Original Research

Journal of Advanced Veterinary Research
(2025) Volume 15, Issue 5, 709-714

# Impact of fermented *Physalis angulata* filtrate and *Lactobacillus acidophilus* on intestine ecology, morphology and broiler carcass quality

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**ARTICLE INFO**

Recieved: 19 September 2025

Accepted: 09 October 2025

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Keywords:

Broilers, carcass quality, Ecology, Fermented fruit filtrate, Intestinal morphology

**ABSTRACT**

The purpose of this study was to evaluate the effect of *Physalis angulata* fruit filtrate fermented with *Lactobacillus acidophilus* on intestinal ecology, small intestine morphology and carcass quality of broilers. A total of 280 Day Old Chick broilers (unsex) were randomly divided into 4 treatments with 7 replicates of 10 chickens each. The treatments included T0 (control), T1 (1% *Physalis angulata* fruit filtrate), T2 (1% *L. acidophilus*), and T3 (1% fermented *Physalis angulata* fruit filtrate). Treatments were administered daily through drinking water from day 1 to day 32. Observed parameters included the counts of lactic acid bacteria (LAB) and coliforms, small intestine morphology, carcass characteristics, and broiler meat quality. Data were analyzed using a Completely Randomized Design. The result show that T3 significantly optimized feed efficiency compared to the other treatments ($p<0.05$). The total lactic acid bacteria in the cecum were higher in T2 and T3 treatments compared to T0 and T1 ($p<0.05$). However, the treatments did not result in significant differences in the number of coliforms, small intestine morphology, carcass characteristics, meat pH, meat color, and chemical composition of broiler meat ($p>0.05$), except for a lower percentage of abdominal fat in T2 and T3 treatments ($p<0.05$) and higher moisture content in breast meat in T2 ($p<0.05$). In conclusion: fermented *Physalis angulata* fruit filtrate can improve feed efficiency, cecal LAB population, reduce abdominal fat, and increase breast meat moisture content, indicating that supplementation with *Physalis angulata* fruit filtrate, *L. acidophilus*, and their fermentation has potential as a feed additive for broilers.

## Introduction

Broilers are known as a type of meat chicken that has the main advantages of very rapid growth and high feed efficiency. These advantages make broilers the primary commodity in the modern livestock industry (Huerta *et al*., 2023). However, behind these advantages, broilers also have weaknesses, namely their vulnerability to various health disorders, especially those related to the digestive tract. Small intestine is one of the most important parts of the broilers digestive system because it functions in nutrient absorption and serves as the center of microorganism interactions that affect the metabolism and immunity of broilers. Therefore, the balance of gut microflora as well as intestinal morphology, such as villi height and crypt depth, are important indicators in assessing the health of the digestive tract (Li *et al*., 2018; Wen *et al*., 2023).

External factors can affect the digestive health of broilers. Factors such as extreme environmental temperatures, suboptimal coop management, high humidity, and pathogen contamination can be the main triggers for intestinal disorders. Environmental stress can weaken the chickens' immune system, and the presence of pathogens like E. coli can also cause intestinal inflammation, which may lead to tissue damage and disrupt nutrient absorption. This will eventually lead to a carcass quality, decline in performance, and an increase in mortality rates (Van der Aar *et al*., 2017; Adedokun and Olojede, 2019; Wang *et al*., 2021; Wickramasuriya *et al*., 2022).

In response to these challenge, researchers and livestock practitioners have started using natural ingredients as feed additives or supplementary materials. Feed additives from natural ingredients are considered safer, do not produce chemical residues, and can naturally improve digestive tract health. Feed additives also contribute to maintaining the balance of microflora in the intestines by increasing the population of beneficial bacteria and reducing the growth of pathogenic bacteria (Peng *et al*., 2022; Kalia *et al*., 2022).

The *Physalis angulata* fruit (*Physalis angulata*) is one of the local plants with great potential as a feed additive. This fruit contains active compounds such as flavonoids, alkaloids, steroids, organic acids, and vitamin C, which provide antioxidant and anti-inflammatory benefits that help sustain gut health and reduce the impact of oxidative stress on broilers (Kikusato, 2021; Wiraswati *et al*., 2024). In addition to their antibacterial properties, phytochemicals such as flavonoids have been proven to stimulate the regeneration of intestinal epithelial cells and improve villi structure, thereby optimizing nutrient absorption (Zhou *et al*., 2025).

