



Milk Production and Blood Health in Ettawa Crossbred Goats with the Substitution of Cassava (*Manihot Utilissima*) Leaves in Feed

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Abstract | Cassava leaves have great potential as an alternative to conventional forages due to their high protein content. However, their use is constrained by anti-nutritional factors such as hydrogen cyanide (HCN) and tannins, which require proper processing. This study aims to assess and examine the processes of haymaking and activated charcoal soaking to optimize the use of cassava leaves as a sustainable substitute for green forage for Ettawa crossbred goats in dry and rainy seasons. A completely randomized design was employed with three treatments: 0% cassava leaves + 100% green forage (T1), 30% cassava leaf hay + 70% green forage (T2), and 30% activated charcoal-treated cassava leaves + 70% green forage (T3). Each treatment has five replications. Parameters measured included dry matter (DM) intake, milk production, production efficiency, hematology profiles and milk fat, protein, lactose, solids not-fat (SNF), hydrogen cyanide (HCN) and tannin levels. Data were analyzed using Analysis of Variance in SPSS and Duncan's Multiple Range Test was performed to identify significant differences. The results indicated that DM intake, HCN and tannin levels in blood and milk were significantly higher ($p < 0.05$) in goats fed with T1. Conversely, milk production, production efficiency and milk protein and lactose levels were significantly higher ($p < 0.05$) in goats fed with T2 and T3. Thus, substituting 30% of green forage with cassava leaves, either as hay (T2) in the dry season or activated charcoal-treated leaves (T3) in the rainy season, can enhance milk production and production efficiency, hematology profiles and milk quality in Ettawa crossbred goats without adverse effects.

Keywords | Blood health, Cassava leaves, Ettawa crossbred goats, Feed, Milk production

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INTRODUCTION

Indonesia's overall milk production is still insufficient to satisfy the growing demand, thus requiring efforts to

produce efficient and productive livestock. Ettawa crossbred goats, a cross between Ettawa goats and local Indonesian breeds, are viable due to their rapid breeding, adaptability, ease of maintenance, and low capital requirements

(Prasetyo, 2019). These goats have a reproductive index of 1.56 to 5.14 kids annually, with a pre-weaning mortality rate of 6.04% (Sodiq, 2010). Furthermore, their milk is rich in protein, enzymes, and vitamin A and does not contain beta-lactoglobulin, which typically causes allergic reactions (Rusdiana *et al.*, 2016).

In dairy goat farming, ensuring a consistent supply of quality feed becomes a significant challenge. To tackle this problem, cassava (*Manihot utilissima*) leaves, a by-product of cassava plantations, offer a promising alternative to conventional green forage. Cassava is widely grown in Indonesia, with an average cultivation area of 849.30 thousand ha (Suryani, 2020). The crop produces 11.786 kg DM ha⁻¹ year⁻¹ (Wanapat, 2002) and its leaves yield 10–40 tons ha⁻¹ annually (Sirait and Simanihuruk, 2010). Cassava leaf is highly nutritious; it contains crude protein (24–35% DM), carotene, beta-carotene, calcium, iron, phosphorus, magnesium, vitamins A, B1 and C (Oresegun *et al.*, 2016), natural dewormers (Wanapat and Khampa, 2006) and lactic acid bacteria with probiotic properties (Samedi and Charles, 2019).

Nevertheless, anti-nutritional factors such as hydrogen cyanide (HCN) and tannins in cassava leaves can harm livestock if ingested in excess (Duong *et al.*, 2005; Kiyothong and Wanapat, 2004). Two pre-processing methods, i.e., haymaking and activated charcoal soaking, can mitigate these risks while retaining cassava leaves' nutritional values. Haymaking decreases moisture and volatilizes HCN, thus lowering cyanide toxicity risks (Adejoro *et al.*, 2018; Ribeiro *et al.*, 2020). This process also preserves crude protein content, making it a nutrient-rich feed for dry seasons (Agbede and Oyewumi, 2022). In addition, sun-drying reduces tannins, which enhances palatability and digestibility (Min *et al.*, 2020). Excessive heat, however, can degrade vitamins and affect feed quality (Huang *et al.*, 2018). Moreover, haymaking alone may not reduce HCN sufficiently for animals with low cyanide tolerance (Ravindran and Kornegay, 1993).

