**Open Access Research Journal of**
**Life Sciences**
Journals home page: https://oarjpublication/journals/oarjls/
ISSN: 2783-025X (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Check for updates

# FUNCTIONAL ROLE OF CACAO POD HUSK (*THEOBROMA CACAO* L.) WASTE AS AN ADDITIVE DIET INGREDIENT IN LOCAL DUCKS (*ANAS PLATYRHYNCHOS DOMESTICUS*) DURING THE GROWTH PHASE

Wapsiaty Utiah *, Linda M.S. Tangkau and Umar Paputungan

Department of Animal Production, Faculty of Animal Sciences, Sam Ratulangi University, Manado 95115, Indonesia.
* Corresponding Author

ORCID Details
Umar Paputungan: https://orcid.org/0000-0003-4903-6357

Open Access Research Journal of Life Sciences, 2026, 12(02), 001–011

Publication history: Received on 29 September 2026; revised on 05 November 2026; accepted on 07 November 2026

Article DOI: https://doi.org/10.53022/oarjls.2026.12.2.0030

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

## ABSTRACT

Cacao pod husk (CPH) waste is a byproduct of cacao bean processing that retains nutritional value potentially beneficial for ducks; it works by facilitating feed ingredient substitution while maintaining nutritional balance within the animal's digestive tract. Field-scale research is required to assess the effectiveness of CPH waste in duck diets for enhancing the growth and production of local ducks, particularly in North Sulawesi. This study aimed to evaluate the growth and production performance of local ducks, thereby supporting innovations in animal protein supply in North Sulawesi through the utilization of CPH waste—a resource that does not compete with human food needs. A Completely Randomized Design (CRD) was employed, featuring four treatments and eight replicates, with two starter-phase ducks per replicate. The treatments were including P0 (control diet without CPH waste of 0%), P1 (ration diet substituted with 6% CPH waste meal), P2 (ration diet substituted with 12% CPH waste meal), and P3 (ration diet substituted with 18% CPH waste meal). Observed variables included feed intake, body weight, body weight gain, and feed conversion ratio. The results indicated that incorporating CPH waste at levels exceeding 12% began to impair duck growth performance; this was evidenced by reduced feed intake, lower cumulative body weight, decreased daily weight gain, and a significant increase in the feed conversion ratio. Fermentation of CPH waste could be performed beforehand to increase protein content and reduce crude fiber levels, enabling its use at levels above 12% in grower-phase duck rations while enhancing the material's nutritional value.

**Keywords:** Cacao pod husk waste, Local duck growth, Cacao pod husk waste, Local duck growth, Ration feed conversion

## 1 INTRODUCTION

Duck farming has made a significant contribution to farmers' incomes, created employment opportunities, and enhanced community productivity, primarily through the production of duck meat and eggs, which help meet the public's demand for animal-based protein [1]. Ducks are a major source of animal protein and represent a key commodity; they are increasingly recognized as a strong competitor to free-range chickens, valued for their distinctive flavor and substantial meat yield [1].

The ration is a critical factor to consider in duck farming. A high-quality ration influences the final outcomes of duck rearing, contributing to high meat and egg production [2, 3], as well as earlier reproductive maturity and greater egg weight [4, 5]. The high cost of feed ingredients—such as corn, soybean meal, and fish meal—compels farmers to seek out affordable yet high-quality alternatives, including the use of cacao pod husks (CPH). Feed costs represent a significant portion of duck farming expenses, accounting for 60–70% of total production costs [6]. To manage these costs, farmers can formulate their own rations using readily available, lower-cost ingredients that still provide the essential nutrients required for the livestock's production, reproduction, and overall health [7].

Cacao pod husks (CPH) possess a nutritional composition comparable to that of other plant-based materials, making them highly promising as an alternative feed source [8]. CPH cannot be stored for long periods due to their high moisture content, which makes them prone to spoilage and mold growth. Consequently, appropriate processing technology is required to handle the material and enhance its nutritional quality before it is fed to livestock. Cacao plantations yield cacao beans as the primary product, with CPH as a by-product. The proportions of fresh cocoa beans, pod husks, and placenta are 24:74:2, respectively [9]—or 50.8:47.2:2.0 when expressed as a dry matter ratio. By determining the volume of cocoa bean production, it is possible to estimate the potential availability of CPH for use as livestock feed.

Trends in cacao land area, production, and productivity in the Greater Bolaang Mongondow region from 2021 to 2024 indicate that the area under cacao cultivation has remained relatively constant over the last four years, recorded at 1,746 hectares, with a cacao bean production of 938.8 tons per year [10]. Based on the ratio of cacao beans to cacao pod husks (CPH), the potential dry matter yield of CPH is estimated at 469.4 tons per year, or 0.269 tons per hectare per year [11]. If utilized as a fiber source to replace other plant-based ingredients (comprising 50% of the dry matter in a ration), this could meet the requirements for 373,611 livestock units (where 1 livestock unit equals 100 ducks), equivalent to 37,361 ducks per year.

Limited knowledge among farmers regarding raw material specifications, feed formulation, and feed production processes has prevented the full utilization of cacao pod husks (*Theobroma cacao* L.)—a byproduct of cacao production. Consequently, there is a need for research into the use of cacao pod husks as a feed additive, incorporated at varying levels into duck rations. This study aims to evaluate the effects of including cacao pod husks in duck diets, beginning during the growth phase and extending through the stages of sexual maturity and the onset of egg production.

## 2 MATERIALS AND METHODS

### 2.1 Research Location

This research was conducted at a duck farm in Matali Village, East Kotamobagu District, Kotamobagu City, over a period of 120 days—consisting of 14 days for the preparation phase and 106 days for data collection and draft processing of manuscript.

