Research Article

Growth Performance, Digestibility, and Fecal Nutrient Value of Garut Ewe Lambs Fed Diets Containing Cassava Pulp

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Abstract | Cassava pulp (CP) is a by-product of tapioca industry, which is generally considered a potential feed source for ruminants. Therefore, this study aims to thoroughly examine the performance of the feed source and evaluate the feces quality of Garut ewe lambs fed with diets containing CP. Twenty Garut ewe lambs aged 6-7 months with a body weight of 15.73 ± 2.23 kg were randomly allocated into 4 diet treatments containing CP at 0% (control), 10% (CP1), 20% (CP2), as well as 30% (CP3) and each treatment was repeated 5 times. Subsequently, the data collected were analyzed using the Duncan test. The results obtained showed that the use of CP in the ration did not have an influence on dry matter intake (DMI), protein intake (PI), and total digestible nutrient intake (TDNI), but provided a significant ($P < 0.05$) increase in average daily gain (ADG), dry matter digestibility (DMD), and organic matter digestibility (OMD). However, it was observed that the use of CP had the potential to reduce feed conversion. On day 30, the use of 20% CP gave the highest ADG and on day 60, the entire diet containing CP increased ADG, DMD, and OMD compared to the control. All feces produced contain a similar volume of organic N, P, K, and C-organic. It is also important to state that although the diet containing CP was found to contain lower N, P, and K compared to the control, it increased the C/N ratio ased on these observations, it was inferred that the inclusion of CP at levels of up to 30% in the diet of Garut ewe lambs improved animal performance and produced feces with nutrient constituents suitable for use as a source of organic fertilizer.

Keywords | Cassava pulp, Feces, Garut ewe lambs, Organic fertilizer, Performances

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INTRODUCTION

Garut sheep are a genetic resource for West Java livestock that must be developed primarily because of the animal's high ability to adapt to new environments and the requirement of a less intensive rearing system. According to previous studies, a female Garut sheep can give birth to more than two lambs in one birth cycle, possesses maternal characteristics, and has superior meat quality (Hernaman *et al*., 2023; Wijayanti *et al*., 2025). This breed was determined by the Minister of Agriculture, Number 2914/Kpts/OT.140/6/2011 on June 17, 2011, as a native Indonesian sheep and local genetic resources.

Increasing the performance of Garut ewe lambs is considered particularly essential for strengthening the population and safeguarding local genetic resources. As stated in a previous exploration, sheep productivity is shaped by both genetic and environmental factors, as well as their interactions (Wanjala *et al*., 2023). These elements act in tandem, interacting with each other to determine the entire performance of the animal. Proper feed management and improved maintenance practices have been shown to enhance lamb birth weights and growth rates (Hernaman *et al*., 2023; Wanjala *et al*., 2023), even when the genetic potential is not particularly superior.

Presently, the diet of Garut sheep consists primarily of grass and concentrate. Rice bran serves as a major component of this concentrate, largely because rice farming dominates agricultural land in West Java. However, its availability has become increasingly limited due to the rapid expansion of poultry farming, which also requires significant amounts of rice bran in feed formulations (Hernaman *et al*., 2025). To compensate for nutrient deficiencies, feed formulations often incorporate pollard, a by-product of wheat processing, but because this ingredient is derived from imported wheat, it contributes to higher production costs for concentrate.
Indonesia ranks among the leading producers of cassava tubers in the world (Rozi *et al*., 2022), which are widely used as raw material for tapioca flour. The main by-product of tapioca processing is cassava pulp (CP), which is generally obtained during the starch extraction process from tubers (Norrapoke *et al*., 2022). Based on previous observations, CP typically retains 60–70% moisture and contains a high carbohydrate content of approximately 50% (Morgan and Choct, 2016).

Tapioca industry in Indonesia is largely concentrated in rural areas, often run on a small scale, and is predominantly established in local sheep farming communities. Despite its abundance, CP has not been widely utilized as poultry feed due to several limiting factors, particularly its high crude fiber content in the form of insoluble fiber. The resource's low protein and carotene levels also make it unsuitable for inclusion in poultry diets (Aro *et al*., 2008).