*Physalis angulata* fruit given directly as a feed additive still has certain drawbacks, one of which is the presence of antinutritional factors that can inhibit nutrient absorption. Fermentation is one effective solution to improve the nutritional quality and antioxidant activity of *Physalis angulata* fruit. Fermentation using lactic acid bacteria has been reported to increase the availability of active compounds, reduce antinutritional content, and produce additional compounds such as lactic acid that help maintain the balance of gut microflora in broilers (Sarıtaş *et al*., 2024; Yang *et al*., 2022). *Lactobacillus acidophilus* is a probiotic bacterium that is commonly used in the fermentation processes because it can survive in acidic conditions, such as those found in the digestive tract, compared to other probiotics. In addition, *Lactobacillus acidophilus* can also produce lactic acid and bacteriocins. Furthermore, these compounds play a role in lowering intestinal pH, suppressing the growth of pathogens, and maintaining digestive health (Wu *et al*., 2021; Sunu *et al*., 2021; Gao *et al*., 2022).

In addition to digestive tract health, carcass quality is another important aspect of the poultry industry. A high-quality carcass has an optimal proportion of breast and thigh meat as well as low fat content. Research by Liu *et al*. (2024) shows that improving the intestinal structure of broilers using feed additives can impact their live weight and carcass quality. Yao *et al*. (2024) also found that using fermented herbal ingredients can improves feed conversion efficiency and increases the nutritional value of the meat.

The utilization of fermented *Physalis angulata* fruit can serve as an innovation in the development of natural feed additives that are effective and do not cause negative effects on the health of animals or consumers.


ISSN: 2090-6277/2090-6269/ 

To date, there has been little research specifically evaluating the effects of fermenting *Physalis angulata* fruit using *Lactobacillus acidophilus* on gut microbial balance, small intestine morphology, and carcass quality in broilers. This research is considered important as an effort to explore sustainable and environmentally friendly local potential. This study aimed to evaluate the impact of *Physalis angulata* fruit filtrate fermented with *Lactobacillus acidophilus* on the gut ecology, small intestine morphology, and carcass quality of broilers.

## Materials and methods

The research was approved by the Animal Research Ethics Committee of the Faculty of Animal and Agricultural Sciences, Universitas Diponegoro (61-05/A-10/KEP-FPP).

*Preparation of treatment*

The treatment preparation was described by Pratama *et al.* (2021) includes the preparation of fruit filtrate and bacterial rejuvenation. The preparation of *Physalis angulata* fruit filtrate starts with thoroughly washing the fruit, then drying and blending it without adding water. The blended fruit is then filtered using a fine cloth to obtain the fruit filtrate.

*Lactobacillus acidophilus* stock cultures were rejuvenated using de Man, Rogosa, and Sharpe (MRS) agar. The bacteria were inoculated onto the medium and incubated under anaerobic conditions for 48 hours at 38°C. After incubation, the grown *Lactobacillus acidophilus* bacteria are harvested. The harvesting process was carried out by adding 10 ml of dissolved and sterilized skim milk to the Petri dish containing *Lactobacillus acidophilus*.

The fermentation process is carried out by mixing the *Physalis angulata* filtrate with *Lactobacillus acidophilus* bacteria, which have been harvested using skim milk, into a sterilized anaerobic jar. The composition used is a ratio of 1% *Lactobacillus acidophilus* (bacterial concentration of $1\times10^8$ CFU/ml) based on the amount of *Physalis angulata* fruit filtrate and then homogenized. The fermentation process is conducted at room temperature for 48 hours.

*In vivo study*

The research design used a Completely Randomized Design. The study used 280 Day Old Chick broilers of the CP-707 strain unsex with an average weight of 42.77±0.42 g. There were divided into 4 treatments with 7 replications. The treatments involved the administration of *Physalis angulata* fruits filtrate, *Lactobacillus acidophilus*, and the fermentation product of both, delivered through drinking water starting from the DOC stage. Treatment was given in the morning during days 0–7 and was consistently monitored. From days 8–32, before treatment was administered, the chicks were water-fasted for approximately 1 hour, then the treatment was given. Each dose was adjusted according to the drinking water standards of the CP-707 strain and was divided into four administrations: morning, noon, afternoon, and evening, after which untreated drinking water was provided ad libitum. The treatments consisted of T0 (Control), T1 (drinking water containing 1% *Physalis angulata* fruit filtrate), T2 (drinking water containing 1% *Lactobacillus acidophilus*), and T3 (drinking water containing 1% fermented filtrate of *Physalis angulata* fruit with *Lactobacillus acidophilus*). Throughout the maintenance period, feed was provided ad libitum. From days 0–7, commercial feed was given, and from days 8–32, a basal feed (Table 1).

