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# Effect the Use of Coconut Water Kefir Supplementation on Performance, Carcass, and Gastrointestinal Tract of Broiler Chicken

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**ABSTRACT**. This study aimed to assess the effects of coconut water kefir (CWK) supplementation on the production performance, carcass characteristics, and gastrointestinal tract morphology of broiler chickens. A total of 400 broiler chickens were used and divided into four treatment groups with five replicates, each containing 20 chickens. The study followed a completely randomized design (CRD). The treatment groups were as follows: T0 (control, no CWK supplementation), T1 (5% CWK), T2 (10% CWK), and T3 (15% CWK). The results indicated that CWK supplementation significantly influenced production performance, including feed intake, final body weight, weight gain, feed conversion ratio, and feed efficiency ratio. Furthermore, CWK supplementation also had a significant effect on carcass traits, such as carcass weight, breast percentage, thigh percentage, and abdominal fat, as well as on gastrointestinal tract parameters, including jejunum percentage, jejunum length, and ileum length. The optimal results were obtained from the 10% CWK supplementation (T2). In conclusion, CWK supplementation effectively improved the production performance, carcass yield, and gastrointestinal tract development in broiler chickens.

**Keywords**: broiler, carcass, gastrointestinal, performance, water kefir

## INTRODUCTION

Coconut (Cocos nucifera), a tree-type palm, is widely cultivated in tropical regions, particularly near coastal areas. There are various types of coconut, including green, yellow, and red coconuts. According to Rethinam and Krishnakumar (2022), coconut water contains 359 kcal, 2.08% sugar, 3.4 g protein, 34.7 mg fat, 14 g carbohydrates, and various minerals such as calcium (21 mg), phosphorus (2 mg), thiamine (2 mg), vitamin A (0.1 mg), and ascorbic acid (46 mg). The rich nutritional composition of coconut water has led to the development of various processing technologies, including coconut water fermentation, specifically coconut water kefir (CWK).

The fermentation of CWK occurs due to the activity of water kefir grains, which contain microorganisms such as *Lactobacillus, Lactococcus, Leuconostoc*, and *Streptococcus*, as well as yeasts like *Kluyveromyces*, *Candida*, and *Saccharomyces* (Raafi et al., 2023). Coconut water kefir is rich in probiotics, which are beneficial for improving digestive health and maintaining the balance of microorganisms in the intestinal microflora (Limbad et al., 2015). Probiotics can inhibit the ability of pathogenic microorganisms to produce toxins, mitigate the negative effects of feed barriers (such as anti-nutrients), and enhance the availability of nutrients. Additionally, they stimulate the production of digestive enzymes, vitamins, and antimicrobial substances, which can improve gastrointestinal health (Rowles, 2017).

The policy banning the use of Antibiotic Growth Promoters (AGP) in feed additives has significantly impacted animal husbandry, especially in poultry farming. The extensive use of feed additives to boost livestock production has led to negative consequences, including antibiotic residues in meat and other animal products, which may affect consumer health. It has also contributed to bacterial resistance to antibiotics and cross-resistance within the same class of antibiotics. The AGP ban has led to challenges in achieving optimal chicken performance, such as body weight gain, feed conversion ratio, and harvest period, while also decreasing gastrointestinal health and immune function. To address these challenges, the use of probiotic feed additives, such as coconut water kefir, presents a promising alternative to antibiotics in poultry farming.

## MATERIALS AND METHODS

The experimental procedures were approved by the Institutional Ethical Committee of the University of Surabaya (Protocol Number 471/KE/XII/2024).

### Animal and Experimental Design

A total of 400 unsexed Cobb CP 707 broiler chickens (8 days old, initial weight 136.18±3.3 g), sourced from PT Charoen Pokphand, were used in this study. The chickens were randomly assigned to four treatment groups with five replicates, each consisting of 20 chickens. The experimental design

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followed a completely randomized design (CRD). The treatment groups were as follows:

T0= Control group (no coconut water kefir supplementation)
T1= 5% coconut water kefir (CWK)
T2= 10% coconut water kefir (CWK)
T3= 15% coconut water kefir (CWK)

The CWK was incorporated into the drinking water in varying percentages based on the daily water intake of the chickens. The chickens were provided with a diet containing the nutritional content outlined in Table 1.