### 2.2 Research Material

A total of 64 ducks of unsexed status were used. The equipment employed included individual cages, weighing scales, feeders, waterers, and other necessary accessories. The feed ingredients consisted of cacao pod husks (CPH), corn, rice bran, and broiler concentrate. The CPH was sourced from local cacao plantations in the vicinity of Kotamobagu City and Bolaang Mongondow Regency; it was finely chopped and sun-dried for approximately 3 days until completely dehydrated. Once dried, the CPH was ground into a fine powder (Figure 3). Other feed ingredients—namely corn, rice bran, and concentrate—were also prepared. These ingredients were formulated to meet the nutritional requirements of meat-type ducks during the grower phase, specifically 16% crude protein (CP) and 3000 kcal/kg of metabolizable energy (ME) [5].




**Figure 1: The research procedure involves the use of cacao pod husk (CPH) waste flour—derived from *Theobroma cacao* L.—as a functional additive in the rations of local ducks (*Anas platyrhynchos domesticus*) during the starter growth phase.**

### 2.3 Enclosures and equipment

The enclosures used in this study consisted of 32 individual pens, each housing 2 ducks, for a total of 64 ducks. Every pen was equipped with a feeder and a waterer. The duck enclosures and their equipment were cleaned, and the enclosures were sprayed with a disinfectant to eliminate any bacteria present.

### 2.4 Research Duck Feed

**Table 1: Nutritional Requirements of Peking Ducks**

| Nutritional Composition | Starter | Grower |
|---|---|---|
| Crude Protein (%) | 20,0 - 22,0 | 16,00 – 19,00 |
| Metabolic Energy (kcal/kg) | 2900 | 3000 |

Source: [5].

**Table 2: Duck Feed Consumption Standards**

| Age (weeks) | Ducks (g/bird/week) |
|---|---|
| 1 | 150 |
| 2 | 310 |
| 3 | 400 |
| 4 | 610 |
| 5 | 780 |
| 6 | 800 |
| 7 | 950 |
| 8 | 1000 |

Source: [5].

Day-old ducks (DOD) were transported to the research site immediately after hatching. Upon arrival, the ducklings were provided with water *ad libitum*, followed by feed. From 0 to 2 weeks of age, the ducklings were fed a commercial ration (BR-1), as starter ducks require a crude protein content of 20–22% and a metabolizable energy level of 2,900 kcal/kg [5]. From 2 weeks of age until 10 weeks of age, the ducklings were provided with an experimental diet formulated from tofu dregs, rice bran, corn, and concentrate. The nutritional requirements for the starter and grower phases were based on the standards for Pekin ducks, as presented in Table 2. Water was provided *ad libitum*, while feed was supplied twice daily (in the morning and afternoon). The body weight of the ducklings was recorded at the beginning of the study and measured weekly thereafter until the end of the research period. The feeding regimen for the grower phase was based on [24], with a 10% modification, as detailed in Table 2.

The feed used in this study was a commercial feed (BR-1) for ducklings aged 0–2 weeks; for the treatment group of ducklings aged 3–10 weeks, the feed ingredients presented in Table 2 were used. The formulations of the experimental rations and their respective nutritional content are shown in Table 3, while the composition of the rations is detailed in Table 4.

**Table 3: Nutrient composition of feed ingredients for the grower phase of ducks**

| Nutrients | Protein (%) | Crude Fiber (%) | Fat (%) | Ca (%) | P (%) | Gross Energy (Kcal/kg) |
|---|---|---|---|---|---|---|
| Corn * | 10,19 | 1,86 | 1,52 | 1,55 | 1,48 | 4.301 |
| Rice bran * | 10,12 | 18,71 | 7,98 | 1,06 | 1,33 | 4.251 |
| Concentrate ** | 32,00 | 6,00 | 5,00 | 11,00 | 1,10 | 2.125 |
| CPH # | 11,30 | 39,33 | 1,48 | 0,22 | 1,07 | 2.600 |

*) Analysis results [1,5].; **) Nutritional content of feed ingredients PT. Japfa Bomfeed Indonesia (2026); #) Analysis results of the Testing Laboratory, Centre for Standardization and Industrial Services, Manado of Indonesia (2026); CPH = Cacao Pod Husk

The composition of feed ingredients for the grower-phase duck ration is as shown in Table 4.

**Table 4: Feed Formulation and Nutritional Content of Feed**

| Feed Ingredients | Treatment | | | |
|---|---|---|---|---|
| | T0 | T1 | T2 | T3 |
| Yellow corn (%) | 50 | 47,00 | 44,0 | 41,00 |
| Rice bran (%) | 5 | 4,70 | 4,40 | 4,10 |
| Concentrate (%) | 45 | 42,30 | 39,60 | 36,90 |
| CPH (%) | 0 | 6,00 | 12,00 | 18,00 |
| Total (%) | 100 | 100 | 100 | 100 |
| **Nutrients *** | | | | |
| Protein (%) | 21.00 | 20.41 | 19.82 | 19.22 |
| Crude fiber (%) | 11.44 | 12.32 | 13.07 | 13.19 |
| Fat (%) | 4.56 | 5.75 | 6.94 | 8.13 |
| Ca (%) | 5.78 | 5.44 | 5.11 | 4.78 |
| P (%) | 1.30 | 1.29 | 1.27 | 1.26 |
| Gross Energy (Kcal/kg) | 3319.3 | 3276.14 | 3232.98 | 3189.83 |

*) Calculated based on the nutrient composition in Table 3; CPH = Cocoa Pod Husk

This study employs a Completely Randomized Design (CRD) with 4 treatments and 8 replications. Each treatment and replication involve 2 ducks in the grower phase. The treatments to be investigated are as follows:

- T0: Basal Diet without CPH (0%),
- T1: Basal diet with CPH additive of 6%,
- T2 : Basal diet with CPH additive of 12%, and

- T3 : Basal diet with CPH additive of 18%.

