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Research Article

In Vitro Evaluation of Gambier Leaf Extract (*Uncaria gambir Roxb.*) from Pangkalan, West Sumatra, as a Natural Feed Additive to Improve Nutrient Digestibility in Ruminants

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ABSTRACT

This study aims to evaluate the effect of supplementing ruminant feed with gambir leaf extract (*Uncaria gambir Roxb*.) from Pangkalan, West Sumatra, as a natural feed additive on the in vitro digestibility of crude fat, crude fiber, and nitrogen-free extract (NFE). The study used a completely randomized design with four treatments: T0 (control, without extract), T1 (0.5% gambir extract), T2 (1% gambir extract), and T3 (2% gambir extract). The parameters observed included crude fat, crude fiber, and NFE digestibility. The results showed that gambir leaf extract supplementation had a significant effect ($P<0.05$) on all parameters tested. Treatment T3 provided the highest digestibility values, namely crude fat 66.47%, crude fiber 66.45%, and NFE 67.99%, compared to the control (64.17%, 64.52%, and 65.70%). This increase is thought to be due to the bioactive content of gambir extract, namely tannins (64.84%), catechins (60.11%), and saponins (0.96%), which work synergistically to modulate rumen microbes, protect nutrients from excessive degradation, and increase fermentation efficiency. In conclusion, gambir leaf extract from Pangkalan has the potential to be a natural feed additive that improves nutrient digestibility in ruminants. These results support utilizing local phytochemical-based resources for feed efficiency and sustainable livestock farming.

Keywords: feed additive, in vitro, nutrient digestibility, ruminants, *Uncaria gambir*

INTRODUCTION

Global ruminant production faces two significant challenges: low nutrient utilization efficiency and high greenhouse gas emissions, particularly methane, which accounts for approximately 3–12% of total energy lost as gas (Ku-Vera et al., 2020). In this context, functional

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feed innovations based on local ingredients are crucial to support more environmentally friendly and sustainable farming practices.

Tannins—polyphenolic compounds commonly found in various tropical plant sources—have been shown to improve nitrogen efficiency through protein protection mechanisms in the rumen and reduce methane production (Pazla et al., 2024; Pazla et al., 2025a). When used appropriately, condensed tannins can increase protein utilization without significantly reducing livestock performance (Ramaiyulis et al., 2022).

Gambir plants (*Uncaria gambir*), which contain high levels of catechins and tannins, have become the focus of research as a source of natural feed additives. A study by Pazla et al. (2025b) found that gambir leaf catechin extract from Talang Maur successfully increased the digestibility of organic matter and protein, while reducing protozoa populations and methane production in vitro. These results indicate a double benefit: higher nutritional efficiency and mitigation of greenhouse gas emissions.

Research with gambir extract from Talang Maur opens opportunities for other areas, such as Pangkalan, Lima Puluh Kota Regency, West Sumatra, to develop similar local potential. Local production data shows that gambir extract is rich in catechins and tannins, potentially increasing the in vitro digestibility of crude fat, crude fiber, and nitrogen-free extract (NFE). If proven effective, this could increase the nutritional value of feed and support the availability of natural alternative feed in the region.

Developing local feed additives from gambir extract benefits nutrition and the environment and contributes to local socio-economic aspects such as reducing import dependency, utilizing local resources, and creating added value for agriculture in West Sumatra. By conducting further research on dosage, extract type, and effects on digestibility (crude fat, crude fiber, NFE), this study will strengthen the scientific basis for practical application in ruminant livestock farming.

MATERIAL AND METHODS

Materials

This study used gambir leaf extract sourced from Pangkalan Subdistrict, Lima Puluh Kota Regency, West Sumatra, Indonesia. Tables 1 and 2 list several basic feed ingredients used in this study, including elephant grass, bran, corn, palm kernel meal, straw, and tofu dregs. Meanwhile, the nutritional composition of the ration can be seen in Table 3.