**Table 1**. Nutrient content of the basal diet

| Nutrients | Starter | Finisher |
|---|---|---|
| Crude protein (%) | 21 | 20 |
| Moisture content (%) | 12 | 12 |
| Fat (%) | 6.95 | 7.11 |
| Crude fiber (%) | 2.79 | 3.51 |
| Ash (%) | 5.19 | 6.23 |
| Calcium (%) | 0.91 | 0.93 |
| Phosphor (%) | 0.74 | 0.78 |
| Lysine (%) | 1.33 | 1.0 |
| Methionine (%) | 0.47 | 0.38 |
| Tryptophan (%) | 0.21 | 0.20 |
| Threonine (%) | 0.76 | 0.79 |
| ME (Kcal/kg) | 3.000 | 3.100 |

Note: Based on the results of proximate tests in the Nutrition and Feed Technology Laboratory. Hasanuddin University

## Making Coconut Water Kefir

The preparation of coconut water kefir (CWK) followed the method described by Dwiloka et al. (2020). First. coconut water was filtered and pasteurized at 60°C for 30 seconds. After pasteurization, the coconut water was allowed to cool to 28°C. Water kefir grains (5% w/v) were then added to the coconut water to initiate the fermentation process. The mixture was incubated at 37°C for 24 hours. The kefir grains used in this process contained *Lactobacillus plantarum*. *Lactococcus cremoris*. *Streptococcus cremoris*. and *Saccharomyces species*. Following incubation. the quality of the resulting CWK was assessed. as outlined in Table 2.

**Tabel 2**. Quality of coconut water kefir

| Variables | Value |
|---|---|
| pH | 4.3 |
| Total acid (%) | 2.35 |
| Viscosity (mPa.S) | 4.65 |
| Total plate count (CFU/ml) | $1.93 \times 10^7$ |

Note: Based on the results of the examination at the integrated laboratory. University of West Sulawesi

## Production Performance

Feed consumption was calculated daily by subtracting the remaining feed from the amount given. Body weight was measured weekly, from the start of the treatment period until the fifth week (weeks 1–5). The average body weight gain was determined by calculating the difference between weekly body weight measurements. The feed conversion ratio (FCR) was computed by dividing the average feed consumption by the average body weight gain for the same week. Feed efficiency was calculated as the ratio of body weight gain to the amount of feed consumed, multiplied by 100%. The performance index (PI) was used to evaluate the success of broiler production over the experimental period. It was calculated based on harvest weight, FCR, harvest age, and the percentage of chickens that survived during rearing.

## Carcass and Abdominal Fat

Carcass weight was determined by weighing the carcass after the removal of feathers, head, feet, giblet, blood and neck. Carcass percentage was calculated by dividing the carcass weight by the live weight and multiplying the result by 100%. Abdominal fat percentage was obtained by dividing the abdominal fat weight by the live weight and multiplying by 100%.

## Digestive Tract

The parameters measured for the digestive tract profile included the proventriculus, ventriculus, small intestine, cecum, colon, liver, and spleen. After 35 days of rearing, the experimental animals were slaughtered to determine the length and weight of the intestines, and the percentage of internal organs based on live weight. After slaughter, the internal organs were removed, weighed using an analytical scale, and measured for length using a measuring tape.

## Data Analysis

The data obtained were analyzed using Analysis of Variance (ANOVA). If significant differences were observed between treatments, post-hoc analysis was conducted using the Duncan's Multiple Range Test.

# RESULTS AND DISCUSSION

## Production Performance

The performance parameters measured for the broilers included feed intake, final body weight, body weight gain, feed conversion ratio (FCR), feed efficiency, depletion, and the performance index. The production performance of the broilers subjected to the different treatments is presented in Table 3.