### 2.4.1 Research Variables

The variables observed include: (a) feed consumption, (b) body weight, (c) body weight gain, and (d) feed conversion. Feed consumption is calculated on a weekly basis by subtracting the amount of leftover feed from the total amount of feed provided over the course of the week.

### 2.5 Statistical analysis

The analysis used for variable estimation, employing a Completely Randomized Design (single-factor) with the following statistical model [38, 39]:

$Y_{ik} = \mu + \alpha_i + \varepsilon_{ik}$

Where: Yik = the k-th observation for the i-th sire; μ = the mean of the observations; αi = the effect of the i-th treatment level of cacao pod husk (CPH); and εik = the deviation due to uncontrolled environmental and genetic factors. The partitioning of variance components—used to estimate the significance level of the treatments based on probability values—was performed via analysis of variance [38, 39], as outlined in Table 6.

**Table 5: Sources of variance, components of analysis of variance, and significance levels of treatments, with corresponding probability (p) values**

| Source of variance | Degrees of freedom (df) | Sum of Squares (SS) | Mean Square (MS) | $F_{Calculated}$ | Significance level (p) | |
|---|---|---|---|---|---|---|
| | | | | | $p < 0.05$ | $p < 0.01$ |
| Treatment (t) | t – 1 = 3 | SSt | SSt /3 | MSt / MSε | 2,99 | 4,68 |
| Error (ε) | t (r – 1) = 28 | SS ε | SSε /28 | | | |
| Total | tr – 1 = 31 | | | | | |

Notes: Treatment (t) = 4 CPH additive level; Replication (r) = 8 replicates (replication)/treatment.; If the value $F_{Calculated} > 4,68$; then, the treatment has a highly significant effect ($p < 0,01$) on duck growth,; if the value $F_{Calculated} > 2,99$; then, the treatment has a significant effect ($p < 0,05$) on duck growth.

## 3 RESULTS AND DISCUSSION

### 3.1 Feed Consumption

The average feed consumption of ducks aged one to four weeks is presented in Table 6. Analysis of variance results indicate that the inclusion of cacao pod husk (CPH) waste has a significant effect ($P<0.05$) on the feed consumption of ducks during the growth phase up to 4 weeks of age. The use of a large amount of CPH waste in treatment R3 resulted in a decrease in feed consumption of approximately 3.69 percent (Table 6), likely because CPH waste is bulky due to its high fiber content. The bulky nature of a feed ingredient can cause a duck's crop to fill up quickly, leading to reduced feed intake, even though the duck's actual nutritional requirements have not yet been met. Furthermore, feed palatability significantly influences feed consumption, which in turn affects live body weight [15].

The best average feed consumption was observed with the control diet, which utilized feed ingredients—including protein sources—of high quality and low crude fiber content. The nutrient sources in the concentrate feed consisted of ingredients containing high-quality amino acids and relatively low crude fiber levels, especially when compared to diets incorporating up to 18 percent cacao pod husks (CPH) (Figure 2). A high crude fiber content in feed can reduce feed intake, as it limits the availability of energy and other essential nutrients. Furthermore, crude fiber acts as a "bulking agent," causing the poultry's crop to reach capacity more quickly; this triggers the cessation of feeding, ultimately leading to a decline in total feed consumption. Bulky feed causes the digestive tract to fill up rapidly, prompting the birds to reduce their feed intake [32].

**Table 6: Mean feed consumption, initial body weight, body weight at 4–8 weeks of age, body weight gain (BWG) during the study, and feed conversion ratio (FCR) for ducks (*Anas platyrhynchos domesticus*)**

| Observational Variables | Treatment (g/animal/week) | | | | |
|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | p |
| Daily feed consumption up to 4 weeks of age (g/bird) | 55,89 ± 0,62 [a] | 55,31 ± 0,62 [a] | 54,69 ± 0,63 [ab] | 53,83 ± 1,13 [b] | .05 |
| Daily feed consumption up to 8 weeks of age (g/bird) | 93,66 ± 0,64 | 93,43 ± 0,69 | 93,08 ± 1,05 | 92,85 ± 0,97 | .12 |
| Body weight of the ducks in the study (4 weeks of age) | 551,62 ± 19,12 [a] | 549,25 ± 20,91[ab] | 534,62 ± 24,02 [bc] | 524,01 ± 29,02 [c] | .01 |
| Body weight of ducks in the study (8 weeks of age, g/bird) | 1376,12 ± 43,89 [a] | 1215,62 ± 73,47 [a] | 1081,75 ± 43,32 [b] | 920,12 ± 49,98 [c] | .01 |
| Body weight gains up to 4 weeks of age (g/bird) | 26,41 ± 3,01 [a] | 24,67 ± 3,89 [a] | 21,08 ± 3,81 [ab] | 18,21 ± 4,58 [b] | .01 |
| Body weight gains up to 8 weeks of age (g/bird) | 23,61 ± 3,67 [a] | 17,37 ± 2,62 [b] | 15,07 ± 1,53 [bc] | 11,37 ± 3,68 [c] | .01 |
| Daily FCR (feed conversion ratio) up to 4 weeks of age | 2,18 ± 0,39 [a] | 2,28 ± 0,31 [b] | 2,79 ± 1,03 [bc] | 3,13 ± 0,82 [c] | .03 |
| Daily FCR (feed conversion ratio) up to 4 weeks of age | 4,06 ± 0,71 [a] | 5,48 ± 0,77 [ab] | 6,18 ± 0,29 [b] | 9,15 ± 1,64 [c] | .03 |

Notes: T0: Feed without cacao pod husk (CPH) (0%); T1: Feed with 6% cacao pod husk (CPH); T2: Feed with 12% cacao pod husk (CPH); and T3: Feed with 18% cacao pod husk (CPH). Different superscripts in the same row indicate highly significant (P<0.01) and significant (P<0.05) differences.