Among smallholder breeders in Indonesia, farming and livestock rearing are often practiced side by side (Mukhlis *et al*., 2022). As previously observed, a key motivation for raising livestock is to obtain organic fertilizer from animal feces (Mukhlis *et al*., 2022), which plays a very significant role in improving crop yields (van den Broek *et al*., 2024). Ruminant manure generally contains essential elements such as nitrogen (N), phosphorus (P), potassium (K), and organic carbon (C-organic), the latter being the main constituent of organic matter (Dadrasnia *et al*., 2021; Wei *et al*., 2025). Accordingly, the long-term use of this form of organic fertilizer has been found to not only enhance soil productivity but also help prevent land degradation (Mukhlis *et al*., 2022; Wei *et al*., 2025).

In addition to its contribution to livestock nutrition, the inclusion of CP in feeding strategies has further been reported to affect fecal composition and nutrient excretion. Feces represent a significant by-product that can be recycled as organic fertilizer, thereby contributing to nutrient cycling and supporting sustainable livestock systems (Nguyen *et al*., 2021). According to a prior investigation, diet composition directly influenced the levels of N, P, K, and C-to-N ratio in feces, which invariably determine the agronomic value of the waste (Wang *et al*., 2024).

Previous research on the use of CP in ruminant livestock has been conducted. CP has been shown to increase dry matter intake and digestibility of nutrients such as organic matter and crude protein in tropical sheep (Khejornsart *et al*., 2022). *In vitro* studies have shown that CP can enhance maize degradation in ruminant rations, leading to increased volatile fatty acid (VFA) production and greater microbial nitrogen synthesis (Putridinanti *et al*., 2019). Fermented CP, when combined with additives such as urea and molasses, can improve rumen fermentation by increasing the synthesis of propionate acid and microbial proteins, while reducing methane production and protozoan populations in beef cattle (Norrapoke *et al*., 2022). CP fermented with yeast waste can replace soybean meals in concentrate without negatively impacting rumen fermentation parameters, while increasing propionate acid concentration and total bacterial population (Dagaew *et al*., 2021). Replacing rice straw with CP in the ration improves feed intake, digestibility and energy efficiency, leading to better growth performance in beef cattle (Dagaew *et al*., 2022). The above studies indicate that CP has positive effects on livestock performance; however, studies specifically involving Garut sheep have not been reported. Therefore, this study provides new information on the use of CP in rations for Garut sheep. Evaluating both animal performance and fecal quality is essential to maximize the dual benefits of improved livestock productivity and environmental sustainability. Accordingly, this study aims to formulate a CP-containing diet for Garut ewe lambs and to assess both animal performance and the quality of feces produced.

MATERIALS AND METHODS

Animals and experimental procedures

The present study was conducted at the Sheep and Goat Breeding and Development Center, Margawati, in compliance with all applicable animal ethics guidelines. The facility is managed by the Food Security and Animal Husbandry Service of West Java Province, Indonesia. This institution annually carries out External Audit and has ISO 9001:2015 Certification.

A total of 20 Garut ewe lambs aged 6–7 months were used during the investigation. The animals were randomly allocated to pens and assigned to four dietary treatments; each replicated five times. The experimental pens comprised individual stage-system cages measuring 73 × 125 cm^2, each equipped with separate feeders and drinkers.

Before the feeding trial began, the obtained sheep were weighed, respective health status assessed, and preventive medication administered. Furthermore, anthelmintic treatment was provided using Albenpros 12.5% per os at a dosage of 2–3 mL per 50 kg of body weight and administered orally. The average initial body weight of the lamb was 15.73 ± 2.23 kg, with a coefficient of variation of 4.99%.

The experimental diets consisted of elephant grass (*Pennisetum purpureum* cv. Taiwan) and a formulated concentrate. The forage was obtained from the grass garden of Sheep and Goat Breeding and Development Margawati Centre, while the concentrate was prepared using CP sourced from the local tapioca industry in Garut, along with other feed ingredients purchased from feed stores in Bandung Regency. Accordingly, the treatment diets included four levels of CP, namely 0% (control), 10% (CP1), 20% (CP2), and 30% (CP3), the level of CP administration based on previous research (Sitanggang *et al.,* 2023). Prior to feeding, the forage was chopped into approximately 5 cm pieces using a chopper and subjected to a one-day withering process by air-drying. The composition and nutrient content of the diet treatments are presented in Table 1.