Activated charcoal soaking is another effective method to improve the quality of cassava leaf feed as it binds cyanogenic compounds and reduces HCN to safe levels (Monteiro *et al.*, 2022). Bamboo-activated charcoal at 2–6% concentrations, soaked for 36 hours, significantly reduces HCN and tannins while improving crude protein (32.89%) and crude fiber (13.91%) contents, with in vitro organic digestibility reaching 67.54% (Siska *et al.*, 2024). Charcoal treatment also increases protein absorption and animal performance (Hassan and Carr, 2021). Studies have shown that treated feeds improve nutrient absorption, milk production and animal growth while lowering the effects of anti-nutritional factors (Jimoh *et al.*, 2020; Huang *et al.*, 2021). In this charcoal soaking process, controlling factors

such as soaking time and charcoal concentration are crucial to avoid nutrient leaching and quality loss (Adejoro *et al.*, 2018; Ribeiro *et al.*, 2020).

This study aims to assess and examine the processes of hay-making and activated charcoal soaking to optimize the use of cassava leaves as a sustainable substitute for green forage for Ettawa crossbred goats in dry and rainy seasons.

MATERIALS AND METHODS

ETHICAL APPROVAL

Ethical permission and formal approval were granted by the Research Ethics Committee of Hasanuddin University, Hasanuddin University Teaching Hospital (RSPTN) and dr. Wahidin Sudirohusodo Central General Hospital (RSUP) Makassar, Indonesia, with approval no. 87/UN4.6.4.5.31/PP36/2024.

FEED PREPARATION AND PROCESSING

The cassava leaves used in this study, without the stems and stalks, were obtained from cassava plantations. Two processing methods were applied to the cassava leaves separately, namely Cassava Leaf Hay (CLH) and Cassava Leaf Charcoal Active (CLCA). The processing method of CLH was sun-drying the leaves until the moisture content reached about 15%. Meanwhile, for CLCA, the leaves were soaked in a 2% bamboo-activated charcoal solution for 36 hours, then washed and dried (Siska *et al.*, 2024).

ANIMAL MANAGEMENT

This study examined 15 Ettawa crossbred goats during the second and third months of the second lactation stage. The average body weight of the goats was 45–50 kg. Each goat was housed individually in cages measuring 0.7–1 m², equipped with feeders and drinkers. The cages were thoroughly cleaned and disinfected for optimal hygienic conditions before the goats were introduced. The goats underwent a 14-day adaptation period, during which they were dewormed to ensure uniform health. This was followed by a 30-day treatment phase to evaluate the effects of the treatments.

EXPERIMENTAL DESIGN

A completely randomized design (CRD) was employed in this study with three treatments and five replications. Applying this approach gives each goat an equal chance of receiving any treatment, thereby minimizing bias. The three treatments used in this study were:

T1: 0% cassava leaves + 100% green forage.

T2: 30% cassava leaf hay (CLH) + 70% green forage.

T3: 30% cassava leaf charcoal active (CLCA) + 70% green forage.

The green forage used in this experiment combined conventional forage and legume with a ratio of 70:30. Each goat was given 5 kg of the designed forage mixture daily based on its group, along with 1 kg of concentrate feed (a mixture of tofu dregs and bran). The feed was provided twice daily, once in the morning and once in the evening. Further details on the nutritional values of feed in treatment can be found in Table 1.

Table 1: Nutrition value of feed in treatment method.

