Research Article

Effect of Sweet Basil Leaf Waste Meal (*Ocimum basilicum* L.) on Gas Emission, Physiological Responses and Production Performance of Quail

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Abstract | The thermoneutral zone for poultry ranges between 20°C and 24°C. The ambient temperature in Indonesia, especially during the day, reaches 35°C. This temperature is above the comfort zone for poultry, causing heat stress which leads to oxidative stress. This condition affects the reduction of NH_3 and H_2S production from excreta, physiological responses, and production performance of quail. One way to overcome this is by adding antioxidants. Sweet basil (*Ocimum basilicum* L.) is a plant that contains bioactive compounds that act as a source of natural antioxidants. This study evaluated sweet basil leaf waste meal supplementation on NH_3 and H_2S production, physiological responses, and performance of quail. The study used 200 quails that were given 4 levels of sweet basil leaf waste meal (0%, 1.5%, 3% and 4.5%) with 5 replicates for 5 weeks. The parameters measured included NH_3 and H_2S production of excreta, physiological responses, hematological values, and production performance. Data were analyzed using one-way analysis of variance (ANOVA), and differences among treatments were determined using Duncan's multiple range test at $p<0.05$. The results showed that supplementation with sweet basil leaf waste meal at 3% and 4.5% significantly reduced NH_3 production ($p<0.05$), whereas H_2S production was significantly reduced by all supplementation levels compared with the control ($p<0.05$). The lowest NH_3 and H_2S values were recorded in T2 and T3. However, supplementation did not significantly affect ($p>0.05$) the physiological responses or production performance of quails. Nevertheless, oxygen saturation numerically increased from 87.74% in the control group to 92.90% in T2, resulting in values within the normal physiological range. Nevertheless, treatment T2 tended to provide better physiological responses and lower feed conversion rates. Supplementation of sweet basil leaf waste meal at a 3% level (T2) significantly reduced NH_3 and H_2S production of quail excreta.

Keywords | Sweet basil leaf waste meal, H_2S production, NH_3 production, Physiological responses, Production performance, Quail

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INTRODUCTION

Quail (*Coturnix coturnix japonica*) is a type of poultry widely cultivated in Indonesia. They produce 250–300 eggs per year (Amo *et al*., 2013). Quail productivity is generally influenced by two factors: Genetics and the environment. One environmental factor is microclimate (Utama *et al*., 2021). Microclimate consists of several elements, one of which is environmental temperature (Fajri and Ngatiman, 2017; Jumadin *et al*., 2024). The environmental temperature in Indonesia is 23-36°C (BMKG, 2023), whereas the comfort zone for poultry is 20-24°C (Ulupi *et al*., 2016). This high environmental temperature causes quail to experience heat stress, which in turn leads to oxidative stress. Oxidative stress is a condition of imbalance between free radical production and antioxidant activity in the body (Maheshwari *et al*., 2017; Jumadin *et al*., 2022). According to Dorovskikh *et al*. (2023), extreme environmental changes can lead to behavioral and physiological changes. Zulkifli *et al*. (2018) reported that quail exposed to heat stress increase their water intake to maintain body fluid balance. Increased water consumption accelerates the digestive process, resulting in wetter excreta (Aggrey *et al*., 2023). Moist litter conditions combined with high environmental temperatures promote the activity of decomposing bacteria, such as *Proteus* spp., which degrade nutrients present in the excreta. This process can increase the production of ammonia (NH_3) and hydrogen sulfide (H_2S) from quail excreta, thereby potentially deteriorating air quality. One approach to mitigate oxidative stress is supplementation of antioxidants and antimicrobial compounds (Anwar *et al*., 2020). Natural sources of antioxidant and antimicrobial compounds can be derived from various plants, including sweet basil.

Sweet basil (*Ocimum basilicum* L.) is a soft-stemmed plant commonly found in tropical regions. Sweet basil is almost the same as lemon basil. According to various references, both belong to the same genus, *Ocimum*, but differ at the species level. Sweet basil is classified as *Ocimum basilicum* L., whereas lemon basil is classified as *Ocimum africanum* L. (Azizah *et al*., 2023; Yadav *et al*., 2025). Lemon basil has often been used as a supplement in animal feed, particularly in poultry feed. The inclusion of lemon basil leaf meal in quail diets during the growing period at levels of 0%, 0.5%, 1.0%, and 1.5% has been evaluated. The results showed that supplementation at the 1.5% level produced the best feed conversion ratio (Aly *et al*., 2024). This finding was not used as a direct basis for dosage determination but as a supportive reference for establishing the inclusion range. To date, sweet basil has primarily been utilized for its seeds, which are commonly used as ingredients in beverages (Munir *et al*., 2017). After seed harvesting, the remaining plant parts, including the leaves, are generally discarded as agricultural waste. Sweet basil leaf waste meal contains various bioactive compounds, such as flavonoids, phenolics, and tannins, which possess antioxidant and antimicrobial properties (Pandey *et al*., 2023). These compounds may improve physiological condition of birds and reduce the formation of NH_3 and H_2S in excreta. Although lemon basil leaf meal has been reported to improve quail performance (Aly *et al*., 2024), information regarding the use of sweet basil leaf waste meal and its effects on NH_3 and H_2S production in excreta, physiological responses, and production performance of quail remains limited. Therefore, this study aimed to evaluate the effects of dietary supplementation with sweet basil leaf waste meal on NH_3 and H_2S production in excreta, physiological responses, and production in laying quail.