Sheep were adapted to the treatment diets for a period of two weeks, during which forage was provided three times daily at 08:00, 14:00, and 16:00 Western Indonesia Time (WIT). Meanwhile, concentrate was supplied once daily at 10:00 WIT. Feed refusals were collected from 07:00 WIT, after which the remaining diet was weighed. It is also important to state that body weight measurements were taken weekly in the 60-day experimental period.

Fecal collection was conducted using specifically designed sheep pants or diapers made from fine porous plastic nets. Sampling was carried out over 7 consecutive days at the end of the trial. Feces from each pen were collected separately and stored in individual plastic bags according to the day of collection. The collected feces were sprayed with 5% boric acid (H_3BO_3). Fresh feces were weighed and 10% was collected from each treatment sample and dried in the sun. All feces from each replicate were then mixed until homogeneous and used to analyze DM (AOAC, 2019), measure dry matter intake (DMD) and organic matter intake (OMD) (Woodmartin *et al.*, 2024). Apart from that, the N, P, K and C-carbon content was measured in the laboratory.

Table 1: Feed material and nutrient compositions of the diet treatments.

Feed ingredients	Control	CP1	CP2	CP3
Elephant grass cv Taiwan (%)	60.00	60.00	60.00	60.00
Soy sauce dregs (%)	1.22	4.58	3.08	0.98
Soybean meal (%)	1.00	1.00	2.11	5.12
Corn gluten feed/CGF (%)	0.10	1.00	2.37	2.20
Coconut cake (%)	0.10	5.19	3.86	1.30
Pollard (%)	8.97	5.36	2.48	0.31
Rice bran (%)	28.62	12.87	6.09	0.10
Cassava pulp (CP, %)	0.00	10.00	20.00	30.00
Total	100	100	100	100
Nutrient composition				
Dry matter (DM, %)	56.70	56.56	56.39	56.16
Crude protein (CPr, %)	12.60	13.10	12.65	12.51
Crude fat (CF, %)	8.94	8.80	8.29	7.87
Crude fiber (Cfi, %)	23.12	22.12	22.04	21.84
Nitrogen-free extract (NFE, %)	44.66	45.21	45.71	46.74
*Total digestible nutrient (TDN, %)	63.59	64.94	64.85	64.87
Ash (%)	15.12	14.74	14.57	14.40
Ca (%)	0.28	0.35	0.40	0.46
P (%)	0.74	0.48	0.34	0.21
K (%)	1.22	1.06	0.93	0.81

*TDN was calculated using the Sutardi equation as described by Hernaman *et al.* (2022): (70.6 + 0.259% CPr + 1.01% CF-0.76% CF i+ 0.0991% NFE).

Procedure for determining N

Nitrogen (N) levels were determined using proximate analysis (AOAC, 2019). A total of 1 g of sample was weighed and then put into a Kjeldahl flask. Next, 500 mg of Selenium and 5 mL of concentrated H_2SO_4 were added and digested until a milky white solution was obtained. The solution was cooled then 40 mL of distilled water and 20 mL of 40% NaOH were added and distilled until a green solution was obtained. Accordingly, 40 mL of the green solution was taken, then titrated with 0.1N H_2SO_4 until it turned pink.