Cacao pod husks (CPH) is a residue generated during the processing of cacao beans into agricultural products; consequently, much of its original nutritional content has been depleted. Nevertheless, CPH remains a potential source of plant-based protein for livestock feed, as its protein content can reach approximately 10.12%, along with a profile of various amino acids [11, 33]. It is suspected that the amino acid content in CPH is reduced, which may lead to a decline in the intake of essential nutrients (amino acids) [33]. Duck feed consumption was higher at 8 weeks of age compared to 4 weeks of age, whereas daily weight gain was lower at 8 weeks of age than at 4 weeks of age (Figure 2). This situation resulted in a higher feed conversion ratio for the ducks at 8 weeks of age compared to 4 weeks of age (Figure 2).

Waterfowl (ducks) prefer wet feed over dry feed. Including increasing amounts of dry cacao pod husks (CPH) waste in the ration results in significant feed wastage; furthermore, it can cause ducks to experience difficulty swallowing, which may lead to respiratory distress—a condition that, if prolonged, can result in sudden death. This, in turn, leads to a reduction in weight gain, consistent with a decline in feed consumption [34]. As noted above, higher levels of CPH waste in the ration are associated with lower feed intake. It was observed that a ration containing up to 18% CPH waste still supported a level of feed consumption that did not differ significantly (p=0.12) from that of the control group (Table 6). However, this increase in feed consumption did not translate into a positive effect on the ducks' daily weight gain or their cumulative live weight by the age of 8 weeks.

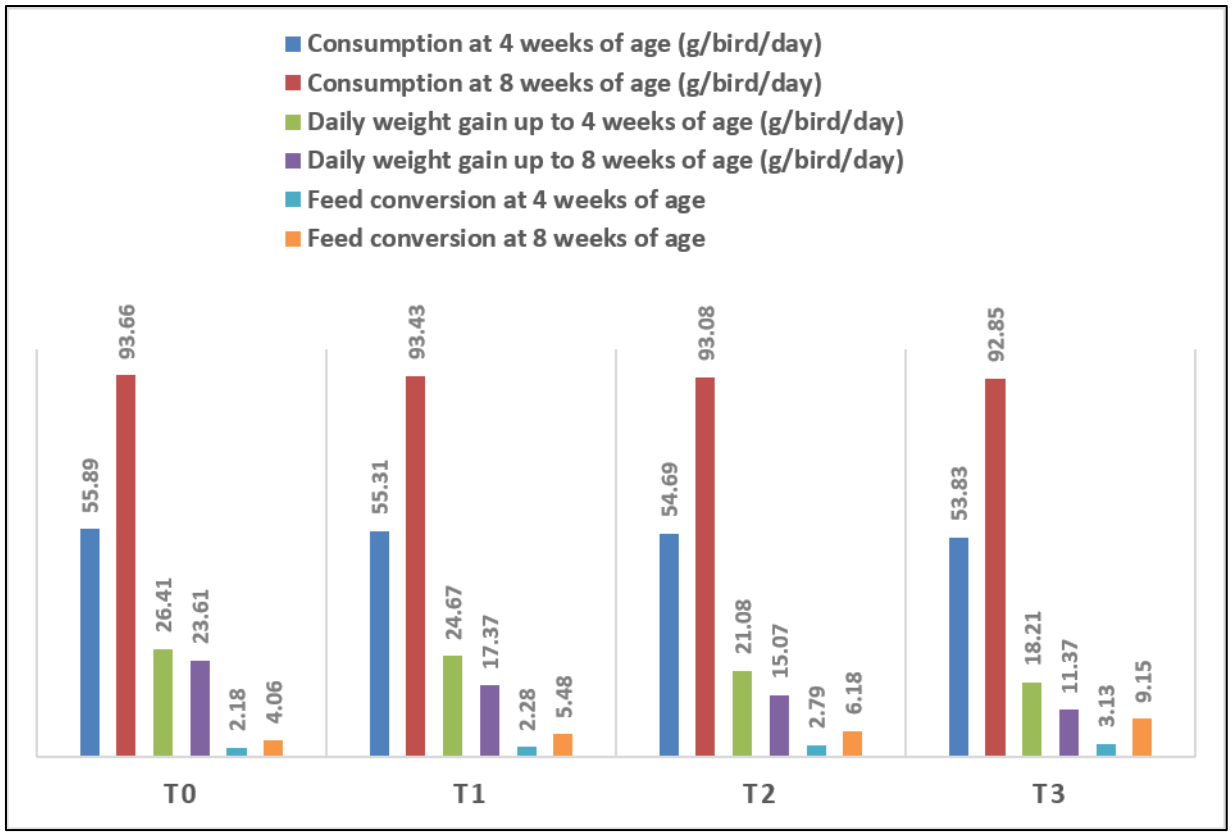



**Figure 2: Feed consumption, daily body weight gain (BWG) of ducks (g/bird/day), and feed conversion ratio at 4 and 8 weeks of age under the following treatments: T0 (feed without CPH waste, 0%), T1 (feed with 6% CPH waste substitution), T2 (feed with 12% CPH waste substitution), and T3 (feed with 18% CPH waste substitution).**