MATERIALS AND METHODS

Time and location

This research was conducted at several locations, namely at Arkan Quail Farm, the Biopharmaceutical Study Center Laboratory of IPB, PT Saraswanti Indo Genetech (SIG), the Environmental Research Center Laboratory of IPB, and the Animal Hospital and Education Center of IPB. The procedures followed the regulations of the Animal Ethics Commission of the School of Veterinary Medicine and Biomedicine of IPB (No. 371/KEH/SKE/IX/2025).

Research tools and materials

This research used a total of 20 cages. Each cage measured 50 × 75 × 36 cm and contained 10 quails. Cage equipment included a feeder, a drinker, an incandescent lamp, and a thermometer. A total of 200 female quails aged 6 weeks were used in this study. The materials used were commercial feed New Hope P100 (crude protein 17%, metabolizable energy 2800 kcal/kg) and sweet basil leaf waste meal. The tools and materials used for laboratory testing were adjusted to the observed parameter procedures.

Preparation of sweet basil leaf waste meal

Sweet basil leaves were obtained from commercial farmers in Lamongan Regency, East Java, Indonesia. The production of sweet basil leaf waste meal began with harvesting sweet basil plants at optimal maturity by local farmers. The harvested sweet basil plants were sun-dried until the leaves wilted, then separated from the stems. Then, sorting was carried out to separate the leaves from the unnecessary parts. The sweet basil leaf waste that was not utilized by the farmers was dried and then ground into sweet basil leaf waste meal. Afterwards, phytochemical and proximate analyses were carried out.

Experimental design

This study used a completely randomized design. Feed was provided twice daily, while drinking water was offered ad libitum. Temperature recording in the cage was carried out daily, namely in the morning (6:00-7:00 a.m.), afternoon (12:00-1:00 p.m.), and evening (4:00-5:00 p.m.). The quail used were 200 birds aged 6 weeks. 3 birds were randomly selected from each cage for physiological measurements, and the values were averaged to represent the cage as the experimental unit. The feed used was New Hope P100 commercial feed with sweet basil leaf waste meal. This study consisted of 4 treatments and 5 replicates: T0 (0% sweet basil leaf waste meal), T1 (1.5% sweet basil leaf waste meal), T2 (3% sweet basil leaf waste meal), and T3 (4.5% sweet basil leaf waste meal).

Research procedures

The initial stage of the research procedure included the determination of ammonia (NH_3) and hydrogen sulfide (H_2S) production in quail excreta. Fresh excreta samples (100 g) were collected from each experimental unit using clean gloves and a spatula, placed in labeled airtight containers, and immediately analyzed. Ammonia (NH_3) and hydrogen sulfide (H_2S) concentrations were determined using modified methods based on SNI 19-7119.1-2005 and SNI 7119.11:2007, respectively. Each excreta sample (100 g) was placed in an Erlenmeyer flask and connected to a second Erlenmeyer flask containing 10 mL of absorbent solution through a tubing system equipped with an aerator. The closed system was incubated for 24 h to facilitate the transfer and absorption of gases released from the excreta into the absorbent solution. Following incubation, the absorbent solution was analyzed using a spectrophotometer at wavelengths of 630 nm for NH_3 and 670 nm for H_2S. Prior to sample analysis, calibration curves were prepared using standard solutions of known concentrations. The concentrations of NH_3 and H_2S were calculated from the absorbance values based on the respective calibration curves and expressed as parts per million (ppm). The physiological response parameters measured included oxygen saturation, respiratory rate, and rectal temperature. Oxygen saturation was measured using a pulse oximeter according to the method of Jumadin *et al.* (2022). The sensor was placed on the plantar surface (footpad) of the quail under standardized handling conditions to minimize stress and movement artifacts, ensuring stable signal acquisition. Respiratory rate was obtained by counting chest movements for one minute. Rectal temperature was measured by inserting a digital thermometer into the quail's rectum to a depth of ±1/3 of the thermometer's length, as described by Hakim *et al.* (2021). Blood samples were taken for analysis of the quail's hematological values. Production performance was monitored using feed consumption, egg production, feed conversion ratio, and mortality. Feed consumption was calculated as the difference between the daily feed intake and the remaining feed (g/bird/day). Egg production was calculated using the quail-day egg production method by dividing the total number of eggs produced by the total number of quail-days during the observation period and multiplying the result by 100. Egg weight was calculated by averaging the total egg weights. Feed conversion ratio was calculated by dividing feed consumption (g) divided by egg mass produced (g). Mortality was calculated by calculating the number of quails that died. Production performance was monitored from the first day to the end of the study period.

Research variables

The gas production in quail excreta was measured based on the concentrations of ammonia (NH_3) and hydrogen sulfide (H_2S). Physiological responses were measured, including oxygen saturation, respiratory rate, and rectal temperature. Hematological values included erythrocytes, hemoglobin, hematocrit, erythrocyte indices, namely Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC), total leukocytes and differential leukocyte count (heterophils, lymphocytes, monocytes, basophils and eosinophils). Production performance was monitored through feed consumption, egg production, feed conversion ratio and mortality.

