treatment ($p>0.05$), although values were numerically higher in the supplemented groups. This finding suggests that green banana powder supplementation did not adversely affect chicken survival during the experimental period. Overall, the results indicate that moderate dietary supplementation with green banana powder, particularly at 2%, improved final body weight, average daily gain, and feed conversion efficiency in H'Mong chickens without affecting feed intake or survival rate.

3.2 Watery droppings and litter quality

Resistant starch derived from green bananas has been considered a promising prebiotic because it escapes enzymatic digestion in the upper gastrointestinal tract and reaches the hindgut, where it may support beneficial microbiota. Fermentation of resistant starch can produce short-chain fatty acids, which have been associated with intestinal function and host physiological stability in previous studies (Dibakoane et al., 2023). Although digestive stability is recognized as an important objective in poultry production, its practical assessment under field conditions remains difficult and poorly standardized (Bindari & Gerber, 2022). Subsequently, watery droppings incidence, wet-dropping days, and litter characteristics were used in the present study as practical, non-invasive indicators of fecal consistency and housing conditions. Wet litter is also recognized as an important problem in poultry production because it is associated with impaired flock health, reduced production efficiency, welfare concerns, and deterioration of the rearing environment (Dunlop et al., 2016).

As shown in Table 2, dietary supplementation with green banana powder significantly affected watery droppings incidence and litter characteristics in H'Mong chickens ($p<0.05$). The control group showed the highest incidence of watery droppings (18.33%), whereas supplementation reduced this parameter, with the lowest value observed in chickens receiving 2% green banana powder (7.50%). A similar pattern was observed for wet-dropping days, which decreased from 11.00 days/pen in the control group to 5.67 days/pen in the 2% group. These findings suggest that moderate supplementation with green banana powder improved fecal consistency under practical rearing conditions.

Table 2. Effects of dietary green banana powder supplementation on watery droppings incidence and litter quality of H'Mong chickens from 1 to 56 days of age (Mean ± SD)

Parameter	Control (0%)	1% GBP	2% GBP	3% GBP	*P-value*
Watery droppings incidence (%)	18.33 ± 2.89[a]	12.50 ± 2.50[b]	7.50 ± 1.44[c]	9.17 ± 1.44[bc]	0.003
Number of days with wet droppings (days/pen)	11.00 ± 1.01[a]	8.33 ± 0.58[b]	5.67 ± 0.58[c]	6.67 ± 0.58[bc]	0.002
Litter moisture (%)	32.8 ± 1.6[a]	29.6 ± 1.4[b]	26.9 ± 1.3[c]	28.1 ± 1.5[bc]	0.001
Litter quality score	3.67 ± 0.58[a]	2.67 ± 0.58[b]	1.67 ± 0.58[c]	2.00 ± 0.00[bc]	0.002
Odor score	3.33 ± 0.58[a]	2.67 ± 0.58[ab]	1.67 ± 0.58[b]	2.00 ± 0.00[b]	0.011

Means with different superscripts in the same row differ significantly (P<0.05). Litter quality score: 1 = dry and loose; 2 = slightly moist; 3 = moderately wet with slight caking; 4 = wet and caked. Odor score: 1 = very slight; 2 = slight; 3 = moderate; 4 = strong.

The reduction in watery droppings may be partly associated with the resistant starch and dietary fiber fractions of green banana powder. Mnisi et al. (2025) suggested that resistant starch from green banana may influence gut function through several pathways (Mnisi et al., 2025), including modulation of microbial activity and stimulation of short-chain fatty acid production. Previous poultry studies have also reported that banana-derived ingredients may support intestinal structure and barrier-related parameters. Sugiharto et al. (2018) and Sugiharto et al. (2023) observed increased villus height and villus height-to-crypt depth ratio in broilers receiving banana-derived ingredients (Sugiharto et al., 2018; Sugiharto et al., 2023), whereas Sugiharto et al. (2020) reported increased *Lactobacillus* spp. and reduced coliform populations in chickens supplemented with fermented banana peel meal (Sugiharto et al., 2020). In addition, resistant starch can be fermented by beneficial bacteria, such as *Lactobacillus* spp., producing short-chain fatty acids that have been associated with intestinal epithelial function and immunomodulatory responses (Li et al., 2022). These mechanisms may partly explain the improved fecal consistency observed in the present study. However, this interpretation should be cautiously treated because gut microbiota, intestinal morphology, inflammatory markers, and short-chain fatty acid production were not directly measured.