**Table 3**. Productive performance of broiler chickens

| Parameter | T0 | T1 | T2 | T3 | SEM | p-value |
|---|---|---|---|---|---|---|
| Feed intake (*g/head/day*) | 118.57±1.53[b] | 96.49±4.84[a] | 99.95±5.26[a] | 100.78±4.64[a] | 2.16 | 0.000 |
| Final body weight (*g/head*) | 1643.80±52.88[a] | 1684.60±50.26[ab] | 1715.40±31.51[b] | 1719.40±33.92[b] | 11.26 | 0.048 |
| Weight gain (*g/head/day*) | 60.72±3.85[a] | 64.27±4.40[ab] | 67.70±4.15[b] | 66.08±0.60[b] | 0.95 | 0.041 |
| FCR | 1.96±0.11[b] | 1.50±0.08[a] | 1.48±0.08[a] | 1.52±0.07[a] | 0.05 | 0.000 |
| Feed efficiency (*%*) | 51.21±0.13[b] | 66.61±0.11[a] | 67.73±0.10[a] | 65.57±0.07[a] | 0.06 | 0.000 |
| Depletion (*%*) | 0.90±0.55 | 0.50±0.45 | 0.40±0.34 | 0.60±0.55 | 0.11 | 0.299 |
| Performance index | 328.23±11.03[a] | 347.41±17.21[b] | 376.13±10.26[c] | 362.04±21.12[c] | 8.51 | 0.000 |

Note: [ab] Means different superscripts in the same row significantly differ (P<0.05); T0= control (100% distilled water); T1= 5% CWK; T2= 10% CWK; T3= 15% CWK; FCR= feed conversion ratio; SEM= standard error of the means

The results of the ANOVA indicated that the provision of coconut water kefir (CWK) had a significant effect on feed consumption, body weight gain, FCR, and feed efficiency of broiler chickens (P<0.05). The amount of feed consumed by broiler chickens is influenced by several factors, including environmental (external) and internal factors. External factors, such as heat stress, can reduce feed intake, while internal factors, such as the regulation of physiological functions, can also affect consumption, including the activity of digestive enzymes (Copat et al., 2020). Probiotics, such as those found in CWK, improve the enzymatic process in the digestive tract, leading to better broiler performance (Adam et al., 2018). As a result, feed is optimally absorbed, meeting the nutritional needs of the chickens, which may lead to reduced consumption due to sufficient nutrient intake (Orlova. 2020).

The lower feed consumption observed in the CWK treatments compared to the control (T0) may be attributed to the beneficial effects of lactic acid bacteria in kefir, which help optimize digestion, thus ensuring the chickens' nutritional needs are met. As a result, the chickens may reduce feed intake (Orlova. 2020).

The provision of probiotics also positively affected weight gain, as the chickens consumed feed more efficiently for growth. Probiotics enhance the activity of digestive enzymes, which break down feed into nutrients that can be absorbed and utilized for tissue growth and weight gain (Orlova. 2020). Probiotics, including those in CWK, can increase the activity of lipolytic, proteolytic, and amylolytic enzymes in the small intestine, with amylolytic enzyme activity being most notably increased (Hidayat and Harimurti. 2016). Additionally, the lactic acid bacteria in CWK inhibit the growth of pathogenic bacteria in the digestive tract, improving chicken health and optimizing the digestive process, which in turn contributes to weight gain.

Production efficiency, as measured by the FCR, is a key indicator of feed utilization by chickens, describing the amount of feed required to produce meat. FCR can be influenced by various factors, including environmental temperature, feed passage rate through the gastrointestinal tract, feed form, and feed intake (Shah et al., 2019). The presence of lactic acid bacteria in CWK can lower pH levels, creating an acidic environment in the digestive tract. This environment inhibits the growth of pathogenic bacteria, which typically thrive in alkaline conditions, thereby improving nutrient absorption efficiency (Hidayat et al., 2018). Consequently, the CWK treatment resulted in a lower FCR, likely due to higher body weight gain and reduced feed consumption in these treatments.

The PI of broilers given CWK (T1, T2, T3) was higher compared to the control group (T0), driven by higher livability and final body weight, and a lower FCR. The increased livability in the CWK treatments indicates improved bird health, resulting in a higher performance index. Without CWK, the performance index was 328, categorized as good, while it increased to over 350 in the T2 and T3 treatments, categorizing them as very good. According to Abdurrahman et al. (2022), the performance index is classified as good within the range of 326-350 and very good within the range of 351-400. Depletion, or mortality, is another key factor influencing broiler production success. The average depletion rate in this study ranged from 0.4% to 0.9%. Based on this, broiler management in this study was deemed successful, as the depletion rate remained low and below the normal range of <5%, as suggested by Nurmi et al. (2018).