### 3.2 Body Weight

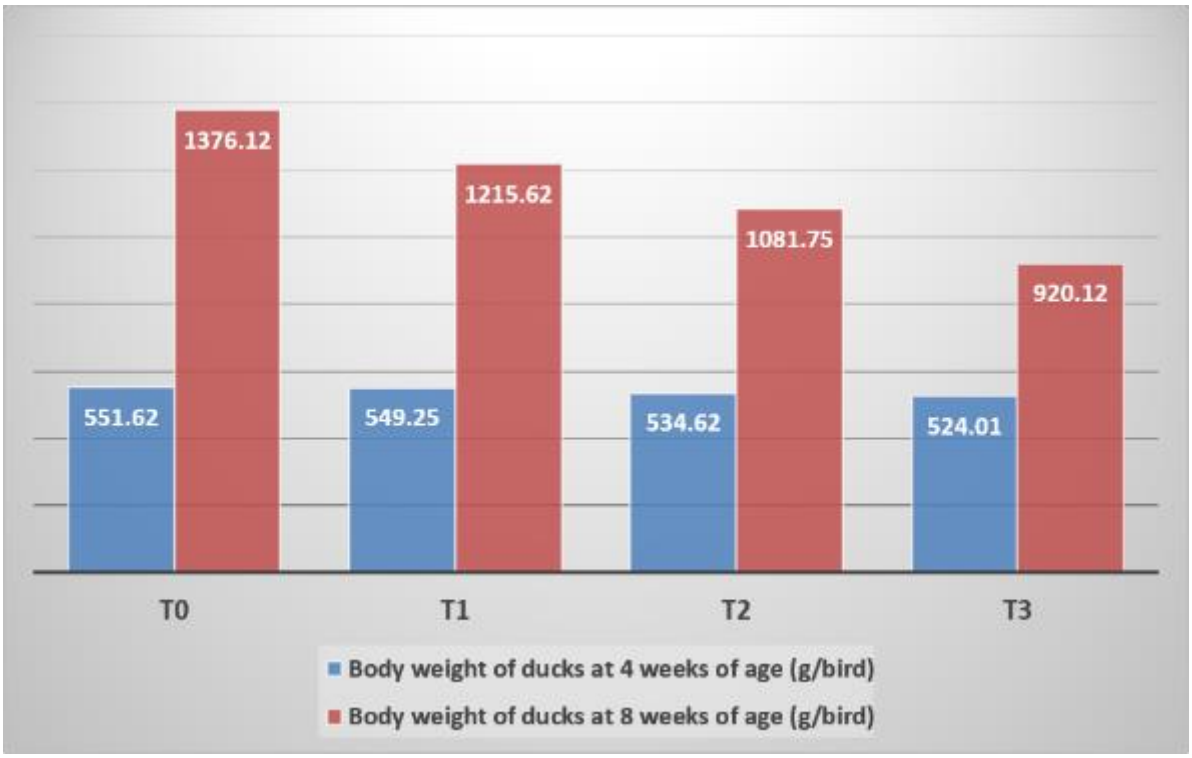



**Figure 3: Cumulative body weight of ducklings at 4 weeks and 8 weeks of age**

The average body weight of ducks from one to eight weeks of age is presented in Table 6. Analysis of variance indicates that the inclusion of CPH waste in the ration has a highly significant effect ($p<0.01$) on the reduction of both daily feed intake and body weight gain, as well as the cumulative body weight of the ducks. Further testing reveals that duck body weight decreases significantly ($p<0.01$) as the proportion of CPH waste in the ration increases. Body weight is strongly influenced by the amount of feed consumed that contains CPH waste; higher consumption of such feed leads to lower body weight (Figure 2). A higher nutrient density in the feed results in greater body weight, whereas a lower nutrient density leads to lower body weight, primarily due to reduced feed intake [35]. This is because feed containing CPH waste often has a lower nutrient density and is generally less palatable; it typically contains higher levels of crude fiber and lower levels of metabolizable energy (Table 4). The results of this study show that cumulative body weight decreases as the level of CPH waste in the ration increases. It is observed that the cumulative body weight of the ducks, starting from the 4-week age period, shows a substantial increase by the 8-week age period (Figure 3). Concurrently, there is a notable surge in feed intake during both the 4-week and 8-week periods (Figure 2), which correlates directly with the sharp rise in cumulative body weight observed by the 8-week mark (Figure 3).

### 3.3 Body weight gain

The average weight gain of the ducks is presented in Table 6. Analysis of variance indicates that the inclusion of cacao pod husk (CPH) waste at varying levels in the diets of ducks aged 1–8 weeks has a highly significant effect ($p<0.01$) on cumulative live body weight and daily weight gain. The CPH waste was sourced as an alternative feed ingredient for ducks. It was collected from community-owned cocoa plantations in the vicinity of Kotamobagu City (Figure 1). The fresh CPH waste was chopped and then sun-dried; the drying process took three days, provided there was no rain. Once dried, the CPH waste was ground using a corn-grinding machine equipped with a sieve, resulting in a cacao pod husk (CPH) meal ready for use as a feed ingredient for ducks.

Body weight gain is strongly influenced by feed intake, as the amount of feed consumed determines the nutrients that enter the duck's body for growth. These findings differ from those of previous studies [36, 37], which reported that feeding ducks a diet containing 10%–30% CPH waste did not affect body weight gain. The variation in body weight observed in this study is attributable to differences in the amount of feed consumed; specifically, higher feed intake—containing up to 18% CPH waste—resulted in reduced body weight gain, likely due to the high crude fiber content.

There are differences in the body weight and weight gain of ducks fed commercial feed versus those fed a formulated (homemade) ration, stemming from variations in their nutritional value—even when the formulated ration is intended to have the same nutritional composition as the commercial feed [37]. This discrepancy can arise because the varying quality of the ingredients used in a formulated ration makes it difficult to ensure that the final product possesses the same nutritional profile as commercial feed. For instance, ingredients such as fish meal, soybeans, and rice bran available on the market vary significantly in quality—ranging from coarse bran and fine bran to rice polishings (bekatul), or a combination of these—making it challenging to guarantee that the nutritional composition of the ingredients meets specific standards. A high protein content, when accompanied by high levels of fiber or lignin, requires a longer duration for the processes of digestion and nutrient absorption in ducks [37]. Consequently, poor absorption of nutrients from the feed leads to a reduction in the ducks' weight gain.