Nutrient, %	Green Forage	Concentrate	CLH	CLAC
Dry matter	18.771	10.870	15.472	12.601
Crude protein	13.413	17.368	30.560	32.885
Crude fat	6.724	5.342	5.923	4.850
Crude fiber	29.269	21.103	18.488	13.915
Ash	14.448	13.959	4.180	4.158
Nitrogen free extract	40.150	42.231	40.848	44.194
Total Digestible Nutrient	58.216	68.298	72.198	77.033
HCN (Hydrogen cyanide) -	-	-	0.005	0.004
Tannin	-	-	0.720	0.570

Notes: ` cassava leaves hay; **CLAC:** cassava leaves active charcoal; **HCN:** Hydrogen cyanide.

PARAMETER

The parameters used in this study are DM intake, milk production, milk production efficiency, hematological profiles and milk quality.

DM INTAKE: Determined using the ratio of feed DM provided to the remaining feed DM (Azrinnahar *et al.*, 2021).

$$DM \text{ intake } (g \text{ day}^{-1}) = (Fresh \text{ provision} \times \% \text{ DM content of feed}) - (fresh \text{ remainder} \times \% \text{ DM content of remainder})$$

MILK PRODUCTION: The amount of milk produced each day, calculated by measuring the results of morning and evening milking on a certain scale (Oliveira *et al.*, 2014).

$$Milk \text{ production } (g \text{ day}^{-1}) = milk \text{ produced in the morning } (g) + milk \text{ produced in the evening } (g)$$

MILK PRODUCTION EFFICIENCY: Measured according to the formula by Novianti *et al.* (2022).

$$EP (\%) = \frac{P}{F} \times 100$$

Description:

EP = Milk Production Efficiency (%)

P = DM contained in milk (g)

F = daily DM intake (g)

HEMATOLOGICAL BLOOD PROFILES: Consisting of red blood cells (RBC), white blood cells (WBC), hemoglobin (HB), hematocrit (HTC), mean corpuscular volume (MCV), hemoglobin in red blood cells (MCH), hemoglobin density in red blood cells (MCHC), lymphocytes (LYM), types of white blood cells (MXD), neutrophils (NEU) and granulocytes (GRAN), were measured using the Mindray BC-3200 auto hematology tool. Blood total protein (TP) levels were quantified using the AMTAST AMR016 Protein Refractometer, while blood HCN and tannin levels were measured using the atomic absorption spectrophotometry method (Harborne, 2006).

MILK QUALITY: Whose indicators include fat, protein, lactose and SNF content, was measured using Lactoscan SP 60. Milk HCN and tannin levels were measured using the atomic absorption spectrophotometry method (Harborne, 2006).

STATISTICAL ANALYSIS

Data were analyzed using Analysis of Variance (ANOVA) in SPSS software version 24.0 at a 5% significance level. For parameters showing significant differences between treatments, Duncan's Multiple Range Test (DMRT) was performed with a significance level of 0.05 to identify specific differences between groups.

Table 2: Performance production of ettawa crossbred goats with the substitution of cassava (*Manihot utilissima*) leaves in feed.

Parameters	Treatment			SE	p-value
	T1	T2	T3		
Dry Matter Intake (g day ⁻¹)	1046.637 ^a	1012.158 ^b	918.214 ^c	14.501	0.000
Milk Production (g day ⁻¹)	840.129 ^b	1227.884 ^a	1308.366 ^a	6.548	0.001
Milk Production Efficiency	11.470 ^b	17.385 ^a	20.592 ^a	13.722	0.003

Notes: Superscript ^{abc} different superscripts in the same row indicate a significant difference (P < 0.05). **T1:** Cassava leaves 0%+ Green forage 100%; **T2:** Cassava leaves hay 30% + Green forage 70% and **T3:** Cassava leaves charcoal active 30% + Green forage 70%.