Table 1. Nutrient Contents

Nutrient Content	Feed Ingredients						
	Rice Straw	Elephant Grass	Bran	Corn	PKM	Tofu Dregs	Gambier Pangkalan
Dry matter	92.84	93.39	85.87	85.55	85.91	16.20	-
Organic matter	80.94	90.88	88.99	95.87	96.13	97.43	-
Crude protein	4.26	9.66	8.94	9.82	22.29	23.55	-
Ash	1.13	2.06	8.76	3.09	10.99	3.00	-
Crude Fiber	29.16	32.6	15.62	9.61	29.96	9.60	-
NFE	46.39	41.86	55.67	73.35	32.89	40.03	-
TDN	54.68	53.91	72.03	77.69	76.85	77.90	-
NDF	72.32	63.63	48.11	58.62	72.59	39.28	-
ADF	40.92	43.78	23.08	34.66	50.33	30.39	-
Cellulose	37.71	20.06	11.05	19.70	29.10	25.08	-
Hemicellulose	31.4	19.85	25.03	23.96	22.26	8.89	-

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Nutrient Content	Feed Ingredients						
	Rice Straw	Elephant Grass	Bran	Corn	PKM	Tofu Dregs	Gambier Pangkalan
Lignin	17.30	5.68	3.78	7.50	9.25	1.80	-
Catechins	-	-	-	-	-	-	60.11
Tannin							64.84
Saponin							0.96

TDN = Total Digestibility Nitrogen; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber, NFE = Nitrogen-Free Extract; PKM= Palm Kernel Meal

Table 2. Ration Composition

Feed Ingredient	Treatment (%)
Rice Straw	20
Elephant Grass	40
Bran	2
Corn	6
Palm kernel Meal	15
Tofu Dregs	16
Minerals	0.5
Salt	0.5
Total	100

Table 3. Ration Nutrient Content

Nutrient content	Value of content (%)
Dry matter	90.01
Organic matter	90.08
Crude protein	12.59
Ash	3.53
Crude Fiber	25.79
Nitrogen-Free Extract	42.85
TDN	62.59
NDF	61.56
ADF	47.55
Cellulose	25.34
Hemicellulose	14.01
Lignin	6.39

TDN = Total Digestibility Nitrogen; NDF = Neutral Detergent Fiber; ADF = Acid Detergent Fiber

Methods

The design used in this study was a completely randomized design with four treatments and four replicates, with the following treatments:

T0= Control (without gambir extract)

T1= 0.5% gambir extract

T2=1% gambir extract

T3= 2% gambir extract

Research Implementation

The method used in in vitro research and the preparation of McDougall's solution used as a buffer solution used the Tilley and Terry (1963) method. Rumen fluid was collected in the morning at the slaughterhouse, the ingesta was squeezed and placed in a thermos to maintain the temperature and keep the microbial environment anaerobic. The feed mixture and rumen fluid were placed in fermentation tubes and incubated for 48 hours at 39°C. The variables observed in this study were crude fiber digestibility, crude fat digestibility, and nitrogen-free extract (NFE). The content of catechins, tannins, and saponins was analyzed using spectrophotometry.

Data Analysis

This study used analysis of variance (ANOVA) to process the data. If there were significant differences between treatments, the DMRT test was performed. All analyses were performed using SPSS statistical software.

RESULTS AND DISCUSSION

Crude Fat Digestibility

Tannins can form complex bonds with proteins and lipids, which inhibit the access of rumen lipase enzymes to fat substrates. However, this protective effect at moderate doses can prevent fat from degrading too quickly, thereby preserving more fatty acids beneficial for fermentation in the abomasum. This study showed increased crude fat digestibility in the T3 treatment (2% extract) (Figure 1), which may be related to the moderate effect of tannins in protecting fat from premature degradation. Studies by Arisya et al. (2019) and Sayd et al. (2022) support that tannins reduce protein degradation products without decreasing the supply of subsequent nutrients (e.g., fat).

Catechins are one of the prominent condensed tannins in gambir. As potent antioxidants, catechins can protect lipids from early oxidation, maintaining their integrity and availability for digestion. This effect improves crude fat digestibility by minimizing oxidative damage prior to fermentation. Frutos et al. (2004) stated that low to moderate concentrations of tannins can increase nutrient uptake and digestion, including fat.