### 3.4 Feed Conversion Ratio (FCR)

Feed conversion is an indicator used to measure the efficiency of feed utilization in producing body weight—including meat—relative to the total body weight gained as the final output. The mean feed conversion ratio (FCR) for the ducks is presented in Table 6. Analysis of variance indicates that the inclusion of CPH (cacao pod husk) waste at varying levels in the ducks' diet has a significant effect ($p<0.05$) on the feed conversion ratio.

Feed conversion is calculated by taking the total daily feed consumption over the 1–8 week period and dividing it by the total daily body weight gain during the same period. Up to 4 weeks of age, the highest mean feed conversion ratio (FCR) was observed in T3 (3.13 ± 0.82), followed by T2 (2.79 ± 1.03), T1 (2.28 ± 0.31), and the lowest in T0 (2.18 ± 0.39). However, these FCR values increased across all feed levels as the ducks transitioned from the 4-week mark toward 8 weeks of age; the highest mean FCR was found in T3 (9.15 ± 1.64), followed by T2 (6.18 ± 0.29), T1 (5.48 ± 0.77), and the lowest in T0 (4.06 ± 0.71) for the period up to 8 weeks of age (Table 6). This indicates that, between 4 and 8 weeks of age, ducks require a significantly higher feed intake—an increase of 100% to 300%—to maintain a linear rate of body weight gain compared to their growth during the first 4 weeks.

The feed conversion ratio (FCR) results obtained here are lower and do not align with the findings of studies [33] and [37] on ducks. Those studies reported that ducks fed diets containing 10%, 20%, and 30% cacao pod husk (CPH) waste over an eight-week rearing period showed no significant differences in their feed conversion ratios. In the present study, the R0 treatment proved to be the most efficient, as it yielded the lowest feed conversion ratio. The observed differences in the feed conversion ratios between ducks receiving commercial feed and those receiving the experimental

(formulated) feed are attributable to variations in the balance between feed intake and the resulting body weight gain [37].

The feed conversion ratio increases as the proportion of cacao pod husk (CPH) in the ration rises. The feed conversion ratio is influenced by two factors: feed consumption and body weight gain [37]. A high feed conversion ratio in ducks is strongly associated with the fiber content of the ration. A higher fiber level, when balanced with an optimal protein content, can improve feed conversion [37]. Feed with a high nutrient density results in better feed efficiency/conversion [33].

The feed conversion ratio indicates the efficiency with which ducks utilize the feed provided. A lower feed conversion ratio signifies higher feed efficiency [33, 38]. A low feed conversion ratio means that less feed is required to achieve an increase in body weight—reflecting high efficiency—which aligns with research findings stating that a lower feed conversion ratio indicates greater efficiency in feed utilization [37]. The feed conversion ratio for ducks is higher at 8 weeks of age compared to 4 weeks of age; this is due to an increase in feed consumption during that period, which is inversely proportional to the gain in body weight (Figure 2).

## 4 CONCLUSION

The inclusion of cacao pod husks (CPH) in feed at levels exceeding 12% begins to impair the growth performance of ducks, as evidenced by a significant reduction in feed intake, cumulative body weight, and daily weight gain, alongside an increase in the feed conversion ratio. Fermenting the CPH can increase its protein content while reducing its crude fiber content; subsequent research could then explore the use of fermented CPH at levels above 12% in the diets of growing ducks, thereby enhancing the nutritional value of this byproduct.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

### *Acknowledgments*

We express our sincere gratitude for the funding support provided for the partnership program of the Sam Ratulangi University Research Institute so that research and writing of this scientific work can run well.

### *Funding Source*

This research was funded by UNSRAT DIPA Funds for Fiscal Year 2026, Contract Number: 2424/UN12.27/LT/2026.

### *Disclosure of conflict of interest*

The authors declared no conflict of interest.

## REFERENCES

[1] Akhadiarto, Sindu. (2009). Utilization of Cacao Waste as Feed for Goats [Pemanfaatan Limbah kakao sebagai pakan ternak kambing]. Jurnal Pusat Teknologi Produksi Pertanian, Badan pengkajian dan penerapan teknologi (Nomor 3 tahun 09). Hlm. 185-191.

[2] Anwar, Rosyid., M Arief Hakim and M Solihin. (2005). Practical Guide to Raising Broiler Chickens [Petunjuk Praktis Beternak Ayam Broiler]. Jakarta: Geneca Exact.

[3] Bachari, Irawati., E Mirwandhono and OM Dana. (2007). Utilization of Fermented Cocoa (Theobroma cacao) Bean Shell Meal—Fermented with *Aspergillus niger*—in Rations and Its Effect on the Performance of Broiler Chickens Aged 0–6 Weeks [Pemanfaatan tepung Kulit Biji Kakao (Theobroma cacao) Fermentasi Aspergillus niger dalam Ransum Terhadap Performans Ayam Broiler Umur 0 – 6 Minggu]. Jurnal Agribisnis Peternakan, Departemen Peternakan Fakultas Pertanian USU (Vol. 3, No. 1 Thn 2007).

[4] Wulandari KY, VDYB Ismadi and Tristiarti (2013). Crude Fiber and Metabolizable Energy Digestibility in 24-Week-Old Kedu Chickens Fed Rations with Varying Levels of Crude Protein and Crude Fiber [Kecernaan Serat Kasar Dan Energi Metabolis pada Ayam Kedu Umur 24 Minggu yang Diberi Ransum Dengan Berbagai Level Protein Kasar Dan Serat Kasar]. J. Animal Agriculture. 2(1): 9 – 17.