RESULTS AND DISCUSSION

DRY MATTER (DM) INTAKE

The treatment has a significant impact on dry matter (DM) intake (p<0.05), with the control group (T1) having the highest intake, followed by T2 and T3 (Table 2). The lower DM intake in T2 and T3 is likely linked to the reduced palatability of cassava leaves processed through CLH or CLCA methods. Cassava leaves inherently have anti-nutritional components, e.g., HCN and tannins, which affect

feed flavor and acceptance (Besharati *et al.*, 2022; Robson, 2007; Rivera-Méndez *et al.*, 2017). Processing methods such as CLH and CLCA can modify the flavor or texture of the feed, making it less palatable. Palatability significantly influences an animal's voluntary feed intake. Typically, higher palatability improves intake and performance, while lower palatability may lower intake and nutrient absorption (Pazla *et al.*, 2023).

Furthermore, cassava leaves used in T2 and T3 contain higher nutrients than forage used in T1, allowing the goats in both treatment groups to meet their nutritional needs faster. According to Suyitman *et al.* (2021), dry feed consumption is also influenced by feed quality, where high-quality feed will result in less consumption since the dietary needs of livestock are fulfilled faster.

MILK PRODUCTION

Despite the lower DM intake in T2 and T3, milk production was significantly higher ($p < 0.05$) in these two treatment groups compared to the control (T1), with T3 yielding the highest milk production. This inverse relationship between DM intake and milk yield suggests that feed quality, particularly the total digestible nutrients (TDN), has a greater effect on milk production than intake volume (Suaryati *et al.*, 2013). Both processing methods, especially CLCA, increase cassava leaf's nutritional values by reducing its anti-nutritional factors (HCN and tannins), which results in higher nutrient bioavailability (Zuhra *et al.*, 2024; Rira *et al.*, 2022). Once toxic compounds were reduced, cassava leaves which are known for their high protein content enable animals to utilize nutrients more efficiently and produce more milk.

Higher crude protein levels considerably enhance milk yield (Katongole and Yan, 2020), which is most evident in T3. This demonstrates that CLCA is superior to CLH in improving nutrient digestibility and utilization. Crude protein content is crucial for milk production. In this study, T3 has the highest crude protein levels, which corresponds to its highest milk yield, signifying that a protein-rich diet substantially facilitates lactation. Conversely, T1, which has lower crude protein levels, produces the least amount of milk. High protein in feed can stimulate increased milk secretion (Marwah *et al.*, 2010). Arief Pazla (2023) stated that dietary protein plays a vital role in the maintenance of mammary gland cells and the production of hormones and enzymes for milk biosynthesis. The greater the amount of crude protein digested and converted into amino acids, the higher the milk production (Rajčević *et al.*, 2003). Amino acids are absorbed by the small intestine wall and transported by the blood to the liver and to body tissues, including the mammary gland, where they are utilized to produce milk (McDonald *et al.*, 2018).

Furthermore, the crude fiber content in T1 is higher. Previous studies have reported that elevated levels of fiber can decrease feed digestibility and hinder nutrient absorption, thus lowering milk yield (Nurhajati, 2013; Pranata and Chuzaemi, 2020). Excessive fiber increases diet bulk, making it harder for the digestive system to break down feed effectively. This study reveals that processing cassava leaves into CLCA raises their crude protein content, which makes them an excellent substitute for forage to boost dairy goats' milk production.

MILK PRODUCTION EFFICIENCY

Production efficiency was also higher in T2 and T3 than in T1 ($p < 0.05$), with T3 showing the most efficient production. This improvement is attributed to a combination of lower DM intake and higher milk yield, indicating that processed cassava leaves, especially those treated with activated charcoal, have better feed digestibility and nutrient availability (Britt *et al.*, 2003). The improved production in T3 was linked to the feed's protein content, energy content, and digestibility, as well as the goats' physiological status, including their lactation stage and metabolic efficiency (de Oндarza and Tricarico, 2017; Purwanto *et al.*, 2014).