Procedure for determining K and P

Sample preparation was conducted using the wet ashing technique (Reitz *et al*., 1960). Approximately 1 g of fecal sample was placed into an Erlenmeyer flask, followed by the addition of 5 mL HNO_3. The mixture was left for 1 hour at room temperature in an acid chamber. Subsequently, it was heated on a hot plate at low temperature for 4–6 hours (in the acid chamber) and allowed to stand overnight with the sample covered. Afterward, 0.4 mL H_2SO_4 was added, and heating was continued on a hot plate until the solution became concentrated, typically after about 1 hour. After making the mixture concentrated, 2–3 drops of a mixed solution of $HClO_4$: HNO_3 (2:1) were added, and heating was maintained until the color gradually changed from brown to dark yellow and finally to light yellow (approximately 1 hour). After the color change, heating was continued for an additional 10–15 minutes. The sample was then cooled, after which 2 mL of distilled water and 0.6 mL of HCl were added. Heating resumed for about 15 minutes to ensure dissolution, and the solution was transferred into a 100 mL volumetric flask. The solution was filtered using glass wool or filter paper to remove every form of sediment, after which the filtrate obtained from wet ashing was analyzed for K using atomic absorption spectrophotometry (AAS) at a wavelength of 766.5 nm (Fishman and Downs, 1966). P content was determined spectrophotometrically, based on the principle that phosphate reacts with ammonium molybdate to form a colored complex. The absorbance of this complex was measured at a wavelength of 660 nm (Shyla *et al*., 2011).

Procedure for determining C-organic

The determination of C-organic in the sample was carried out following the method proposed by Black (1965). Approximately 0.5 g of the sample was weighed and placed in a 100 mL volumetric flask. To this sample, 5 mL of 2 N $K_2Cr_2O_7$ solution was added and shaken, followed by the addition of 7.5 mL concentrated H_2SO_4. The mixture was mixed again and allowed to stand for 30 minutes. The solution was then diluted with deionized water, cooled, and left to settle. On the following day, the absorbance of the clear solution was measured using a spectrophotometer at a wavelength of 561 nm.

Data analysis

The type of statistical test used is a parametric test using ANOVA and the validity of assumptions was tested using a normality test. All data were analyzed using one-way Analysis of Variance (ANOVA), with the levels of cassava pulp (CP) in the diet treated as the independent variable. Accordingly, statistical analyses were performed using IBM SPSS Statistics, version 26, and when significant effects were observed, Duncan's multiple range test was applied to identify differences among treatment groups.

RESULTS AND DISCUSSION

Performance of Garut ewe lambs

After 60 days of rearing, the data obtained on the performance of Garut ewe lambs are presented in Table 2. The results showed ADG on days 30 and 60 differed very significantly ($P < 0.01$). The mean ADG on day 30 was markedly lower compared with day 60 (14.88–19.28 vs. 29.91–58.05 g/head/day). The relatively low ADG on day 30 was attributed to the fact that lambs were still adjusting to the diets, despite having undergone a two-week adaptation period before the experiment. From day 30 onwards, the animals appeared to adapt more effectively to the treatment of diets. Although digestibility and ADG improved over time, feed efficiency showed a declining trend on day 60 in groups receiving CP compared with the control. This decline may be related to the higher intake of fermentable carbohydrates, which, while promoting growth, may also increase maintenance energy requirements and reduce efficiency when feeding continues over extended periods (Nguyen *et al*., 2021). Interestingly, dry matter intake (DMI), protein intake (PI), and total digestible nutrient intake (TDNI) did not differ significantly across treatments. Based on these observations, CP inclusion still enhanced performance, suggesting that its benefits were derived not from increased intake but from improved nutrient digestibility and energy utilization efficiency (Wang *et al*., 2024).

CP-based diets influenced ADG directly, as evidenced by the fact that on day 30, lambs in CP2 treatment showed the highest ADG among the groups ($P < 0.01$). By day 60, all CP treatments outperformed the control diets ($P < 0.01$). As stated by Uskenov *et al*. (2024), ADG typically reflected feed consumption, since variations in dry matter intake directly influence nutrient and energy supply, thereby stimulating growth. The results of this study are consistent with those of Hernaman *et al*. (2022), who reported an average ADG of 62.5 g/head/day in growing Garut ewe lambs. The results of the study were higher than Handiwirawan *et al*. (2004) who reported the ADG of Garut sheep aged 6-9 months of 51.4 g/head/day. This means the ADG of the research sheep is still within the normal range.