Data analysis

Data were analyzed using SPSS software (version 25). Prior to analysis, data were tested for normality using the Shapiro–Wilk test and for homogeneity of variance using Levene's test. Data that met the assumptions were subjected to one-way analysis of variance (ANOVA). When a significant treatment effect was detected, mean comparisons were performed using Duncan's multiple range test. Differences were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

Temperature and humidity in quail cages

The environmental conditions observed during quail rearing included temperature and humidity. The results of these measurements are presented in Table 1. Temperatures from morning to evening was above the poultry comfort zone. According to Rini *et al.* (2019), the optimum humidity for quail is 50–70%. Although morning relative humidity (78–85%) exceeded the optimum range for quail (50–70%), the ambient temperature during the same period was only slightly above the comfort zone (24.5–27.2°C). Therefore, the negative effect of high humidity on evaporative heat loss through panting may have been limited during the morning period and likely less pronounced than under conditions of both high temperature and high humidity. Consequently, the ability of quails to dissipate body heat through panting was likely not severely compromised during the morning period. High environmental temperatures trigger heat stress, characterized by panting. This heat stress can progress to oxidative stress. Oxidative stress occurs when the number of free radicals exceeds the body's antioxidant capacity (Maheshwari *et al.*, 2017). Treatment measures are needed, including administering sweet basil leaf waste meal as a natural antioxidant to reduce the effects of this stress.

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Table 1: Temperature and humidity in quail cages.

Parameters	Morning	Afternoon	Evening
Temperature (°C)	24.5-27.2	30.4-32.7	26.6-32.0
Humidity (%)	78-85	60-73	54-79

Phytochemical and nutritional analysis of sweet basil leaf waste

The phytochemical and proximate composition of sweet basil leaf waste meal was quantitatively analyzed. The results of the phytochemical analysis in Table 2 indicate that sweet basil leaf waste meal contains bioactive compounds, including flavonoids, phenolics, and tannins. The phenolic content was the highest. Flavonoids are compounds derived from polyphenols (Hussain *et al.*, 2022). Phenolic compounds primarily enhanced the physiological responses of quail through their antioxidant properties. Flavonoids had antioxidant properties and the potential to inhibit bacterial growth (Salim *et al.*, 2018). Flavonoids may contribute to maintaining immune function and physiological status in quail. Tannins have antioxidant properties and the ability to scavenge free radicals (Fraga-Corral *et al.*, 2021). The reduction in NH_3 and H_2S production may be associated with the combined effects of bioactive compounds present in sweet basil leaf waste meal, including phenolics, flavonoids, and tannins. However, the specific mechanisms underlying the reduction in gas emissions were not investigated in the present study.

Table 2: Results of phytochemical analysis of sweet basil leaf waste.

Components	Results (%)
Flavonoids	0.64
Phenolics	5.38
Tannins	0.05

Table 3: Nutritional content of sweet basil leaf waste meal.

Components	Results
Protein (%)	14.50
Crude Fiber (%)	13.80
Water (%)	11.30
Ash (%)	12.92
Fat (%)	3.61
Fe (mg 100 g^{-1})	29.00

The nutritional content of sweet basil leaf waste meal is presented in Table 3. The protein content of sweet basil leaf waste meal was quite high at 14.50%, suggesting it would increase the protein content of the feed. The fiber content in sweet basil leaf waste meal reached 13.80%. Crude fiber cannot be digested by poultry (Kheravii *et al.*, 2018). This condition is caused by the absence of the cellulase enzyme, which degrades cellulose components (Prawitasari *et al.*, 2012). Therefore, the amount and proportion of sweet basil leaf waste meal in feed must be regulated appropriately to avoid disrupting the health and productivity of quail. Sweet basil leaf waste meal contained 29 mg/100 g Fe. This Fe content may contribute to hemoglobin synthesis and erythropoiesis, thereby improving oxygen transport capacity and supporting the physiological and hematological status of quail (Feijo *et al.*, 2024).

Gas emission

Data on NH_3 and H_2S production in quail excreta are presented in Table 4. The results of the study showed that the provision of sweet basil leaf waste meal in feed had a significant effect ($p<0.05$) on NH_3 production in quail excreta. Treatments T2 and T3 did not differ significantly, but both were significantly different from the control treatment (T0). NH_3 is a gas resulting from the decomposition of nitrogenous waste materials in excreta such as unabsorbed protein (Bist *et al.*, 2023). The higher the undigested protein content, the higher the NH_3 concentration. This finding aligns with previous research that reported that the addition of 9 g/kg of moringa leaf meal significantly reduced ammonia levels ($p<0.05$) in broiler chickens (Amin *et al.*, 2022). The reduction in NH_3 production observed in the present study may be attributed to the tannin content of sweet basil leaves. Previous studies have suggested that tannins can form complexes with proteins and may contribute to the suppression of proteolytic and urease-producing microorganisms in the digestive tract and excreta (Adamczyk *et al.*, 2017; Besharati *et al.*, 2022). This mechanism may reduce protein degradation and the conversion of nitrogenous compounds into ammonia, thereby decreasing NH_3 production (Vazifehkhoran *et al.*, 2024). In the present study, the lack of effect at 1.5% and the significant reductions at 3% and 4.5% suggest a possible threshold response, where the lower dose was insufficient to influence NH_3 formation, while higher levels were effective. The results showed that the addition of sweet basil leaf waste meal in feed had

Table 4: Mean gas emission in the excreta of quail supplemented with sweet basil leaf waste meal in feed.