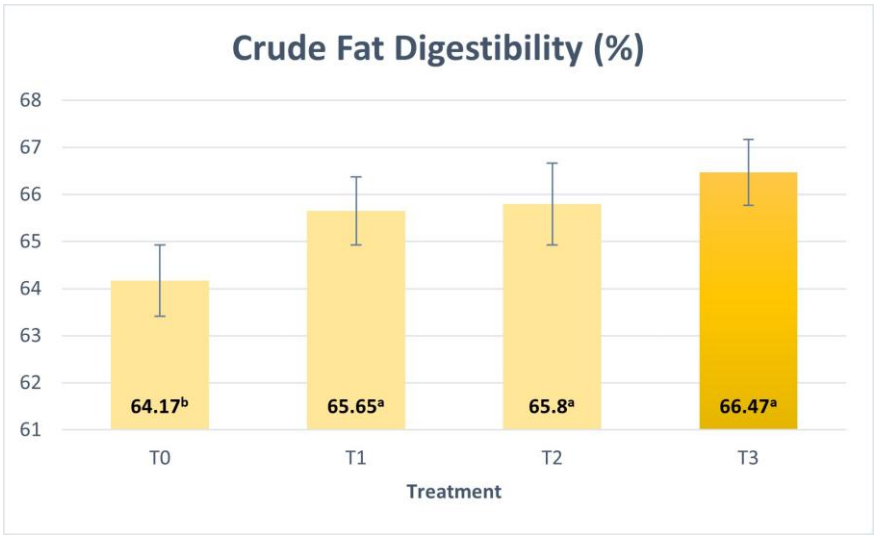


Figure 1. Crude Fat Digestibility (%). Note: T0 = Control, T1 = 0.5% Gambir Extract, T2 = 1% Gambir Extract, T3 = 2% Gambir Extract

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Saponins are known as defaunating agents, which reduce the rumen protozoa population. Protozoa phagocytose bacteria and lipids, so their reduction will decrease fat degradation by protozoan microbes and allow bacterial cells to produce fatty acids more efficiently. Zhou et al. (2012) and Liu et al. (2019) showed that tea saponin supplementation improved NDF and ADF digestibility, with similar effects likely occurring for crude fat.

The combination of tannins, catechins, and saponins allows for physical and enzymatic protection of fats and increased activity of fat-digesting bacteria. While tannins maintain structural stability, saponins modify the microbial community so lipid fermentation proceeds more efficiently. Jadhav et al. (2018) and Kumar (2023) highlight that tea seed saponins increase rumen fermentation and nutrient digestibility while reducing methane emissions.

The increased fat digestibility in the gambir leaf extract treatment is likely due to the combined effects of tannins' protective effect on lipids, catechins' antioxidant properties, and saponins' modification of the microbial community. These interactions create fermentation conditions that are more conducive to digesting crude fat in vitro.

Crude Fiber Digestibility

High tannin concentrations reduce crude fiber digestion by limiting access to cellulolytic bacteria. However, tannins may protect bacterial proteins and microbial structures at optimal levels, thereby not significantly inhibiting fiber degradation. Sun et al. (2025) showed that supplementation with chestnut tannins (CHTs) up to 2% did not reduce crude protein digestibility, but 6% caused a significant decrease. By analogy, gambir extract at a concentration of 2% is likely to be within a safe threshold that maintains fiber efficiency (Figure 2).

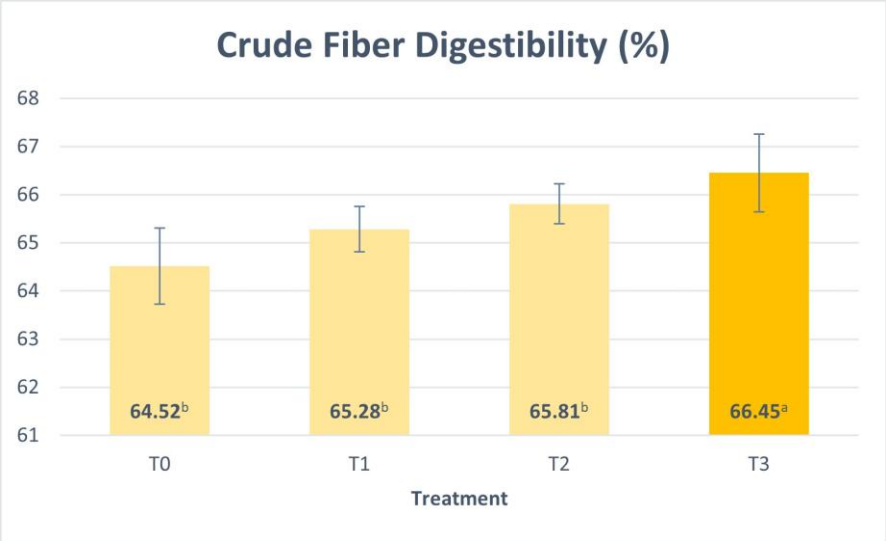


Figure 2. Crude Fiber Digestibility (%). Note: T0 = Control, T1 = 0.5% Gambir Extract, T2 = 1% Gambir Extract, T3 = 2% Gambir Extract

Catechins can form selective bonds with specific microbial proteins without damaging cellulolytic enzymes. This can maintain an optimal population of fiber-digesting bacteria. Rodríguez et al. (2014) and Vasta et al. (2019) noted that polyphenols such as tannins influence carbohydrate fermentation and fiber degradation through microbial and substrate interactions.