Milk production efficiency observed in T2 and T3 is also influenced by tannin in cassava leaves. In moderate amounts, tannin can increase total digestible nutrients (TDN), support intestinal health and provide natural antiparasitic effects (Prapaiwong *et al.*, 2021). Furthermore, Prapaiwong *et al.* (2023) stated that tannin can enhance nutrient digestibility and rumen fermentation as well as reduce bacteria that cause mastitis in the udder. The findings of this study confirm that well-processed cassava leaves can serve as an effective forage replacement for dairy goats since they improve both milk yield and milk quality while optimizing feed efficiency.

HEMATOLOGY PROFILES

As seen in Table 3, blood parameters such as red blood cells (RBC), white blood cells (WBC), hemoglobin (HB), hematocrit (HTC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), lymphocytes (LYM), mixed cell percentage (MXD), neutrophils (NEU), and granulocytes (GRAN) are not significantly influenced by the dietary treatments ($p > 0.05$). These results indicate that forage substitution with cassava leaves, in either CLH or CLCA form, does not cause physiological imbalances in the goats. The normal levels of these blood parameters suggest homeostasis in the goats, reflecting their overall health during the feeding treatment stage.

However, this study reveals that the treatments significantly affect total blood protein (TP) levels ($p < 0.05$), with goats

in T3 having the highest TP levels, followed by T2 and T1. This increase in TP is likely due to the higher protein content of the cassava leaves, particularly in the CLCA treatment, which improves amino acid absorption and utilization. This elevated protein availability is believed to stimulate blood protein synthesis, a key marker of nutritional status, suggesting that cassava leaf supplementation improves the overall nutrient profile without negatively affecting other blood health parameters (Zhang *et al.*, 2022; Wanapat *et al.*, 2013).

Table 3: Hematological profiles of ettawa crossbred with the substitution of cassava (*Manihot utilissima*) leaves in feed.

Parameters	Treatment			SE	p-value
	T1	T2	T3		
RBC ($\times 10^6 \mu\text{L}^{-1}$)	12.826	12.358	12.906	0.219	0.578
WBC ($\times 10^3 \mu\text{L}^{-1}$)	13.026	13.676	13.750	0.445	0.792
HB (g dL^{-1})	8.600	8.252	8.976	0.151	0.147
HTC (%)	21.776	20.952	22.252	0.458	0.538
MCV (fL)	16.752	16.952	16.576	0.198	0.769
MCH (pg)	6.702	6.700	6.550	0.069	0.618
MCHC (pg)	32.752	39.800	39.802	2.434	0.424
LYM ($\times 10^3 \mu\text{L}^{-1}$)	7.460	6.920	7.280	0.335	0.823
MXD ($\times 10^3 \mu\text{L}^{-1}$)	0.880	0.860	0.900	0.024	0.821
NEU ($\times 10^3 \mu\text{L}^{-1}$)	4.700	4.800	4.580	0.371	0.050
GRAN ($\times 10^3 \mu\text{L}^{-1}$)	4.700	5.780	5.800	0.291	0.220
TP (g dL^{-1})	6.400 ^b	8.080 ^a	8.120 ^a	0.278	0.005
HCN (mg L^{-1})	0.046 ^c	0.032 ^b	0.018 ^a	0.000	0.003
Tannin (mg L^{-1})	25.872 ^c	14.014 ^b	4.851 ^a	0.000	2.450

Notes: Superscript ^{abc} different superscripts in the same row indicate a significant difference ($P < 0.05$). **T1:** Cassava leaves 0%+ Green forage 100%; **T2:** Cassava leaves hay 30% + Green forage 70% and **T3:** Cassava leaves charcoal active 30% + Green forage 70%. **RBC:** red blood cells; **WBC:** white blood cells; **HB:** hemoglobin; **HTC:** hematocrit; **MCV:** mean corpuscular volume; **MCH:** hemoglobin in red blood cells; **MCHC:** hemoglobin density in red blood cells; **LYM:** lymphocytes; **MXD:** types of white blood cells; **NEU:** Neutrophils (NEU); **GRAN:** granulocytes; **TP:** Total Protein and **HCN:** Hydrogen cyanide.