Parameters	T0	T1	T2	T3
NH_3 (ppm)	$130,21 \pm 1,47^b$	$129,04 \pm 1,31^b$	$100,07 \pm 2,36^a$	$99,07 \pm 2,71^a$
H_2S (ppm)	$0,073 \pm 0,013^b$	$0,023 \pm 0,002^a$	$0,020 \pm 0,007^a$	$0,018 \pm 0,004^a$

Note: Different superscripts on the same row indicate significant differences ($p<0.05$); T0: without sweet basil leaf waste meal (control); T1: 1.5% sweet basil leaf waste meal; T2: 3% sweet basil leaf waste meal; T3: 4.5% sweet basil leaf waste meal.

a significant effect ($p<0.05$) on H_2S production in quail excreta. Treatments T1, T2, and T3 were significantly different from the control treatment (T0), indicating that the addition of sweet basil leaf waste meal significantly reduced the accumulation of harmful gases in quail excreta. H_2S is the result of the breakdown of sulfur-containing amino acids contained in excreta (Tran *et al.*, 2023). Sulfur is primarily found in cysteine and methionine. Adding sweet basil leaf waste meal to quail feed increases nutrient absorption efficiency. The amount of undigested amino acids excreted through excreta is reduced (Hossain *et al.*, 2024). In addition, tannins possess antimicrobial properties that can suppress the growth of putrefactive microorganisms involved in the decomposition of sulfur-containing amino acids (Cao *et al.*, 2024). This condition reduces H_2S formation during the fermentation of excreta. As a result, NH_3 and H_2S production from the excreta of quail supplemented with sweet basil leaf waste meal were lower. Therefore, reduction in NH_3 and H_2S production observed in the excreta of quail supplemented with sweet basil leaf waste meal indicates a lower generation of noxious gases. The tannin content, which may inhibit protein degradation and the activity of gas-producing microorganisms, is likely one of the factors contributing to the reduction in NH_3 and H_2S production. The decreased production of these gases may also reduce their potential release into the atmosphere, thereby contributing to improved air quality in poultry production environments. From a practical perspective, these findings suggest that sweet basil leaf waste meal could be used as a feed additive to reduce NH_3 and H_2S production while providing a value-added use for an underutilized agricultural by-product in quail production systems.

Physiological responses

The results of observations of the physiological responses of quail are presented in Table 5. The supplementation of sweet basil leaf waste meal in quail feed had no significant effect on oxygen saturation, respiratory rate and rectal temperature ($p>0.05$). Although dietary sweet basil leaf waste meal did not significantly affect oxygen saturation, numerically higher mean oxygen saturation values were observed in T1 and particularly in T2 compared with the control. Oxygen saturation increased from 87.74% in T0 to 92.90% in T2, whereas a slight decrease was observed in T3. This numerical trend may suggest a potential improvement in blood oxygenation at the moderate inclusion level of sweet basil leaf waste meal. The observed tendency could be partly related to the Fe content of sweet basil leaf waste meal, as Fe is essential for hemoglobin synthesis and oxygen transport (Morgan *et al.*, 2026). According to Abu *et al.* (2024), oxygen saturation below 90% indicates hypoxemia. Accordingly, the mean oxygen saturation values in T1 and T2 exceeded this threshold, whereas the mean value of the control group remained below it. However, because these differences were not statistically significant, the observed numerical trend should be interpreted with caution. The respiratory rate of the quail in this study was above the normal range. The average respiratory rate in this study ranged from 48 to 51 breaths/minute. This result is above the normal range. The normal respiratory rate in poultry is 20-30 breaths/minute (Iftitah *et al.*, 2022). The high respiratory rate was caused by the environmental temperature conditions being above the quail's comfort zone. Panting is the primary mechanism for evaporative heat loss through the respiratory tract when the ambient temperature rises (Aryani *et al.*, 2021). Although respiratory rate remained relatively high in all treatments, rectal temperature was maintained within the normal physiological range, suggesting that panting contributed to thermoregulation under heat exposure. The numerically higher oxygen saturation observed in T2 was not accompanied by a statistically significant reduction in respiratory rate, indicating that the improved oxygen saturation did not result in measurable changes in respiratory rate under the conditions of this study. Observations of rectal temperatures showed that all treatment groups remained within the normal physiological range for quail, which is around 40 °C to 41°C. Despite the high ambient temperatures during the experimental period, rectal temperature remained within this range, while respiratory rate was relatively high (48.0–51.0 breaths/min). These findings suggest that the quails maintained body temperature through panting, the primary thermoregulatory mechanism in birds. Therefore, the normal rectal temperature observed in this study likely reflects successful thermoregulation rather than the absence of thermal challenge.

Table 5: Mean oxygen saturation, respiratory rate, and rectal temperature of quail supplemented with sweet basil leaf waste meal in feed.

Parameters	T0	T1	T2	T3
Oxygen Saturation (%)	87,74 ± 7,42	90,64 ± 5,64	92,90 ± 4,59	89,50 ± 1,12
Respiratory Rate (bird/minute)	51,0 ± 3,52	48,5 ± 2,54	48,0 ± 2,21	50,0 ± 3,11
Rectal Temperature (°C)	40,71 ± 0,38	40,67 ± 0,21	40,84 ± 0,31	40,85 ± 0,46

Note: T0: without sweet basil leaf waste meal (control); T1: 1.5% sweet basil leaf waste meal; T2: 3% sweet basil leaf waste meal; T3: 4.5% sweet basil leaf waste meal.