*Broiler performance*

Feed intake, feed conversion ratio (FCR) and weight gain are measured and recorded weekly throughout the rearing period. Live weight is calculated by weighing the final weight (at 32 days of age) (Park *et al.*, 2021). Slaughter weight is calculated by weighing the broiler after slaughter and bleeding (Fatima and Sabow, 2022). Feed intake is calculated by dividing the total feed consumed by the broiler population (Ningrum *et al.*, 2022). Feed efficiency is calculated by dividing body weight during rearing by the total feed consumed, multiplied by 100% (Agusetyaningsih *et al.*, 2023). Mortality is calculated by dividing the number of dead chickens (during rearing) by the population and then multiplying by 100%. European Production Efficiency Factor (EPEF) is calculated using the formula: (viability (%)×live weight (kg)/age (days)×FCR)×100 (Huff *et al.*, 2013).

Tabel 1. Feed Composition of Broiler.

| Ingredient | Starter | Finisher |
|---|---|---|
| Yellow maize (%) | 50,4 | 58,7 |
| Coconut oil (%) | 2,9 | 2,9 |
| Soybean meal (%) | 43,1 | 34,7 |
| Methionine (%) | 0,2 | 0,2 |
| Bentonite (%) | 0,75 | 0,75 |
| Limestone (%) | 1 | 1 |
| Monocalcium Phosphate (%) | 1,1 | 1 |
| Premix (%) | 0,34 | 0,34 |
| Choline chloride (%) | 0,07 | 0,07 |
| Natrium chloride (%) | 0,4 | 0,4 |
| **Nutrient Content Analysis Results*** | | |
| Metabolizable Energy (Kkal/kg)** | 2972,49 | 3068,07 |
| Nitrogen-Free Extract | 61,19 | 60,48 |
| Crude Protein | 22,54 | 22,16 |
| Crude Fiber | 5,49 | 5,88 |
| Crude Fat | 5,68 | 6,18 |
| Water Content | 12,97 | 12,8 |
| Ash | 5,09 | 5,3 |

*Analyzed at the Laboratory of Nutrition and Feed Science, Faculty of Animal and Agricultural Sciences, Universitas Diponegoro, Semarang (2025). **Results calculated based on the Bolton formula (1967) in Sugiharto (2017) EM = 40.81 {0.87 [Crude Protein + 2.25 Crude Fat + NFE] +2.5}

*Total intestinal bacteria*

The broilers were slaughtered and digesta were collected from the ileum and cecum. The calculation of the counts of LAB and coliform colonies used the Total Plate Count (TPC) method (Sugiharto *et al.*, 2018). Ileal and cecal digesta were cultured on MRS agar and incubated for 48 hours at 38°C under anaerobic conditions. Lactic acid bacteria were identified as colonies with a white appearance. Coliform bacteria were cultured on MacConkey agar and incubated for 24 hours at 38°C under aerobic conditions. Total bacteria were calculated using the formula: number of colonies × (1/dilution factor).

*Histology of the small intestine*

Histological analysis of the duodenum, jejunum, and ileum was described by Tunc *et al.* (2019). Intestine samples were sectioned using a microtome to a thickness of 5μm, followed by staining with hematoxylin and eosin. Villi height and crypts depth were measured under an optical microscope, with five replicates for each broiler.

*Carcass characteristics*

Carcass characteristic analysis was described by Pawesti *et al.* (2022). Broiler carcasses were separated into 8 commercial parts (breast, back, 2 thighs, 2 wings, and 2 drumsticks) and abdominal fat, then weighed using an analytical balance. The carcass percentage was calculated using the formula: (total carcass weight/live weight) × 100%. The percentage of carcass parts was calculated using the formula: carcass part weight/

carcass weight × 100%. The percentage of abdominal fat was calculated using the formula: (abdominal fat weight/carcass weight) × 100%.