The findings of this study also prove that blood HCN and tannin levels of the goats are significantly lower in T2 and T3 compared to the control (T1). This reduction is critical because HCN, a cyanogenic compound found in cassava leaves, can be toxic in high concentrations. The processing methods applied in this study, namely CLH (sun-drying) and CLCA (soaking in activated charcoal), effectively reduce HCN concentration to safe levels, below the tolerable limit. The liver detoxifies HCN by converting it to thiocyanate (Jaszczak *et al.*, 2017; Maciel *et al.*, 2023), which

is excreted through urine, ultimately reducing its toxicity risks (Bahri and Tarmudji, 1984; Robson, 2007; Andama and Oloya, 2017).

Tannin levels also remain within acceptable limits in the T2 and T3 treatment groups. This is vital for maintaining digestibility and milk production. Moderate tannin intake can improve total digestible nutrients (TDN), support gut health and offer natural anti-parasitic effects (Prapaiwong *et al.*, 2023). Conversely, excessive tannin intake can bind proteins and impair nutrient absorption, affecting digestibility and milk yield (Waghorn and Shelton, 1997; Molan *et al.*, 2002). The lower tannin levels in T2 and T3 suggest that both CLH and CLCA feeds help mitigate the adverse effects of cassava leaves while preserving their benefits (Andama and Oloya, 2017).

Table 4: Milk Quality of ettawa crossbred goats with the substitution of cassava (*Manihot utilissima*) leaves in feed.

Parameters	Treatment			SE	p-value
	T1	T2	T3		
Fat (%)	5.620	5.306	5.146	0.066	0.002
Protein (%)	3.550 ^b	3.756 ^a	3.948 ^a	0.067	0.040
Lactose %)	3.363 ^b	3.350 ^a	3.684 ^a	0.062	0.091
SNF (%)	7.368	7.454	7.460	0.129	0.955
HCN (mg kg^{-1})	0.010 ^c	0.008 ^b	0.005 ^a	0.008	0.000
Tannin (mg kg^{-1})	13.475 ^c	11.912 ^b	10.780 ^a	12.053	0.000

Notes: Superscript ^{abc} different superscripts in the same row indicate a significant difference ($P < 0.05$). **T1:** Cassava leaves 0%+ Green forage 100%; **T2:** Cassava leaves hay 30% + Green forage 70% and **T3:** Cassava leaves charcoal active 30% + Green forage 70%. **SNF:** Solid Nonfat; **HCN:** Hydrogen cyanide.

MILK QUALITY

The nutrient profiles of milk from Ettawa crossbred goats fed with various combinations of forage and cassava leaves are presented in Table 4. The dietary treatments significantly affect milk protein levels ($P < 0.05$), with goats in T3 having the highest protein content than those in T2 and T1. This indicates that the nutritional profile of the feed, enhanced by better feed quality and processing, directly influences protein absorption, milk composition and milk quality (Arief and Pazla, 2023; Pazla *et al.*, 2023). Furthermore, the nonsignificant difference between T2 and T3 implies that both diets are effective, although T3 may better optimize protein absorption due to its particular formulation (Table 1). The study's results support previous studies' findings that high-protein diets directly correlate with improved milk protein levels (Utari *et al.*, 2012; Ratya *et al.*, 2017). In addition to feed quality, goat breed, lactation stage and milk yield also influence milk protein levels. One of the factors that affect milk protein is the dietary protein

consumed. The primary raw material for milk protein synthesis is amino acids, which are obtained from animal feed through absorption in the small intestine, and there is a positive linear relationship between dry feed consumption and milk protein production (Ali *et al.*, 2017; Setiadi *et al.*, 2020; Jamarun *et al.*, 2020).