Generally, when ruminants are exposed to a new diet, the rumen microbial population requires time to adjust before the feed can be digested efficiently. During this transitional period, nutrient absorption and utilization by the host animal are often insufficient to support optimal growth

(Hristov *et al*., 2019). Microbial adaptation includes both shifts in community composition and changes in metabolic activity, which enable rumen microbes to process the new substrates more effectively. This process is influenced not only by time but also by feed type, rumen conditions, and feeding management practices (Hristov *et al*., 2019).

Table 2: Average daily gain (ADG, g/head/day), dry matter intake (DMI, g/head/day), total digestible nutrient intake (TDNI, g/head/day) feed efficiency (%), dry matter digestibility (DMD, %), and organic matter digestibility (OMD, %) of lambs supplemented with different levels of cassava pulp (CP, n = 5).

Parameters	Control	CP1	CP2	CP3	SEM
ADG					
Day-30	16.66^{a}	14.88^{a}	19.28^{b}	15.47^{a}	0.511**
Day-60	29.91^{a}	58.05^{b}	45.20^{ab}	57.95^{b}	3.611**
DMI					
Day-30	640.15^{a}	616.22^{a}	664.76^{a}	643.93^{a}	8.626^{NS}
Day-60	691.14^{a}	666.87^{a}	721.55^{a}	710.34^{a}	3.611^{NS}
PI					
Day-30	80.66^{a}	80.72^{a}	84.10^{a}	80.55^{a}	1.042^{NS}
Day-60	87.09^{a}	87.35^{a}	91.28^{a}	88.86^{a}	1.285^{NS}
TDNI					
Day-30	407.09^{a}	400.16^{a}	431.08^{a}	417.75^{a}	5.631^{NS}
Day-60	439.52^{a}	433.05^{a}	467.90^{a}	460.83^{a}	6.978^{NS}
Feed conversion					
Day-30	38.73^{ab}	41.63^{b}	34.49^{a}	41.98^{b}	0.994*
Day-60	28.74^{b}	11.78^{a}	16.34^{a}	12.33^{a}	2.049**
DMD	64.39^{a}	76.77^{b}	72.30^{ab}	68.45^{ab}	1.64*
OMD	74.48^{a}	84.02^{b}	82.20^{b}	79.37^{ab}	1.23*

NS: non-significant; * P<0.05; ** P<0.01

In this study, no significant differences were observed in DMI, PI, or TDNI as an energy source (Table 2). However, the improvement in DMD and OMD with CP supplementation confirmed its positive effect on nutrient availability. Similar results have been reported in previous studies, where CP enhanced ruminal fermentation and digestibility, thereby improving weight gain in small ruminants (Phanthavong *et al*., 2021; Sutardi *et al*., 2020).

Under conditions of equal feed consumption, it would be typically expected that comparable ADG would be obtained across a herd, but the results obtained during the present exploration showed otherwise. This discrepancy can be explained by the inclusion of CP in the diet, which did not reduce the palatability of the diets but also made the diets easier to digest. Data presented in Table 2 shows that diets containing CP achieved significantly higher DMD and OMD (P < 0.05) compared to the control. This improvement is largely due to the addition of CP, which increased the proportion of NFE while reducing CF content (Table 1).

The lowest feed conversion ratio (P < 0.05) was observed in CP20% treatment on day 30. By day 60, all diets supplemented with CP showed significantly lower feed conversion (P < 0.01) compared to the control. Feed conversion is essentially a measure of feed efficiency, defined as the ratio of body weight gain to feed intake. A lower feed conversion showed higher efficiency (Davison *et al*., 2023). In this study, all Garut ewe lambs receiving CP-supplemented diets showed improved feed efficiency. The increased ADG observed at similar levels of DMI (Table 2) explains the reduced feed efficiency in these treatments. The results further reflected how CP can effectively substitute rice bran and pollard in the diet without negatively impacting the performance of Garut ewe lambs.

The digestibility of dry matter in the CP-containing ration ranged from 68.46-76.77%, this value was greater than the previous study of 60.39- 63.65% in sheep rations with different levels of molasses (Sanjaya *et al*., 2020). Also, the digestibility of organic ingredients in this study ranged from 79.37–84.02%, higher than the previous study of 69.28-72.58% (Sanjaya *et al*., 2020). These results show that the addition of CP has a beneficial effect on the digestibility of sheep rations.