*Meat quality*

Meat quality is determined by measuring the pH and color of the meat, chemical composition of the meat such as protein, fat, and moisture content, and water holding capacity (WHC). Meat color is analyzed using a CR-400 chromameter. This chromameter is placed on the breast and thigh meat samples and left until the value appears on the monitor. The parameters in the meat color analysis consist of several categories, namely L* (brightness), a* (redness), and b* (yellowness) (Che *et al*., 2023). The measurement of meat pH is carried out using a pH-meter until the pH score is detected (Hudák *et al*., 2021). Water holding capacity analysis is performed using the Barbut method Zhang *et al.* (1993) with slight modifications. Analysis is conducted by mincing the meat, mixing 10 grams of meat with 20 mL of 0.6 M NaCl, and centrifuging the mixture at 7000 rpm for 30 minutes at a temperature of 4°C. Volume of supernatant was discarded and sediment is weighed. Water holding capacity is calculated using the formula: ((20 mL - amount of supernatant poured off)/20 mL) × 100% (Lee *et al*., 2015).

The analysis of meat chemical composition was described by Vanathi (2022). Moisture content analysis was performed by homogenizing the meat sample and then placing it in an oven at 105°C for 4 hours. Percentage of moisture content was calculated using the formula: (initial sample weight – (final sample weight – crucible weight)) / initial sample weight) × 100%. Fat analysis is performed using the Soxhlet method. The meat is homogenized, placed in filter paper, and dried in an oven at 105°C for 1 hour, then the sample is placed into the Soxhlet extraction apparatus and added with ether solution at 2.5 – 3 times the volume of the extraction flask already containing the sample, and extraction is carried out for 6 hours. After that, the sample is dried in the oven again at 105°C for 1 hour. The percentage of fat is calculated using the formula: ((initial sample weight – final sample weight) / constant sample weight) × 100%. Protein analysis of meat is carried out using the Kjeldahl method. The meat is homogenized, then placed into a Kjeldahl flask with the addition of selenium and sulfuric acid. The destruction process continues until the color turns clear green. The distillation process uses 5 ml of 4% $H_3BO_3$ and 2 drops of MR and MB indicators. The sample is added with 100 ml of distilled water and 40 ml of 45% NaOH. Distillation is carried out until the sample turns green, yielding a distillate of 40 ml. Titration is performed using 0.1N HCl until the color changes to purple. The percentage of protein is calculated using the formula: ((titrant sample – blank) × N HCl × 14.008) / (sample weight × 100) × 100% (the calculation result is then multiplied by a conversion factor of 6.25).

*Statistical analysis*

The collected data were then analyzed using analysis of variance (ANOVA) at a 5% significance level. When significant effects on the data, the analysis was continued with Duncan's test to determine differences between treatments. All data are presented as means and statistical analysis was performed using SPSS version 25.0.

## Results

*Performance of broilers*

The administration of fermented *Physalis angulata* fruit filtrate in T3 showed a higher feed efficiency value ($p<0.05$) compared to other treatments. However, the treatment had no significant effect ($p>0.05$) on live weight, carcass weight, feed intake, mortality, and EPEF in the performance of broilers (Table 2).

Table 2. Performance of Broilers.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Live Weight (g) | 1860.29 | 1943 | 1925.29 | 1972.29 | 19.14 | 0.2 |
| Slaughter Weight (g) | 1775.71 | 1845.71 | 1831.43 | 1877.86 | 17.56 | 0.22 |
| FE (%) | 75.87$^{b}$ | 77.12a$^{ab}$ | 77.41a$^{ab}$ | 79.13$^{a}$ | 0.4 | 0.03 |
| Total FI (g/ekor) | 2409.09 | 2429.05 | 2426.91 | 2381.68 | 18.1 | 0.8 |
| Mortality (%) | 0.01 | 0.01 | 0.03 | 0 | 0.01 | 0.54 |
| EPEF | 388.03 | 403.86 | 401.44 | 422.09 | 5.44 | 0.17 |

$^{a, ab, b}$: Different superscripts in the same row indicate a significant difference ($P<0.05$). T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% *Physalis angulata* and *Lactobacillus acidophilus* fermentation. SEM: standard error of mean, FE: Feed Efficiency, FI: Feed Intake, EPEV: European Production Efficiency Factor.

*Intestinal bacterial populations of broilers*

The results of bacterial population analysis in treatments T2 and T3 showed that the number of LAB in the ceacum was higher ($p<0.05$) compared to T0 and T1. However, the treatments did not have a significant effect ($p>0.05$) on cecal coliforms, as well as ileal LAB and coliforms in broilers (Table 3).