No significant difference in lactose production is observed between T2 and T3, suggesting that both treatments support lactose synthesis efficiently. Combining forage with concentrates such as cassava leaves and palm kernel cake enhances milk yield and composition by supplying essential nutrients for milk biosynthesis (Arief and Pazla, 2023). Since lactose acts as an osmoregulatory molecule in the udder gland (Ratya *et al.*, 2017; Cai *et al.*, 2024), the rise in lactose levels in both treatment groups aligns with their higher milk yield. Lactose synthesis heavily depends on feed quality and poor-quality forage can hinder lactose synthesis. Glucose, the primary precursor for lactose, is crucial for lactose synthesis and milk fat production (Yuzbashian *et al.*, 2021). Lactose regulates osmotic pressure between blood and milk lumen, aiding the transfer of water into milk and boosting milk yield (Cai *et al.*, 2024).

In terms of feed safety and quality, the dietary treatments significantly affect the milk HCN and tannin levels ($p < 0.05$). HCN and tannin levels in milk, which are influenced by dietary intake, correspond directly to their concentrations in blood plasma (Robson, 2007; Besharati *et al.*, 2022). Cant *et al.* (2002) explained that the rate of milk component synthesis depends on the uptake of milk precursors from blood capillaries. Efficient detoxification processes during feed preparation decreased levels of toxic compounds in T2 and T3 treatments which contain properly treated cassava leaves. This improves the safety of the milk produced and the goats' overall health. Consequently, replacing traditional forages with well-processed cassava leaves can enhance milk quality in Ettawa crossbred goats while maintaining their health (Robson, 2007; Besharati *et al.*, 2022).

CONCLUSIONS AND RECOMMENDATIONS

Compared to the control (T1), substituting 30% of green forage with cassava leaf hay (T2) and activated charcoal-soaked cassava leaves (T3) can enhance milk production and production efficiency in lactating Ettawa crossbred goats without affecting the blood profile. In treatments T2 and T3, total blood protein levels increase, while blood HCN and tannin levels decrease. Additionally, this substitution can improve Ettawa crossbred goats' milk quality, as shown by increased milk protein and lactose levels and decreased milk HCN and tannin levels in treatments T2 and T3 compared to the control (T1).

Based on the results of this study, it is recommended to use CLH and CLAC as a substitute for green fodder in order to increase milk production and improve the health of lactating Ettawa crossbred goats. The use of CLH and CLAC in the long term requires further research. Several previous studies such as (Wanapat *et al.*, 2000; Yousuf *et al.*, 2007; Granum *et al.*, 2007; Khampa *et al.*, 2009; Dung *et al.*, 2010; Siska *et al.*, 2014) regarding the use of cassava leaves as a substitute for feed can also be considered.

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NOVELTY STATEMENT

Cassava leaves soaked in activated charcoal are new in this study. Previous studies of activated charcoal were widely used for feed mixtures as feed additives. Previous studies of cassava leaves were widely used in hay, silage and fermentation. Cassava leaves soaked in activated charcoal can reduce HCN, tannin levels and improvements in the quality of cassava leaves, levels of soluble protein, crude protein, crude fiber, IVDM and IVOD occurred when treated with 2% activated bamboo charcoal levels (Siska *et al.*, 2024) and this study proves the ability of cassava leaves to improve the productivity of Ettawa crossbred goats in Indonesia, making them a viable forage alternative, both in the form of sun-dried hay during the dry season and after treatment with activated charcoal during the wet season.

AUTHOR'S CONTRIBUTIONS

Imelda Siska: Conducting the research, data collection, and laboratory work. Ambo Ako: Responsible for research design, corresponding author, and supervision of the research. Asmuddin Natsir: Research design, and supervision of the research. Renny Fatmyah Utamy: Research design, and supervision of the research.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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