[5] Balai Pengkajian Teknologi Pertanian (BPTP). (2010). Fermentation of Cacao Pod Husks for Livestock Feed [Fermentasi Kulit Buah Kakao Untuk Pakan Ternak]. PDF nitropdf.com/professional. Sumatera Barat.

[6] Herlinae, Yemima and G Priyono (2017). The subsequent effect of substituting tofu dregs into a basal diet (BR-2) on the performance of broiler chickens aged 4–6 weeks (finisher phase) [Pengaruh lanjutan substitusi ampas

tahu pada pakan basal (br-2) terhadap penampilan ayam broiler umur 4-6 minggu fase finisher]. J. Ilmu Hewani Tropika. 6 (1): 42-46.

[7] Harsini T dan Susilowati. (2010). Utilization of cacao fruit husks—a byproduct of cacao plantations—as a raw material for pulp production via the organosol v process [Pemanfaatan kulit buah cacao dari limbah perkebunan cacao sebagai bahan baku pulp dengan proses organosol V]. Jurnal Ilmiah Teknik Lingkungan 2 (2):80-89.

[8] Puastuti W, D Yulistiani. (2011). Utilization of urea and fish meal in cocoa pod silage based rations to increase the growth of Etawah crossbred goats. In: Ali A, Kamil KA, Alimon AR, Orskov, Zentek J, Tanuwiria UH, editors. Proc 2nd Int Semin AINI Feed Saf Heal Food. Jatinangor, July 6-7, 2011. Bandung (Indonesia): Padjadjaran University. p. 463-469.

[9] Haryati T, B Hardjosuwito. (1984). Utilization of cocoa waste as a raw material for pectin production [Pemanfaatan limbah cokelat sebagai bahan dasar pembuatan pektin]. Jurnal Menara Perkebunan 6 (3): 23-34.

[10] BPS Sulut. (2024). North Sulawesi Province in Figures [Provinsi Sulawesi Utara Dalam Angka]. sulut.bps.go.id › id › publication Provinsi Sulawesi Utara Dalam Angka 2024

[11] Puastuti, W and IWR Susana. (2014). Potential and Utilization of Cacao Pod Husks as Alternative Feed for Ruminant Livestock [Potensi dan Pemanfaatan Kulit Buah Kakao sebagai Pakan Alternatif Ternak Ruminansia]. Wartazoa Vol. 24 No. 3: 151-159. DOI: http://dx.doi.org/10.14334/wartazoa.v24i3.1072

[12] Akhadiarto, Sindu. (2009). Utilization of Cacao Waste as Feed for Goats [Pemanfaatan Limbah kakao sebagai pakan ternak kambing]. Jurnal Pusat Teknologi Produksi Pertanian, Badan pengkajian dan penerapan teknologi (Nomor 3 tahun 09). Hlm. 185-191.

[13] Balai Pengkajian Teknologi Pertanian (BPTP). (2010). Fermentation of Cacao Pod Husks for Livestock Feed [Fermentasi Kulit Buah Kakao Untuk Pakan Ternak]. PDF nitropdf.com/professional. Sumatera Barat.

[14] Murni R, Akmal, Y Okrisandi. (2012). Utilization of cocoa pod husks fermented with the fungus *Phanerochaete chrysosporium* as a substitute for forage in goat rations [Pemanfaatan kulit buah kakao yang difermentasi dengan kapang *Phanerochaeta chrysosporium* sebagai pengganti hijauan dalam ransum ternak kambing]. Agrinak. 2:6-10.

[15] Puastuti W, D Yulistiani and Supriyati. (2009). Cocoa pod husk-based rations enriched with minerals: a review of digestibility and in vitro rumen fermentation [Ransum berbasis kulit buah kakao diperkaya mineral: tinjauan pada kecernaan dan fermentasi rumen in vitro]. Prosiding Seminar Nasional. Teknologi Peternakan dan Veteriner. Bogor 13-14 Agustus 2009. Bogor (Indonesia): Puslitbangnak. p. 442-447.

[16] Rasyaf M. (2002). Raising broiler chickens [Beternak ayam pedaging]. Publisher : Penebar swadaya. Jakarta.

[17] Suriono. (2006). Business Analysis of Substituting Rice Bran with Cacao Pod Husks Fermented by *Aspergillus niger* in Rations for 'Raja' Ducks Aged 0–7 Weeks [Analisis Usaha Subtitusi Dedak Padi dengan Kulit Buah Kakao yang Difermentasi *Aspergillus niger* dalam Ransum Itik Raja Umur 0 – 7 minggu]. Skripsi Peternakan Fakultas Pertanian Sumatera Utara.

[18] Abidin Z. (2002). Increasing the Productivity of Broiler Chickens [Meningkatkan Produktivitas Ayam Ras Pedaging]. Jakarta : Agro Media Pustaka.

[19] Anwar, Rosyid, M Arief Hakim and M Solihin. (2005). Practical Guide to Raising Broiler Chickens [Petunjuk Praktis Beternak Ayam Broiler]. Jakarta: Geneca Exact.

[20] Delgado-Ospina J, Lucas-González R, Viuda-Martos M, Fernández-López J, Pérez-Álvarez JÁ, Martuscelli M, Chaves-López C. (2021). Bioactive compounds and techno-functional properties of high-fiber co-products of the cacao agro-industrial chain. *Heliyon*. *7*, e06799. [Google Scholar] [CrossRef] [Scilit].

[21] Campos-Vega R, Nieto-Figueroa KH, Oomah BD. (2018). Cocoa (*Theobroma cacao* L.) pod husk: Renewable source of bioactive compounds. *Trends Food Sci. Technol. 81*, 172–184. [Google Scholar] [CrossRef] [Scilit].