Tabel 3. Intestinal bacterial populations of broilers.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Ileum | | | | | | |
| LAB (log cfu/g) | 3.6 | 4.41 | 5.69 | 5.25 | 0.32 | 0.08 |
| Coliform (log cfu/g) | 1.35 | 0.91 | 3.11 | 2.37 | 0.33 | 0.06 |
| Caecum | | | | | | |
| LAB (log cfu/g) | 10.07$^{b}$ | 10.37$^{b}$ | 11.41$^{a}$ | 11.70$^{a}$ | 0.15 | <0.01 |
| Coliform (log cfu/g) | 5.72 | 5.93 | 5.87 | 5.57 | 0.17 | 0.88 |

$^{a,b}$: Different superscripts in the same row indicate a significant difference ($P<0.05$). T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% fermentation of *Physalis angulata* and *Lactobacillus acidophilus*. SEM: standard error of mean. LAB: lactic acid bacteria.

*Intestinal morphology of broilers*

The results of the analysis showed that administering fermented filtrate of *Physalis angulata* fruit with *Lactobacillus acidophilus* had no significant effect ($p>0.05$) on the villi height and crypt depth of the small intestine in broilers (Table 4).

Table 4. Intestinal morphology of broilers.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Duodenum | | | | | | |
| Villi height (μm) | 1649.34 | 1686.35 | 1684.23 | 1802.77 | 35.64 | 0.47 |
| Crypt depth (μm) | 368.28 | 350.9 | 340.91 | 317.47 | 10.91 | 0.44 |
| Jejunum | | | | | | |
| Villi height (μm) | 1293.86 | 1088.74 | 1148.4 | 1090.08 | 38.36 | 0.19 |
| Crypt depth (μm) | 308.17 | 299.2 | 262.25 | 293.5 | 12.34 | 0.6 |
| Ileum | | | | | | |
| Villi height (μm) | 681.3 | 666.15 | 686.63 | 640.07 | 26.53 | 0.94 |
| Crypt depth (μm) | 160.13 | 174.91 | 169.41 | 180.51 | 7.92 | 0.84 |

T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% fermentation of *Physalis angulata* and *Lactobacillus acidophilus*. SEM: standard error of mean.

*Carcass traits of broilers*

The results of the analysis on treatments T2, T3, and T4 showed that the percentage of abdominal fat was lower ($p<0.05$) compared to T0.

However, the administration of the treatments did not have a significant effect (p>0.05) on carcass weight, carcass percentage, and carcass parts of broilers (Table 5).

Table 5. Carcass traits of broilers.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Carcass weight (g) | 1271.91 | 1356.98 | 1316.92 | 1353.66 | 330.15 | 0.1 |
| Carcass (% LBW) | 68.37 | 69.85 | 68.43 | 68.62 | 17.2 | 0.16 |
| Breast (% CW) | 37.49 | 35.99 | 37.74 | 37.09 | 9.29 | 0.6 |
| Wing (% CW) | 11.93 | 12.04 | 11.57 | 11.8 | 2.97 | 0.87 |
| Thigh (% CW) | 15.64 | 15.35 | 16.13 | 14.8 | 3.89 | 0.29 |
| Drumstick (% CW) | 13.87 | 14.33 | 14.21 | 14.04 | 3.53 | 0.84 |
| Back (% CW) | 21.07 | 22.28 | 20.34 | 22.26 | 5.37 | 0.27 |
| Abdominal Fat (% CW) | 1.057$^{a}$ | 0.935$^{b}$ | 0.918$^{b}$ | 0.912$^{b}$ | 0.02 | 0.04 |

$^{a, b}$: Different superscripts in the same row indicate a significant difference (P<0.05). T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% fermentation of *Physalis angulata* and *Lactobacillus acidophilus*. SEM: standard error of mean. LBW: live body weight, CW: carcass weight.

*Meat color*

Studies showed that the treatments did not have a significant effect (p>0.05) on the color value of broiler meat (Table 6).