### Carcass and Abdominal Fat

Carcass quality was evaluated based on carcass weight, carcass percentage, and abdominal fat percentage. These parameters were assessed at the end of the study, after 5 weeks of CWK administration. The detailed results of the post-treatment carcass quality analysis are presented in Table 4. The results of the ANOVA showed that the provision of coconut water kefir (CWK) had a significant effect (P<0.05) on the percentages of breast, upper thighs, and abdominal fat, but had no significant effect on the percentages of carcass, back, wings, and drumsticks. The provision of CWK influenced muscle mass formation in broiler chickens, as evidenced by the significantly different percentages of breast, thigh, and abdominal fat compared to broiler chickens not given CWK. The addition of 10%-15% CWK to the daily drinking water improved carcass quality. The lactic acid bacteria contained in CWK are believed to help maintain the health of the digestive tract by inhibiting the growth of pathogenic bacteria, thus improving the efficiency of feed nutrient absorption and supporting better muscle mass formation.

**Table 4**. Carcass of broiler chickens after coconut water kefir feeding

| Parameters | T0 | T1 | T2 | T3 | SEM | p-value |
|---|---|---|---|---|---|---|
| Carcass weight (*g/b*) | 1208.80±11.43$^{a}$ | 1263.00±16.01$^{b}$ | 1321.10±13.43$^{d}$ | 1302.30±11.99$^{c}$ | 10.87 | 0.000 |
| Carcass percentage *(% live BW)* | 73.19±1.24 | 75.25±2.62 | 77.07±4.53 | 74.68±0.61 | 0.64 | 0.196 |
| Breast *(% carcass)* | 32.76±0.55$^{a}$ | 33.73±0.90$^{ab}$ | 34.15±0.87$^{b}$ | 32.91±0.54$^{a}$ | 0.20 | 0.025 |
| Back *(% carcass)* | 21.15±0.42 | 21.12±0.71 | 20.56±1.22 | 21.06±0.38 | 0.17 | 0.579 |
| Wings (*% carcass*) | 10.24±0.34 | 9.99±0.22 | 9.66±0.45 | 10.02±0.31 | 0.08 | 0.101 |
| Thigh (*% carcass*) | 21.33±0.40$^{a}$ | 21.16±0.36$^{a}$ | 21.44±0.41$^{a}$ | 22.00±0.34$^{b}$ | 0.11 | 0.017 |
| Drumstick (*% carcass*) | 14.51±0.37 | 14.00±0.48 | 14.19±1.26 | 14.01±0.27 | 0.15 | 0.649 |
| Abdominal fat (*% carcass*) | 1.51±0.19$^{b}$ | 1.35±0.06$^{ab}$ | 1.32±0.08$^{a}$ | 1.28±0.12$^{a}$ | 0.03 | 0.050 |

Note: $^{ab}$ Means with different superscripts in the same row significantly differ (P<0.05); T0= control (100% distilled water); T1= 5% CWK; T2= 10% CWK; T3= 15% CWK; BW= body weight; SEM= standard error of the means

Sumarsih et al. (2020) reported that administering *Lactobacillus salivarius* 7.5 ml/L in drinking water was able to increase carcass percentage and reduce abdominal fat. Lactic acid bacteria, which function as probiotics, positively influence body heat regulation, disease resistance, and carcass quality. Similarly, Reuben et al. (2021) noted that probiotics can improve growth performance, feed efficiency, gut health, and reduce the inflammatory responses, clinical signs, and mortality associated with *Pasteurella multocida* infections in broilers. El-Hack et al. (2020) also stated that chickens receiving probiotics demonstrated improved gut microbial suppression and better control of intestinal inflammation due to Salmonella infection.