Hematological values

The results of observations of quail hematological values are presented in Table 6. Dietary supplementation with sweet basil leaf waste meal had no significant effect on any hematological parameters ($p > 0.05$). The observed hematological values include erythrocyte counts, hemoglobin, hematocrit, erythrocyte indices, leukocyte counts, and differential leukocyte count. Higher levels of sweet basil leaf waste meal increased the number of erythrocytes, hemoglobin and hematocrit concentrations, and increased the erythrocyte indices (MCV, MCH and MCHC). The average leukocyte count was in the normal range, namely 17.20-22.91×10^3/mm^3. The average percentages of heterophils, lymphocytes, monocytes, eosinophils, and basophils were within the normal range. Erythrocytes are the main type of blood cell that function in the transfer of oxygen and nutrients throughout the body (Kuhn *et al*., 2017). Increasing the level of sweet basil leaf waste meal in the feed increased the number of erythrocytes, hemoglobin concentration, and hematocrit, and maintained them within the normal range. The Fe content in sweet basil leaf waste meal may contribute to hemoglobin synthesis and erythropoiesis, thereby enhancing oxygen transport capacity in quail (Morgan *et al*., 2026). An increase in hematocrit indicates an increase in erythrocyte size. This condition helps red blood cells maximize their function of carrying oxygen to cells and carbon dioxide from cells to the lungs, thus improving metabolic processes (Zoneff *et al*., 2024). Increasing the level of sweet basil leaf waste meal in quail feed has been shown to increase erythrocyte indices, including MCV, MCH, and MCHC. Leukocytes are blood components that play a role in the body's immune system. The average leukocyte count in this study was within the normal range, namely 17.20-22.91x10^3/mm^3 (Agustono *et al*., 2025), indicating that leukocytes have the same potential in maintaining body immunity. The results showed that the average percentage of heterophils, lymphocytes, monocytes, eosinophils, and basophils was within the normal range, indicating that the health status and immune system of the quail were not affected by the addition of sweet basil leaf waste meal. The relatively large standard deviation values observed for several hematological parameters suggest substantial individual variation among birds, which may have reduced the statistical power to detect significant treatment effects. Thus, it can be concluded that supplementation with sweet basil leaf waste meal to this level is safe and does not have a negative impact on the physiological performance of the quail.

Table 6: Hematological values of quail supplemented with sweet basil leaf waste meal in feed.

Parameters	T0	T1	T2	T3
Erythrocytes (10^6/mm^3)	2,82 ± 0,72	2,64 ± 1,11	2,78 ± 0,41	3,12 ± 1,16
Hemoglobin (g/dL)	8,42 ± 2,21	9,30 ± 3,08	9,78 ± 3,83	10,42 ± 3,99
Hematocrit (%)	33,29 ± 6,40	33,30 ± 12,57	34,07 ± 6,72	41,62 ± 16,23
Erythrocytes index				
MCV (fL)	123,56 ± 11,07	129,04 ± 15,93	129,54 ± 7,39	132,64 ± 6,26
MCH (Pg)	33,24 ± 3,21	36,66 ± 4,17	37,38 ± 4,01	33,48 ± 1,92
MCHC (g/dL)	27,37 ± 1,25	28,48 ± 2,33	28,78 ± 1,87	25,18 ± 0,88
Leukocytes (10^3/mm^3)	22,74 ± 10,27	17,64 ± 2,09	18,14 ± 4,50	18,32 ± 5,24
Differential Leukocyte Count				
Heterophils (%)	28,40 ± 13,16	26,60 ± 8,73	27,80 ± 14,45	26,40 ± 15,22
Lymphocytes (%)	62,60 ± 20,68	65,60 ± 10,09	63,40 ± 16,61	63,00 ± 16,26
Monocytes (%)	2.80 ± 0.84	4.00 ± 1.58	4.60 ± 2.17	5.20 ± 3.90
Eosinophils (%)	6,20 ± 8,29	3,80 ± 1,95	4,20 ± 2,28	5,40 ± 4,11
Basophils (%)	ND	ND	ND	ND

Note: T0: without sweet basil leaf waste meal (control); T1: 1.5% sweet basil leaf waste meal; T2: 3% sweet basil leaf waste meal; T3: 4.5% sweet basil leaf waste meal; ND: Not Detected.

Table 7: Production performance of quail supplemented with sweet basil leaf waste meal in feed.

Parameters	T0	T1	T2	T3
Feed intake (g/bird/day)	24,85 ± 1,63	24,32 ± 2,23	24,22 ± 0,97	24,58 ± 1,65
Egg production (%)	67,92 ± 7,93	62,03 ± 9,15	67,40 ± 6,87	77,35 ± 8,45
Egg weight (g/egg)	10,75 ± 0,37	10,85 ± 0,35	11,10 ± 0,38	10,78 ± 0,28
Feed conversion ratio	2,31 ± 0,17	2,24 ± 0,15	2,18 ± 0,08	2,28 ± 0,15
Mortality (%)	0	0	0	0

Note: T0: without sweet basil leaf waste meal (control); T1: 1.5% sweet basil leaf waste meal; T2: 3% sweet basil leaf waste meal; T3: 4.5% sweet basil leaf waste meal.