The mechanism of CP affecting the performance of female arrowhead sheep is explained as follows. CP is a by-product of tapioca production, which is high in starch. The starch content of CP ranges from 48.71-72.43% (Abdullah *et al*., 2019). CP is rich in starch (Putridinanti *et al*., 2019), where in proximate analysis starch is included in the NFE component (Zaefarian *et al*., 2021). In ruminants, NFE, particularly starch, is generally more readily digestible than crude fiber. Starch is easily broken down by rumen microbes and enzymes, producing volatile fatty acids (VFAs) which are a major source of energy for ruminants (Putridinanti *et al*., 2019). Crude fiber, on the other hand, is a more complex form of carbohydrate that requires more extensive microbial fermentation in the rumen for digestion (Gondo, 2025). VFAs and adenosine triphosphate (ATP) together with N-NH_3 come from fermentation of feed protein, which can be used as an N source in rumen microbial synthesis. Balanced diets of carbohydrate and protein can increase VFAs and N-NH_3 production that contribute to rumen microbial population (Putridinanti *et al*., 2019) which plays a role in digesting feed. Microbial protein, VFAs as a source of energy and other digested nutrients are typically used by ruminants for growth. This condition will ultimately increase the digestibility of dry ingredients and organic ration ingredients. This improvement in digestion will improve performance through the sheep's ADG indicator.

Quality of feces

The analysis showed that sheep feces contained N, P, K, and C-organic. Total fecal output and C-organic content did not differ significantly across dietary treatments. However, the inclusion of CP reduced the concentrations of N, P, and K in the feces, and increased C/N ratio. Fecal output was not significantly different among treatments, which is consistent with the similar DMI observed across groups (Table 2). Although DMD and OMD varied, the differences were not sufficient to markedly influence the total quantity of feces excreted. Regardless of the insignificant difference observed, CP supplementation led to significant changes in fecal nutrient composition (Table 3).

The comparable amount of fecal DM across treatments was primarily associated with similar diet consumption, despite significant differences in digestibility. However, these variations were not substantial enough to influence the entire fecal output.

The reduced N content in CP-supplemented diets suggested that dietary protein (N) was more efficiently utilized for growth, leaving less unutilized N to be excreted. As stated in a prior study, CP starch, which is a highly digestible carbohydrate, generates substantial amounts of VFAs (Putridinanti *et al*., 2019). These VFAs stimulate microbial protein synthesis in the rumen, a process that also requires N derived from N-NH_3 released during feed protein fermentation. As a result, N is more effectively incorporated into microbial protein, improving digestibility and invariably supporting greater growth performance in the observed sheep.

Differences in feed ingredient composition were observed to further influence the mineral content of both diets and feces (Table 1). For instance, pollard and rice bran are known to be rich in phytic acid, which contains high levels of P (Canan *et al*., 2021; Wulandari *et al*., 2018). These ingredients also supply greater amounts of K compared to CP (Sapwarobol *et al*., 2021; Fanelli *et al*., 2024; Chauynarong *et al*., 2015). Therefore, substituting rice bran and pollard with CP significantly lowered the dietary concentrations of both P and K (Table 1). As reported by Yilmaz and Uysal (2025), dietary mineral intake is positively correlated with fecal mineral excretion, reflecting that reduced dietary mineral content led to reduced excretion. Based on this insight, an inference can be made that the lower levels of P and K observed in feces with CP inclusion reflect the reduced mineral content of the diet. Importantly, this outcome carries environmental significance as lower fecal P reduces the potential for nutrient runoff and associated pollution (Paik, 2001), making CP supplementation not only beneficial for animal growth but also environmentally sustainable.

C-organic content across all treatments showed no significant differences, which corresponds to the similar fecal output observed. Feces are the by-product of digestion, consisting of undigested feed residues, particularly components resistant to microbial degradation such as lignin. In this context, lignin is a complex polymer present in plant cell walls and represents a major source of carbon. It is a highly abundant, renewable, and aromatic biopolymer with a carbon content of approximately 60–65%, making the polymer an important precursor for various carbon-based materials (Yao *et al*., 2022).