Coconut water kefir, as a feed additive, has a considerable impact on broiler performance, particularly in enhancing the percentage of breast and upper thigh muscle mass. El-Hack et al. (2020) emphasized that probiotic supplementation enhances mineral retention, particularly phosphorus, calcium, nitrogen, and protein efficiency ratios. These improvements in nutrient absorption contribute to better muscle formation. Zhang et al. (2021) reported that the addition of probiotics increased both the absolute and relative weight of breast meat. Additionally, broiler carcass quality improved with probiotic supplementation, as evidenced by reduced Salmonella contamination levels.

### Digestive Tract of Broilers

The digestive tract is a system comprising various organs responsible for the physical and chemical processes that metabolize food into nutrients that can be absorbed by the intestinal walls. In broiler chickens, the digestive tract consists of the mouth, oesophagus, cache, proventriculus, ventriculus, small intestine, cecum, colon, and cloaca. The effects of CWK administration on the digestive tract profile of broiler chickens are summarized in Tables 5 and 6.

The provision of CWK to broiler chickens had a significant effect (P<0.05) on the relative weight of the small intestine. However, statistical analysis indicated no significant effect (P>0.05) on the percentage of liver, proventriculus, ventriculus, duodenum, ileum, cecum, or colon. The average hepatic percentage ranged from 2.03%-2.18%. which is within the normal range of 1.93%-2.34% according to Wang et al. (2021). The absence of significant effects on hepatic function suggests that CWK did not induce any liver enlargement or affect its regular physiological activity. Several factors, including genetics, body size, breed, feed composition, temperature, and humidity, influence liver size and weight (Selim et al., 2021).

**Table 5**. The percentage of digestive tract organs of broiler chickens given coconut water kefir

| Average percentage of organ weight (% BW) | T0 | T1 | T2 | T3 | SEM | p-value |
|---|---|---|---|---|---|---|
| Proventriculus | 0.42±0.07 | 0.47±0.11 | 0.47±0.11 | 0.41±0.05 | 0.02 | 0.603 |
| Ventriculus | 1.43±0.15 | 1.40±0.11 | 1.44±0.25 | 1.25±0.04 | 0.04 | 0.223 |
| Duodenum | 0.62±0.05 | 0.70±0.09 | 0.75±0.09 | 0.70±0.05 | 0.02 | 0.065 |
| Jejunum | 0.84±0.16$^{a}$ | 1.19±0.16$^{b}$ | 1.35±0.03$^{b}$ | 1.33±0.06$^{b}$ | 0.05 | 0.000 |
| Ileum | 0.69±0.05 | 0.77±0.08 | 0.82±0.12 | 0.82±0.12 | 0.02 | 0.104 |
| Cecum | 0.20±0.02 | 0.17±0.06 | 0.18±0.04 | 0.14±0.03 | 0.01 | 0.250 |
| Colon | 0.19±0.04 | 0.18±0.04 | 0.21±0.04 | 0.19±0.03 | 0.01 | 0.662 |
| Liver | 2.03±0.15 | 2.17±0.17 | 2.14±0.22 | 2.18±0.87 | 0.04 | 0.452 |
| Spleen | 0.14±0.03 | 0.22±0.06 | 0.23±0.09 | 0.19±0.03 | 0.01 | 0.076 |

Note: $^{ab}$Means with different superscripts in the same row significantly differ (P<0.05); T0= control (100% distilled water); T1= 5% CWK; T2= 10% CWK; T3= 15% CWK; BW= body weight; SEM= standard error of the means

**Tabel 6**. Length of small intestine of broiler chickens given coconut water kefir

| Length of small intestine (cm) | T0 | T1 | T2 | T3 | SEM | p-value |
|---|---|---|---|---|---|---|
| Duodenum | 46.8±2.17 | 49.6±3.20 | 51.8±4.15 | 50.8±0.84 | 0.73 | 0.071 |
| Jejunum | 68.2±4.32$^{a}$ | 82.0±6.21$^{b}$ | 88.2±2.86$^{c}$ | 87.4±1.14$^{c}$ | 2.02 | 0.000 |
| Ileum | 52.8±2.78$^{a}$ | 58.2±3.11$^{b}$ | 61.2±2.17$^{b}$ | 61.0±2.00$^{b}$ | 0.94 | 0.000 |