Production performance

The results of observations of quail production performance are presented in Table 7. Parameters observed included feed consumption, egg production, egg weight, feed conversion ratio, and mortality. Dietary sweet basil leaf waste meal had no significant effect on feed consumption, egg production, egg weight, feed conversion ratio and mortality ($p>0.05$). Mean values were similar across treatments, although T2 tended to produce slightly heavier eggs. The lowest feed conversion ratio value (best efficiency) was found in T2. All treatment groups had 0% mortality rate during maintenance. Average feed consumption was relatively uniform across all treatments. According to Fadhila *et al.* (2023), feed consumption is influenced by quail age, environmental temperature, and metabolizable energy in the feed. The consistent energy content and ambient temperature in this study resulted in consistent feed consumption. The T3 treatment showed slightly higher average egg production than the other treatments. Adding sweet basil leaf waste meal increased the feed protein content. Protein is an essential macronutrient in the growth process, providing amino acids to support tissue growth (Xiong *et al*., 2023). Sweet basil leaf bioactive compounds have the potential to suppress oxidative stress and support reproductive function, thereby improving production performance. The relatively small difference in egg weight indicates that adding sweet basil leaves did not significantly affect egg size. Treatment T2 tended to produce slightly higher egg weights than the other treatments. A lower feed conversion ratio (FCR) reflects greater feed utilization efficiency (Yi *et al*., 2018). In the present study, treatment T2 exhibited the lowest FCR among all treatments (2.18), representing an approximately 5.6% improvement compared with the control group (2.31). Although the difference was not statistically significant ($p>0.05$), the numerical reduction suggests improved feed utilization efficiency for egg production. Improved feed utilization efficiency has the potential to reduce feed costs and increase profitability for farmers, as feed represents the largest component of poultry production costs. All treatment groups showed zero mortality during rearing, confirming that the use of sweet basil leaf waste meal in quail feed is safe and does not negatively impact the health or survival of the birds.

CONCLUSIONS

Sweet basil leaf waste meal contains phytochemical compounds with reported antioxidant properties and may have potential as a functional feed ingredient. The supplementation of sweet basil leaf waste meal did not show significant effects on the physiological responses and production performance of quail. Supplementation with 3% and 4.5% sweet basil leaf waste meal (T2 and T3) significantly reduced NH_3 production in quail excreta compared with the control, whereas supplementation with 1.5%, 3%, and 4.5% significantly reduced H_2S production in quail excreta. Future studies should focus on evaluating sweet basil leaf waste meal supplementation in poultry species other than quail, such as chickens and ducks, to determine the consistency of its effects on gas emission, physiological responses, and production performance.

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NOVELTY STATEMENT

This study demonstrates the potential of sweet basil leaf waste meal (*Ocimum basilicum* L.), an underutilized agricultural by-product, as a functional feed additive for laying quail to reduce NH_3 and H_2S production from excreta while maintaining physiological status and production performance under tropical rearing conditions. By integrating environmental, physiological, productive, and economic evaluations, this study provides a comprehensive assessment of sweet basil leaf waste meal as a sustainable waste-to-feed strategy for improving environmental sustainability in quail production

AUTHOR'S CONTRIBUTION

Conceptualization and methodology: NU, MS, HM. Investigation, resources, and data curation: MS, W. Formal analysis, software and visualization: MS. Funding acquisition and supervision and writing review and editing: NU, HM. Writing original draft: MS, HM.

Generative AI and AI assisted technology statement

The authors declare that no generative AI and AI assisted technology was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abu K, Khraiche ML, Amatoury J (2024). Obstructive sleep apnea diagnosis and beyond using portable monitors. Sleep Med., 113: 260-274. https://doi.org/10.1016/j.sleep.2023.11.034

Adamczyk B, Simon J, Kitunen V, Adamczyk S, Smolander A (2017). Tannins and their complex interaction with different organic nitrogen compounds and enzymes: Old paradigms versus recent advances. Chem. Open., 6(5): 610-614. https://doi.org/10.1002/open.201700113

Aggrey SE, Ghareeb AFA, Milfort MC, Ariyo OW, Aryal B, Hartono E, Kwakye J, Sovi S, Hipple SA, Stevenson C, Fuller AL, El Sabry MI, Stino F, Rekaya R (2023). Quantitative and molecular aspects of water intake in meat-type chickens. Poult. Sci., 102(11): 1-10. https://doi.org/10.1016/j.psj.2023.102973

Agustono B, Yunita MN, Lokapirnasari WP, Warsito SH, Marbun TD, Windria S (2025). Dietary supplementation of microbiota inoculum and single clove garlic extract on growth performance, egg quality, reproductive organ, and hematological trait in laying quail. Open Vet. J., 15(2): 690–699. https://doi.org/10.5455/OVJ.2025.v15.i2.17

Aly MM, Bahnas MS, Soliman SIR (2024). Effect of basil leaves powder on productive and physiological performance in growing Japanese quail. J. Agric. Res. Dev., 38(3): 512-523. https://doi.org/10.21608/fjard.2024.301364.1056

Amin RF, Hertamawati RT, Muhammad N, Syahniar TM, Mahanani RS, Farlinda S, Rahmasari R (2022). Addition of moringa leaf powder (*Moringa oleifera*) feed additive to mitigate ammonia on carcass quality and abdominal fat in broiler chickens. Proc. Conf. Appl. Anim. Sci., 3: 142-147. https://doi.org/10.25047/animpro.2022.349

Amo M, Saerang MN, Keintjem J (2013). Effect of turmeric (*Curcuma domestica* Val.) powder supplementation in the diet on egg quality of Japanese quail (*Coturnix coturnix japonica*). Zootec., 33(1): 48-57. https://doi.org/10.35792/zot.33.1.2013.3335

Anwar P, Jiyonto, Santi MA (2020). Broiler growth performance with andaliman (*Zanthoxylum acanthopodium* DC) supplementation as an additive in feed. J. Trop. Anim. Prod., 21(2): 246-252. https://doi.org/10.21776/ub.jtapro.2020.021.02.8

Aryani A, Solihin DD, Sumantri C, Afnan R, Sartika T (2021). Physiological response of KUB (Kampung Unggul Balitbangtan) chickens and walik chickens with different HSP70 gene haplotypes exposed to acute heat stress. Indones. J. Agric. Sci., 26(2): 276-283. https://doi.org/10.18343/jipi.26.2.276

Azizah NS, Irawan B, Kusmoro J, Safriansyah W, Farabi K, Oktavia D, Doni F, Miranti M (2023). Sweet basil (*Ocimum basilicum* L.) A review of its botany, phytochemistry, pharmacological activities, and biotechnological development. Plants, 12(24): 1-25. https://doi.org/10.3390/plants12244148

Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) (2023). Indonesian weather forecast data. https://www.bmkg.go.id. Accessed on December 2025.