Table 6. Meat color.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Breast | | | | | | |
| L* | 55.91 | 55.75 | 58.48 | 56.94 | 14.19 | 0.33 |
| a* | 1.55 | 2.39 | 1.42 | 1.68 | 0.54 | 0.32 |
| b* | 11.68 | 11.02 | 11.36 | 11.24 | 2.86 | 0.8 |
| Thigh | | | | | | |
| L* | 56.17 | 54.23 | 57.59 | 57.09 | 14.08 | 0.1 |
| a* | 5.8 | 3.77 | 5.14 | 7.63 | 1.55 | 0.25 |
| b* | 13.09 | 12.19 | 12.91 | 14.13 | 3.29 | 0.11 |

T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% fermentation of *Physalis angulata* and *Lactobacillus acidophilus*. SEM: standard error of mean. L*: Lightness; a*: redness; b*: yellowness.

*pH value and chemical composition of broiler meat*

The results of the analysis on the administration of *Lactobacillus acidophilus* showed that the water content value in the breast was higher (p<0.05) compared to the other treatments. However, the administration of the treatments did not have a significant effect (p>0.05) on the pH value, protein, fat, and WHC in the breast and thigh of broilers (Table 7).

## Discussion

The observed improvement in feed efficiency in T3 indicates that fermentation of *Physalis angulata* fruit filtrate with *Lactobacillus acidophilus* can increase nutrient absorption and utilization in broilers. Wang *et al*. (2024) showed that fermented herbal ingredients can improve the efficiency of feed utilization relative to the resulting body weight. Fermentation of phytobiotics with probiotics can increase nutrient digestibility and optimize feed efficiency. Active compounds in herbal fermentation are able to incrase feed efficiency by optimizing enzyme activity in the digestive tract (Zaikina *et al*., 2022; Obianwuna *et al*., 2024). In addition, the increase in feed efficiency values in broilers is also suspected to be due to the fermentation process with the probiotic such as *Lactobacillus acidophilus* which can support digestive tract health by increasing LAB and decreasing pathogenic bacteria, thus enabling optimal absorption and utilization of nutrients in the feed (Liu *et al*., 2025; Anee *et al*., 2021).

Table 7. pH value and chemical composition of broiler meat.

| Variables | Treatments | | | | SEM | P Value |
|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | | |
| Breast | | | | | | |
| pH | 7.12 | 7.2 | 7.24 | 7.22 | 0.02 | 0.07 |
| Protein | 18.02 | 19.13 | 17.89 | 16.92 | 17.93 | 0.53 |
| Fat | 2.95 | 3 | 3.01 | 3.2 | 3.03 | 0.57 |
| Weter Content | 73.27$^{b}$ | 74.38$^{ab}$ | 74.86$^{a}$ | 73.48$^{b}$ | 73.68 | 0.01 |
| WHC | 47.07 | 47.43 | 47.07 | 46.93 | 46.93 | 0.99 |
| Thigh | | | | | | |
| pH | 7.25 | 7.37 | 7.32 | 7.36 | 7.3 | 0.2 |
| Protein | 16.67 | 17.06 | 17.21 | 16.94 | 16.91 | 0.97 |
| Fat | 3.75 | 3.52 | 3.63 | 3.39 | 3.56 | 0.28 |
| Weter Content | 75.69 | 75.86 | 76.05 | 75.83 | 75.53 | 0.98 |
| WHC | 47.79 | 48.57 | 46.07 | 46.21 | 46.95 | 0.22 |

$^{a, ab, b}$: Different superscripts in the same row indicate a significant difference (P<0.05). T0: 100% water, T1: 100% water + 1% *Physalis angulata* filtrate, T2: 100% water + 1% *Lactobacillus acidophilus*, and T3: 100% water + 1% *Physalis angulata* and *Lactobacillus acidophilus* fermentation. SEM: standard error of mean. WHC : Water Holding Capasity.

*Physalis angulata* fruit fermentation filtrate through drinking water can increase the counts of LAB in the cecum of broilers. Sugiharto *et al*. (2021) reported that providing fermented herbal materials can increase the counts of LAB in the intestines of broilers. *Physalis angulata* fruit filtrate contains organic compounds such as organic acids and flavonoids, so during the fermentation process with *Lactobacillus acidophilus*, it can support the growth of beneficial bacteria. The increase in beneficial bacteria in the fermented product will optimize the growth of LAB and decrease pathogenic bacteria in the digestive tract of broilers. In addition, *Lactobacillus acidophilus* used during the fermentation process is considered capable of producing lactic acid and bacteriocins, which play a role in lowering intestinal pH, thereby increasing the counts of LAB and decreasing the amount of pathogens in the digestive tract of broilers (Ashayerizadeh *et al*., 2018; Pratama *et al*., 2021; Wu *et al*., 2021).