Note: $^{ab}$Means with different superscripts in the same row significantly differ (P<0.05); T0= control (100% distilled water); T1= 5% CWK; T2= 10% CWK; T3= 15% CWK; SEM= standard error of the means

The provision of CWK did not significantly affect the percentages of proventriculus and ventriculus (P>0.05). This outcome may be due to the role of probiotic bacteria in CWK, which supports the performance of these digestive organs in processing crude fiber. In this study, the percentages of proventriculus (0.41%-0.47%) and ventriculus (1.25%-1.44%) remained within normal ranges (0.40%-0.60% for proventriculus and 1.4%-2.3% for ventriculus) as reported by Wang et al. (2021). The type of feed given, such as commercial feed with appropriate nutritional content, can also influence the size and weight of these digestive organs, causing them to become thicker, longer, and heavier due to fiber content (Selim et al., 2021).

The percentages of colon and cecum were unaffected by CWK treatments. The percentage of colon in this study was 0.18%-0.21%, which lies within the normal range of 0.17%-0.20% (Wang et al., 2021). The relative percentage of the cecum ranged from 0.14%-0.20%, which is lower than the 0.46%-0.49% reported by Dauksiene et al. (2021), but still within the normal range of 0.20%-0.40%. The presence of lactic acid bacteria in CWK may contribute to increased immunity and improved digestive tract performance by stimulating pancreatic enzyme secretion, suppressing pathogenic bacteria, and promoting the growth of beneficial microflora, thereby enhancing nutrient absorption and digestive efficiency (Zhang et al., 2021).

A significant effect (P<0.05) was observed in the percentage of jejunum following CWK administration. The percentages of the duodenum (0.62%-0.75%), jejunum (0.84%-1.35%), and ileum (0.69%-0.82%) were higher in the 10% CWK treatment (T2), showing the most substantial increase in jejunum percentage. Coconut water kefir contains various lactic acid bacteria, such as the general *Lactobacillus*, *Lactococcus*, *Leuconostoc*, and *Streptococcus*, which improve microbial diversity in the small intestine. These microorganisms produce organic acids that inhibit harmful microbes, enhancing nutrient absorption and digestibility. Additionally, the increase in small intestine weight may be attributed to short-chain fatty acids (SCFAs) from the fermented probiotic product, which stimulate the growth of small intestinal epithelial cells (Sirisopapong et al., 2023).

The percentage of spleen was not significantly affected by CWK treatments (P>0.05). The spleen percentage ranged from 0.14%-0.23%, with the highest percentage observed in the 10% CWK group (T2). This value is higher than the normal broiler spleen percentage of 0.09%-0.14% for five-week-old chickens (Wang et al., 2021). The spleen plays a crucial role in white blood cell production, particularly lymphocytes, which are vital for antibody formation. Together with the bone marrow and liver, the spleen helps in the degradation of old erythrocytes and acts as a blood filter (Zhou et al., 2023). The higher percentage of relative spleen weight in chickens fed CWK may be due to the role of kefir as a probiotic. Lactic acid bacteria in CWK improve immune function by stimulating lymphocyte production, enhancing the body's ability to respond to antigens and produce antibodies.

### Small Intestine Length

The relative length of the small intestine was significantly affected (P<0.05) by the provision of CWK. Treatments with 5%, 10%, and 15% CWK each produced favorable effects on small intestine length. The average lengths for the duodenum (46.8-51.8 cm), jejunum (68.2-88.2 cm), and ileum (52.8-61.2 cm) were observed. The highest small intestine length was observed in the 10% CWK group (T2). This result is consistent with previous studies by Wang et al. (2021), where the average small intestine lengths were duodenum (36.00-41.00 cm), jejunum (65.50-72.50 cm), and ileum (43.00-48.50 cm). The increased length of the small intestine observed in this study suggests that a longer intestine provides a larger surface area for nutrient absorption, resulting in more efficient nutrient uptake.

## CONCLUSION

Coconut water kefir has proven effective in enhancing the production performance, carcass quality, and digestive tract profile of broiler chickens.

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