Badan Standardisasi Nasional (2005). Ambient air – Part 1: Test method for ammonia (NH_3) using the indophenol method by spectrophotometry. SNI 19-7119.1-2005. Jakarta, Indonesia: Badan Standardisasi Nasional.

Badan Standardisasi Nasional (2007). Ambient air Part 11: Test method for hydrogen sulfide (H_2S) using a spectrophotometer. SNI 7119.11: 2007. Jakarta, Indonesia: Badan Standardisasi Nasional.

Besharati M, Maggiolino A, Palangi V, Kaya A, Jabbar M, Eseceli H, De Palo P, Lorenzo JM (2022). Tannin in ruminant nutrition: Review. Molecules, 27(23): 8273. https://doi.org/10.3390/molecules27238273

Bist RB, Subedi S, Chai L, Yang X (2023). Ammonia emissions, impacts, and mitigation strategies for poultry production: A critical review. J. Environ. Manage., 328: 1-31. https://doi.org/10.1016/j.jenvman.2022.116919

Cao Q, Liu X, Wang Q, Liu Z, Xia Y, Xun L, Liu H (2024). Rhodobacteraceae methanethiol oxidases catalyze methanethiol degradation to produce sulfane sulfur other than hydrogen sulfide. mBio., 15(3): 1-16. https://doi.org/10.1128/mbio.02907-23

Dorovskikh IG, Yurasov AA (2023). The influence of extreme living conditions and physical exertion on the formation of adaptive shifts in a number of physiological systems of the body. Sci. Med. Bull. Ugra., 36: 11-15. https://doi.org/10.25017/2306-1367-2023-36-2-11-15

Fadhila RM, Ulupi N, Maheshwari H (2023). Utilization of coconut shell liquid smoke on quail performance at grower period. J. Anim. Prod. Technol., 11(3): 163-169. https://doi.org/10.29244/jipthp.11.3.163-169

Fajri M, Ngatiman (2017). Study of microclimate and topography in the habitat of *Parashorea malanonan* Merr. J. Dipterocarp. Ecosyst. Res., 3(1): 1-12. https://doi.org/10.20886/jped.2017.3.1.1-12

Feijo JC, Vieira SL, Maria DDB, Horn RM, Favero A, Altevogt WE, Nicola BS (2024). Dietary contribution of iron from limestone and dicalcium phosphate for broiler chickens. Poult. Sci., 103(4): 1-8. https://doi.org/10.1016/j.psj.2024.103558

Fraga-Corral M, Otero P, Cassani L, Echave J, Garcia-Oliveira P, Carpena M, Chamorro F, Lourenço-Lopes C, Prieto MA, Simal-Gandara J (2021). Traditional applications of tannin rich extracts supported by scientific data: Chemical composition, bioavailability and bioaccessibility. Foods, 10(2): 1-33. https://doi.org/10.3390/foods10020251

Hakim L, Nova K, Santosa PE, Riyanti RR (2021). The effect of gender differences on breathing rate, heart rate, shank temperature, and rectal temperature in KUB chickens. J. Res. Innov. Anim., 5(2): 94-98. https://doi.org/10.23960/jrip.2021.5.2.94-98

Hossain MM, Cho S, Kim IH (2024). Strategies for reducing noxious gas emissions in pig production: a comprehensive review on the role of feed additives. J. Anim. Sci. Technol., 66(2): 237-250. https://doi.org/10.5187/jast.2024.e15

Hussain S, Mirza W, Murtaza M, Nazir A, Hanif I, Ahmad M (2022). Sources and chemistry of flavonoids; their biological and therapeutic potential. Sci. Inq. Rev., 6(2): 33-58. https://doi.org/10.32350/sir.62.03

Iftitah D, Arisandi B, Widyani RR, Juniah (2022). Physiological conditions of broiler chickens during transportation with vitamin treatment and distance difference. J. Ilmu-Ilmu Peternak., 32(3): 313–327. https://doi.org/10.21776/ub.jiip.2022.032.03.02

Jumadin L, Maheshwari H, Ulupi N, Satyaningtijas AS (2022). Physiological and productivity performances of Japanese quail supplemented with cassava leaf paste. Trop. Anim. Sci. J., 45(4): 460-466. https://doi.org/10.5398/tasj.2022.45.4.460

Jumadin L, Maheshwari H, Ulupi N, Satyaningtijas AS, Zubaidah DW, Walukou MA, Darlian L, Damhuri, Santoso K (2024). Evaluation of Cassava leaf paste on egg performance and egg quality of quail egg laying period. Acta Vet. Indones., 12(2): 106-111. https://doi.org/10.29244/avi.12.2.106-111