Litter moisture was also significantly affected by dietary treatment ($p<0.05$). Chickens receiving green banana powder showed lower litter moisture than the control group, with the lowest value observed at the 2% supplementation level (26.9%). This finding is practically important because excessive litter moisture is associated with deterioration of housing conditions and increased microbial proliferation. Poultry litter consists of excreta, bedding material, feathers, feed residues, and microorganisms and may influence environmental quality and interactions within the intestinal microbial ecosystem (Bindari & Gerber, 2022). Previous litter-related studies have mainly focused on pathogenic bacteria such as *Salmonella*, *Escherichia coli*, *Campylobacter*, and *Clostridium perfringens* (Bennett et al., 2005).

The lower litter moisture observed in supplemented groups was consistent with litter quality scoring results. Chickens in the control group had the poorest litter condition, with a litter quality score of 3.67, indicating a wet, partially caked litter. In contrast, the 2% supplementation group had the best litter condition, with a score of 1.67, indicating a dry, loose litter. Odor score was also lower in supplemented groups, suggesting reduced litter deterioration under practical farm conditions. However, ammonia concentration was not directly measured; therefore, the odor score should be interpreted only as a subjective indicator of litter condition rather than as evidence of reduced ammonia emission.

The chemical composition of green banana-derived products may further support these responses. Tribess et al. (2009) reported that green banana flour contains approximately 52.7–54.2 g/100 g resistant starch and 6.3–15.5 g/100 g dietary fiber on a dry matter basis (Tribess et al., 2009). In addition, green banana-derived products contain phenolic compounds, flavonoids, vitamins, and minerals that may contribute to their functional properties (Ferreira & Tarley, 2020). These nutritional and bioactive characteristics may help support fecal consistency and reduce moisture excretion, thereby improving litter condition.

Increasing the supplementation level to 3% did not provide additional benefits compared with 2%. This response may indicate that excessive inclusion reduces the positive effect, possibly because higher dietary fiber levels can limit nutrient digestibility or alter gastrointestinal transit dynamics. Under the conditions of the present study, supplementation with 2% green banana powder appeared to be the most suitable level for improving watery droppings-related indicators and litter quality in H'Mong chickens.

Overall, the findings suggest that moderate supplementation with green banana powder improved feed efficiency, fecal consistency, and litter condition in H'Mong chickens raised under practical tropical production conditions.

4 Conclusion

Under the conditions of the present study, dietary supplementation with green banana powder improved final body weight, average daily gain, feed conversion ratio, watery droppings-related indicators, and litter condition in H'Mong chickens. Chickens receiving 2% green banana powder showed the most favorable overall response, including improved feed efficiency, lower incidence of watery droppings, fewer wet-dropping days, lower litter moisture, and better litter quality scores. Increasing the supplementation level to 3% did not provide additional benefits, suggesting that excessive inclusion may reduce the positive response, possibly because of higher dietary fiber levels. Therefore, supplementation with 2% green banana powder appears to be a practical feeding strategy for improving productive performance and litter condition in H'Mong chickens raised under tropical farm conditions.

Nevertheless, the present study was limited by the absence of direct analyses of green banana powder composition, complete laboratory nutrient analysis of experimental diets, gut microbiota, intestinal morphology, short-chain fatty acid production, pathogen load, and ammonia concentration. Consequently, the proposed mechanisms related to resistant starch fermentation, microbial modulation, and digestive stability should be interpreted cautiously and confirmed in further studies.

Use of Artificial Intelligence

Generative AI tools were not used to generate scientific content, data, analyses, interpretations, or conclusions. AI-assisted technology was only used for minor language editing. The authors take full responsibility for the accuracy, integrity, and final content of the manuscript.

Conflict of Interest

We declare that no conflict of interest.

Author Contributions

N.T.M.P.: Methodology, formal analysis, and writing – original draft. P.N.: Conceptualization, data curation, supervision, and writing – review and editing. All authors reviewed and approved the final manuscript.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Ethical Considerations

This study was a farm-based feeding trial that included routine dietary supplementation and non-invasive measurements. Formal animal ethics approval was not required according to local institutional practice because no blood sampling, surgical procedures, euthanasia, necropsy, experimental disease challenge, or other painful interventions were performed. All animal care, handling, feeding, and monitoring procedures complied with the Law on Animal Husbandry of Vietnam (No. 32/2018/QH14), issued by the National Assembly of the Socialist Republic of Vietnam. Animal welfare was daily monitored and ensured throughout the experimental period.

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