While saponins reduce protozoa, cell-wall bacteria populations (e.g., *Fibrobacter succinogenes*) increase, as Liu et al. (2019) reported, promoting the degradation of fibers such as

NDF and ADF. The reduction in protozoa may decrease competition with cellulolytic bacteria, thereby improving the digestibility of crude fiber.

A meta-analysis by Yanza et al. (2024) found that the effects of saponins on nutrient digestibility are complex and vary depending on dosage and ruminant type, but generally do not reduce digestibility when used optimally. This supports the possibility that the dual weight of gambir extract (tannins + saponins) improves or maintains fiber digestibility without adverse effects.

The improvement or stability of crude fiber digestibility in the 2% gambier treatment (T3) is likely the result of a synergistic effect between the protective effect of catechins on microbial structure and the antiprotozoal effect of saponins, which supports cellulolytic bacteria. Combining these phytochemical components creates fermentation conditions more conducive to fiber degradation.

Digestibility of Nitrogen-Free Extract (NFE)

NFE includes non-fiber carbohydrates and low-fiber carbohydrates such as starch and sugar. Tannins can form complexes with proteins and polysaccharides, which may slow down the fermentation of free carbohydrates. However, at moderate tannin levels (such as 2% catechin), the protective effect helps preserve carbohydrates for more efficient slow fermentation in the hindgut, improving NFE digestibility.

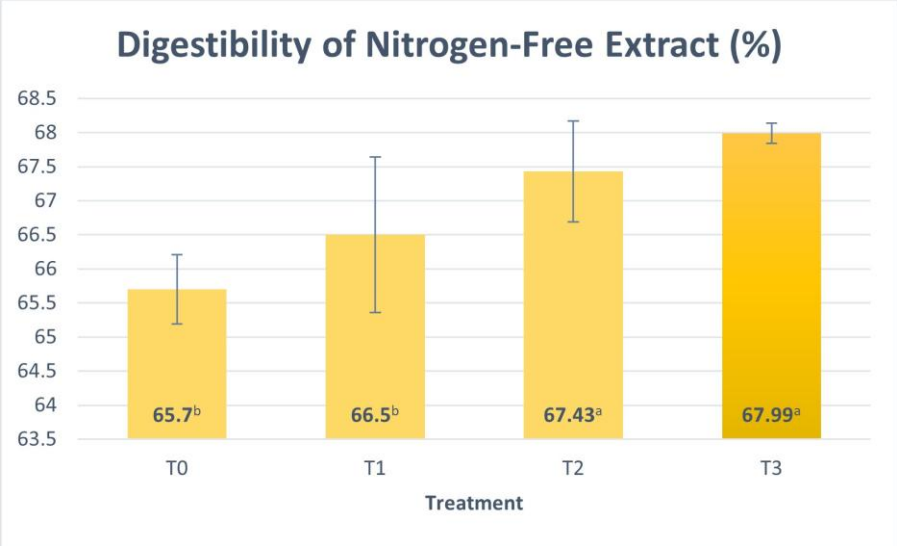


Figure 3. Digestibility of Nitrogen-Free Extract (%). Note: T0 = Control, T1 = 0.5% Gambir Extract, T2 = 1% Gambir Extract, T3 = 2% Gambir Extract

Because catechins are antioxidants, they protect NFE from oxidation before microbial fermentation, maintaining a better substrate for in vitro digestion. Saponins enhance the growth of non-fiber carbohydrate-degrading bacteria by reducing unproductive microbial genera such as protozoa. Liu et al. (2019) showed increased VFA and propionate fermentation—the main non-fiber carbohydrate fermentation products—which means more NFE is digested. Yanza et al.'s (2024) meta-analysis of response variation confirms that saponins do not always negatively affect digestibility, especially in NFE; the effect is highly dependent on type and dose. This indicates that saponins can maintain or enhance NFE digestibility under optimal conditions. The increase in NFE digestibility in the 2% gambir extract treatment (Figure 3) is likely due to catechin protection

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against oxidation and initial degradation, combined with saponin stimulation of non-fiber carbohydrate fermentation. This combination creates optimal fermentative conditions to maximize NFE digestibility (Pazla et al., 2025c),

CONCLUSIONS

Supplementation with gambir leaf extract (*Uncaria gambir Roxb*.) from Pangkalan, West Sumatra, significantly affected the digestibility of crude fat, crude fiber, and nitrogen-free extract (NFE) in ruminant diets. Adding extract up to a level of 2% (T3) resulted in the highest digestibility values for all parameters observed.

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