The fermented filtrate of *Physalis angulata* fruit had no significant effect on villus height and crypt depth in small intestine of broilers. Ding *et al*. (2021) found that the adding fermented herbal materials with probiotics did not affect villus height and crypt depth in the small intestine of broilers. Chang *et al*. (2019) also showed that the administration of fermented herbal materials containing probiotics had no significant effect on villus height and crypt depth in jejunum of broilers. The bioactive compounds and lactic acid bacteria in this study had no significant effect on villus height and crypt depth in the small intestine of broilers. This is thought to be because the broilers were not under environmental stress, so there was no intestinal mucosal damage (Santos *et al*., 2015). The absence of mucosal damage meant that the potential of the bioactive compounds in the fermented filtrate of *Physalis angulata* fruit to improve the morphology of the small intestine had no significantly observed in this study.

The fermented filtrate of *Physalis angulata* fruit through drinking water had no significant impact on broiler carcass characteristics. It is suspected that this is because the bioactive compounds in the treatment do not directly affect muscle tissue growth in broilers. This is evident in the live weight and slaughter weight among treatment groups, which did not differ significantly, resulting in no notable changes to carcass weight and carcass percentage. Pratama *et al*. (2021) showed that administering fermented herbal ingredients with probiotics does not affect broiler carcasses. However, the treatment did significantly reduce the abdominal fat content compared to the control. The content of bioactive compounds in the treatment can play a role in enhancing fat metabolism, thereby reducing the amount of abdominal fat in broilers (Nan *et al*., 2022). Bostami *et al*. (2017) found that administering fermented herbal ingredients with probiotics can decrease the percentage of abdominal fat in broilers due to the presence of bioactive compounds that help reduce fat synthesis. The increase in bioactive compounds from herbal ingredients during the fermentation process with probiotics is thought to be able to boost the secretion of digestive enzymes, thereby optimizing fat metabolism and reducing fat accumulation in abdominal of broilers (Kikusato, 2021; Iwiński *et al*., 2023).

Based on the research results, it was found that administering fermented filtrate of *Physalis angulata* fruit did not cause significant changes in the color of breast and thigh meat in broilers. A similar study was also conducted by Gungor and Erener (2020) who reported that administering fermented Prunus cerasus L. fruit had no effect on the meat color values of either the breast or thigh. The same results were shown in the study by Xie *et al*. (2021) found that administering fermented herbal materials did not have a significant effect on the color values of broiler breast and thigh meat. Stęczny and Kokoszynski (2019) also reported that probiotics did not significant effect on the meat color values in broilers. The color of broiler meat is influenced by the chemical composition and WHC of the meat. These factors can influence the amount of myoglobin, the protein responsible for imparting color to the meat (Zhang *et al*., 2020; Qamar, 2019). In this study, no significant differences were observed in the chemical composition of the meat, which consists of protein, fat, and water content, as well as WHC values, so the meat color also showed no significant effect (Kierończyk*et al*., 2023).

Probiotics in the form of *Lactobacillus acidophilus* can breast meat moisture content in broiler breast meat. This may be due to the breast meat's potential to retain water, thereby increasing its moisture content. Soumeh *et al*. (2021) who observed that probiotic supplementation could increase the moisture content in broiler meat. This effect is thought to occur because *Lactobacillus acidophilus* can produce lactic acid, which helps stabilize muscle pH after slaughter, thus influencing glycogen metabolism. This process can improve muscle structure and increase the meat's water holding capacity (del Puerto *et al*., 2016; Cramer *et al*., 2018).

## Conclusion

The fermentation of *Physalis angulata* fruit filtrate with *Lactobacillus acidophilus* improve feed efficiency, promotes the population of cecal LAB, decrease abdominal fat, and increase breast meat moisture content in broiler breast meat. Therefore, the administration of *Physalis angulata* fruit filtrate, *Lactobacillus acidophilus*, and their fermentation products has potential to serve as a natural feed additive to improve intestinal health and carcass quality in broilers.

## Acknowledgments

This research was funded by the Faculty of Animal and Agricultural Sciences, Universitas Diponegoro (21/UN7.F5/PP/I/2025). The author also extends gratitude to the laboratory and all parties who actively participated during the course of this research.

## Conflict of interest

The authors have no conflict of interest to declare.

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