In decomposition and composting processes, C-organic and N were observed to play complementary roles. C-organic serves as an energy source for microorganisms, while N is essential for microbial protein synthesis. An optimal C/N ratio of about 30:1 is generally required for efficient decomposition (Xie *et al*., 2022). In this present study, C/N ratio of feces increased with CP supplementation, primarily due to the reduction in fecal N content (Table 3). However, the average C/N ratio of the feces remained relatively low (<20). This shows that if the feces were to be processed into compost, additional high-carbon materials would need to be incorporated to achieve the ideal

Table 3: Mean feces (g/head/day), N (g/head/day), P (g/head/day), K (g/head/day), C-organic (g/head/day), of lambs supplemented with different levels of casava pulp (n = 5).

Parameters	Control	CP1	CP2	CP3	SEM
Total Feces	234.99^{a}	170.60^{a}	210.57^{a}	238.95^{a}	12.04^{NS}
Total Nitrogen (N)	5.57^{b}	3.50^{a}	3.74^{a}	4.55^{ab}	0.27*
Total Phosphorus (P)	4.36^{d}	2.64^{c}	2.38^{b}	1.73^{a}	0.22**
Total Potassium (K)	3.34^{c}	2.10^{b}	1.52^{a}	1.29^{a}	0.19**
Total C-organic	62.10	73.22	64.52^{a}	89.41	4.31^{NS}
Ratio carbon to nitrogen (C/N)	11.22^{a}	21.35^{b}	18.31^{b}	20.51^{b}	1.41*

NS: non-significant; * P<0.05; ** P<0.01

C/N ratio and promote efficient microbial activity during composting. When compared to previous studies, in this study the N value ranged from 3.50-4.55 g/head/day, P between 1.73-2.64 g/head/day, and K between 1.29-2.10 g/head/day, higher than the previous study with N ranging from 2.27-2.53 g/head/day, P between 0.57-0.67 g/head/day, and K between 0.21-0.37 g/head/day (Ayuningsih *et al*., 2019). This shows that the quality of NPK feces in this study is better to be used as organic fertilizer.

CP is known for its high carbohydrates which are a source of energy for ruminants. However, it has a low content of crude protein and other nutrients, so it requires processing or supplementation to increase its nutritional value (Akhadiarto, 2009; Widyawati, 2010). Lack of rations in ruminant rations can lead to dependence on other feed sources, which has the potential to affect feed efficiency and growth performance (Ali, 2012). The recommendations made can be used for urea molasses mineral blocks (UMMB) (Utamy *et al*., 2025) and balance the ratio of concentrate and fiber along with nutrient supplementation to complete the ration containing CP (Tamba *et al*., 2015).

CONCLUSIONS

In conclusion, the results of this study showed that diets containing up to 30% CP significantly improved the growth, digestibility, and feed efficiency of Garut ewe lambs. Furthermore, the feces obtained from CP-fed ewe lambs were found to contain N, P, K, and C-organic, suitable for organic fertilizer, although composting requires added carbon sources. This exploration recommends that regional governments in tapioca-producing areas should promote CP as a sustainable sheep feed to significantly reduce reliance on rice bran and imported pollard while supporting feed self-sufficiency and eco-friendly livestock production.

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NOVELTY STATEMENT

This research is to obtain the best ration formula containing CP for Garut ewe lambs which is currently not available. Apart from that, to look for the quality of the feces as organic fertilizer.

AUTHOR'S CONTRIBUTION

IH, BA, TD, AB, and UR: Conceptualized the study, methodology, manuscript preparation and drafted the manuscript. AU, PAL, NPB, FRNR: Data collection and methodology. DP and DSW: Methodology, formal analysis, and drafted the manuscript. All authors have read and approved the final manuscript.

Generative AI and AI-assisted technology statement

The writing of this manuscript was the result of our own thoughts and did not use generative AI and AI-assisted technology

Conflict of interest

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