Kheravii SK, Swick RA, Choct M, Wu SB (2018). Upregulation of genes encoding digestive enzymes and nutrient transporters in the digestive system of broiler chickens by dietary supplementation of fiber and inclusion of coarse particle size corn. BMC Genom., 19(1): 1-14. https://doi.

org/10.1186/s12864-018-4592-2

Kuhn V, Diederich L, Keller TCS, Kramer CM, Lückstädt W, Panknin C, Suvorava T, Isakson BE, Kelm M, Cortese-Krott MM (2017). Red blood cell function and dysfunction: redox regulation, nitric oxide metabolism, anemia. Antioxid. Redox Signal, 26(13): 718-742. https://doi.org/10.1089/ars.2016.6954

Maheshwari H, Samita AN, Farajallah A, Achmadi P, Santoso K (2017). The effect of temperature on leukocyte differential and malondialdehyde (MDA) levels in quails (*Coturnix coturnix japonica*). Bioma, 13(1): 81-89. https://doi.org/10.21009/Bioma13(2).4

Morgan NK, O'Keeffe JL, Hackett MJ (2026). A review of the iron requirements and its determination in commercial poultry. Anim Nutr., 26: 1-21. https://doi.org/10.1016/j.aninu.2026.01.002

Munir M, Qayyum A, Raza S, Siddiqui NR, Mumtaz A, Safdar N, Shible S, Afzal S, Bashir S (2017). Nutritional assessment of basil seed and its utilization in development of value added beverage. Pak. J. Agric. Res., 30(3): 266–271. https://doi.org/10.17582/journal.pjar/2017.30.3.266.271

Pandey AK, Tiwari SP, Biswas D, Patel Y, Jajda HM, Dave GS (2023). Evaluation of phytochemicals, antioxidant and anti-inflammatory properties of leaves of *Ocimum basilicum* L. Res J Pharm Technol., 16(4): 1981–1986. https://doi.org/10.52711/0974-360X.2023.00325

Prawitasari RH, Ismadi VDYB, Estiningdriati I (2012). Digestibility of crude protein and crude fiber and the rate of digestion in Arab chickens fed diets with varying levels of Azolla microphylla. Anim. Agric. J., 1(1): 471-483. https://ejournal3.undip.ac.id/index.php/aaj/article/view/688

Rini SR, Sugiharto S, Mahfudz LD (2019). The effect of maintenance temperature differences on the physical quality of broiler chicken meat during the finisher period. Indones. J. Anim. Sci., 14(4): 387-395. https://doi.org/10.31186/jspi.id.14.4.387-395

Salim AN, Sumardianto S, Amalia U (2018). The effectiveness of papaya seed antibacterial powder on white shrimp (*Penaeus merguensis*) during cold storage. Indones. J. Fish Prod. Process., 21(2): 188-198. https://doi.org/10.17844/jphpi.v21i2.22836

Tran PQ, Bachand SC, Hotvedt JC, Kieft K, McDaniel EA, McMahon KD, Anantharaman K (2023). Physiological and genomic evidence of cysteine degradation and aerobic hydrogen sulfide production in freshwater bacteria. mSystems, 8(3): 1-18. https://doi.org/10.1128/msystems.00201-23

Ulupi N, Afnan R, Rukmiasih (2016). Level of ammonia, dust, production performance, and egg quality of laying hens on cage and litter system in tropical area. Int. J. Sci. Basic Appl. Res., 30(5): 339-348.

Utama CS, Wahyono F, Haidar MF (2021). The effect of elevation differences on the litter profile of broiler chickens raised in closed houses. J. Petern. Indones., 23(2): 115-121. https://doi.org/10.25077/jpi.23.2.115-121.2021

Vazifehkhoran AH, Pedersen J, Guldberg LB, Svane S, Karring H, Feilberg A, Hansen MJ (2024). Effects of polyphenol-rich extracts and compounds on methane and ammonia emissions from pig slurry during 28-day incubation. Biosyst. Eng., 248: 218-228. https://doi.org/10.1016/j.biosystemseng.2024.11.002

Xiong T, Wu Y, Hu J, Xu S, Li Y, Kong B, Zhang Z, Chen L, Tang Y, Yao P (2023). Associations between high protein intake, linear growth, and stunting in children and adolescents: A cross-sectional study. Nutrients, 15(22): 1-15. https://doi.org/10.3390/nu15224821

Yadav R, Fatima SK, Dhawan SS (2025). Unlocking the medicinal potential of *Ocimum africanum*: A review of its phytoconstituents and pharmacological activities. S. Afr. J. Bot., 184: 617-630. https://doi.org/10.1016/j.sajb.2025.06.020

Yi Z, Li X, Luo W, Xu Z, Ji C, Zhang Y, Nie Q, Zhang D, Zhang X (2018). Feed conversion ratio, residual feed intake and cholecystokinin type A receptor gene polymorphisms are associated with feed intake and average daily gain in a Chinese local chicken population. J. Anim. Sci. Biotechnol., 50(9): 1-9. https://doi.org/10.1186/s40104-018-0261-1

Zoneff E, Wang Y, Jackson C, Smith O, Duchi S, Onofrillo C, Farrugia B, Moulton SE, Williams R, Parish C (2024). Controlled oxygen delivery to power tissue regeneration. Nat. Commun., 15(1): 1-16. https://doi.org/10.1038/s41467-024-48719-x

Zulkifli, Nurliana, Sugito (2018). The effect of black cumin (*Nigella sativa*) administration on broiler chicken carcasses exposed to heat stress. Proc. Natl. Semin. Biot., 5(1): 626-631.