[22] Suparjo, KG Wiryawan, EB Laconi and D Mangunwidjaja. (2011). Performance of goats fed fermented cocoa pod husks [Performans kambing yang diberi kulit buah kakao terfermentasi]. Media Peternakan. 34:35-41.

[23] Olubajo FO, MM Asonibare and EO Awolumate. (1987). Cacao pod silage and cacao-pod grass silage in goat and sheep nutrition. International Livestock Research Institute. Available from: /www.ilri.org/InfoServ/Webpub/Fulldocs/X5490e/x5 490e0t.hm

[24] Rinduwati and Ismartoyo. (2002). Degradation characteristics of several types of feed (in sacco) in the rumen of goats [Karakteristik degradasi beberapa jenis pakan (in sacco) dalam rumen ternak kambing]. Buletin Nutrisi dan Makanan Ternak. 31:1 14.

[25] Oluokun JA. (2005). Intake, digestion and nitrogen balance of diets blended with urea treated and untreated cowpea husk by growing rabbit. African J Biotechnol. 4:1203-1208.

[26] Aji DP, U Sri and Suparwi. (2013). Effect of fermenting cacao (Theobroma cacao L.) pod husks using *Aspergillus niger* on VFA and N-NH3 levels: an *in vitro* study. [Fermentasi kulit buah kakao (Theobroma cacao L.) menggunakan Aspergillus niger pengaruhnya terhadap kadar VFA dan N-NH3 secara in-vitro]. J Ilmu Peternakan. 1:774-780.

[27] Alexander J, D Benford, A Cockburn, J Cravedi, E Dogliotti, A Domenico, A Di, ML Férnandez-cruz, P Fürst, JF gremmels and CL Galli. (2008). Theobromine as undesirable substances in animal feed 1 Scientific opinion of the panel on contaminants in the food chain adopted on 10 June 2008. EFSA J. 725:1-66.

[28] Priyanto D, A Priyanti and I Inounu. (2004). Potential and opportunities for integrating goat farming into smallholder cocoa plantations in Lampung Province [Potensi dan peluang pola integrasi ternak kambing pada perkebunan kakao rakyat di Provinsi Lampung]. Dalam: Haryanto B, Mathius IW, Prawiradiputra BR, Lubis D, Priyanti A, Djajanegara A, penyunting. Pros Semnas Sistem Integrasi Tanaman-Ternak. Denpasar, 20-22 Juli 2004. Bogor (Indonesia): Puslibangnak. p. 381-388.

[29] Laconi EB. (2009). The evaluation of rumen metabolism of Fries Holstein (FH) calves fed biofermented cocoa pods using Phanerochaete chrysosporium. In: Sustain Anim Prod food Secur safety 1st Int Semin Anim Ind Fac Anim Sci. Bogor, 23-24 November 2009. Bogor (Indonesia): Bogor Agricultural University. p. 171 175.

[30] Zain M. (2009). Substitution of field grass with ammoniated cocoa pod husks in the rations of local sheep [Substitusi rumput lapangan dengan kulit buah coklat amoniasi dalam ransum domba local]. Media Peternakan. 31:47-52.

[31] Afrijon. (2011). The effect of using urea in the ammoniation of cocoa pod husks on in-vitro dry matter and organic matter digestibility [Pengaruh pemakaian urea dalam amoniasi kulit buah coklat terhadap kecernaan bahan kering dan bahan organik secara *in-vitro*]. J Embrio. 4:1-5.

[32] Saili T, Marsetyo, DP Poppi, P Isherwood, L Nafiu and SP Quigley. 2010. Effect of treatment of cocoa pod with Aspergillus niger on liveweight gain and cocoa poad intake of Bali (Bos sondaicus) cattle in South-East Sulawesi. Anim Prod Sci. 50:693-698.

[33] Haryati T and I Sutikno. (1994). Enhancement of the nutritional value of cocoa bean husks through bioprocessing using several types of fungi [Peningkatan nilai nutrisi kulit biji coklat melalui bioproses menggunakan beberapa jenis kapang]. Ilmu dan Peternakan. 8:34-37.

[34] Lateef A, JK Oloke, EBG Kana, SO Oyeniyi, QR Onifade, AO Oyeleye, OC Oladosu and AO Oyelami. (2008). Improving the quality of agro-wastes by solid-state fermentation: enhanced antioxidant activities and nutritional qualities. World J Microbiol Biotechnol. 24:2369-2374.

[35] Devendra C and RA Leng. (2011). Feed resources for animals in Asia: issues, strategies for use, intensification and integration for increased productivity. Asian Australasian J Anim Sci. 24:303-321.

[36] Long JA. and G. Kulkarni. (2004). An Effective Method for Improving the Fertility of Glycerol-Exposed Poultry Semen. J. Poult. Sci, 83: 1594-1601.

[37] Rohmatul AR, W Rita and Sari, W.R. (2020). Effectiveness of using cocoa husks as an ingredient in livestock feed [Efektivitas pengunaan kulit kakao sebagai campuran pakan ternak]. JAASI Journal (Journal Animal Agricultural Science of Indonesia). Vol. 1 No.1: Penggunaan Kulit Kakao Pakan ternak-5-Des-2020.pdf

[38] Byrkit DR. (1987). Statistics Today: A Comprehensive Introduction. The Benjamin/Cummings Publishing Company, Inc. 2727 Sand Hill Road Menlo Park, California, 94025, USA. urn:lcp:statisticstodayc0000byrk:epub:fc8b8040-6b64-4d13-852d-64f58ea7bc09

[39] Steel RGD. and JH Torrie. (1996). Principles and Procedures of Statistics. Second edition. McGraw-Hill