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Research Article

Optimization of Fiber Digestibility and Methane Reduction with Gambier Leaf Extract from Pangkalan for Sustainable Ruminant Farming

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ABSTRACT

Ruminant livestock production plays an important role in providing animal protein sources, but faces major challenges in terms of feed utilization efficiency and environmental impact due to methane emissions. Methane produced by rumen fermentation not only contributes nearly 30% of global greenhouse gas emissions but also causes energy losses of 7-12% of total feed energy. This study aimed to evaluate the effect of gambier (Uncaria gambier) leaf extract from Pangkalan, West Sumatra, on the digestibility of fiber fractions (NDF, ADF, cellulose, hemicellulose) and methane gas production in ruminant rations. The study was conducted in vitro using the method of Tilley and Terry (1963) with a randomized group design consisting of four treatments: T0 (control without gambier extract), T1 (0.5% gambier extract), T2 (1% gambier extract), and T3 (2% gambier extract), with four replications using goat rumen fluid. Results showed that the addition of gambier extract significantly increased NDF and ADF digestibility to 64.30% and 63.77% at T3, respectively, compared to the control of 61.67% and 61.56%. Cellulose digestibility increased from 64.57% at T0 to 67.20% at T3, while hemicellulose increased from 64.78% to 67.44%. In addition, methane gas production decreased significantly from 22.45 ml/g DOM in the control to 16.67 ml/g DOM in T3, equivalent to a decrease of 25.74%. The optimal dose to increase fiber digestibility and decrease methane production was 2% gambier leaf extract (T3 treatment). Thus, gambier leaf extract from Pangkalan can be used as an effective natural feed additive to improve feed efficiency while reducing the environmental impact of ruminant farming.

Keywords: gambier leaf extract, fiber digestibility, methane production, Pangkalan, *Uncaria gambier*

INTRODUCTION

Ruminant livestock production contributes significantly to the provision of animal protein for human needs. However, the sector also faces major challenges related to feed utilization efficiency and environmental impacts. Methane (CH_4), a major greenhouse gas produced during fermentation in the rumen, accounts for up to 30% of total global methane emissions (Black *et*

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al., 2021; Pazla *et al*. 2022). In addition, methane represents a form of energy loss amounting to 7-12% of the total feed energy consumed by ruminants (Malik *et al*., 2012). This not only decreases production efficiency but also worsens the environmental impact of livestock farming. Therefore, strategies to improve feed efficiency while reducing methane emissions are needed to support the sustainability of the sector.

Several studies have identified bioactive compounds in plants, such as tannins, catechins and saponins, as natural feed additives that can improve rumen fermentation efficiency and reduce methane production (Antonius *et al*., 2023; Laura *et al*. 2024; Putri *et al*., 2024). One local plant that has great potential is gambier (*Uncaria gambier*) leaves, which are rich in tannins and grow widely in Pangkalan, Lima Puluh Kota Regency, West Sumatra, Indonesia. Gambier from Pangkalan contains 64.84% tannins (Unpublished data). Tannins are known to reduce protozoan populations in the rumen, which play a role in supporting methanogen activity (Elihasridas *et al*., 2024; Pazla, 2024). In addition, catechins in gambier can increase fibroolytic microbial activity responsible for fiber degradation. Nevertheless, the use of gambier extract as a feed additive on a research scale is still limited, especially to study its impact on fiber fraction digestibility and methane emissions in detail.

To date, research related to the effect of tannin-based feed additives has mostly focused on their effect on methane reduction without integrating their effect on improving crude fiber use efficiency. In addition, there has been no specific research using gambier from Pangkalan, West Sumatra, as a feed additive. This region is known to have unique geographical and climatic characteristics, which allow gambier leaves to contain higher concentrations of tannins and catechins compared to other regions. Therefore, this study offers an in-depth analysis of how gambier leaf extract from Pangakalan can optimize animal feed efficiency through increasing fiber digestibility and decreasing methane production.

The novelty of this research lies in the utilization of gambier leaf extract from Pangkalan which has not been widely studied, both from the aspect of locality of the material and its effect on overall rumen performance. This research not only fills the knowledge gap on tannin-based feed additives, but also offers local-based solutions that are environmentally friendly to support the sustainability of the livestock sector. Thus, the results of this study are expected to make a significant contribution in the development of more efficient and sustainable feed strategies.

MATERIAL AND METHODS

Research Materials

The materials used in this study included feed rations composed of rice straw, elephant grass, rice bran, corn, palm kernel meal, and tofu dregs (Table 1). The ration composition was adjusted to the nutritional needs of ruminants with a Crude Protein content of 12.59% and Total Digestible Nutrient 62.59% (Table 2). Gambier leaf extract was obtained from gambier plants from Pangkalan, West Sumatra. Rumen fluid was used as a source of fermentation microbes and was obtained from goats. Equipment used included an incubator, spectrophotometer, gas meter, and analytical balance. Fiber and feed nutrient analysis were conducted using chemicals according to the methods of AOAC (2016) and Van Soest *et al*. (1991).

Research Design

This study used a group randomized design with four treatments and four replicates. The treatments were T0 as control without gambier leaf extract, T1 with 0.5% gambier extract, T2

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with 1% gambier extract, and T3 with 2% gambier extract. The replicate groups used goat rumen fluid from four different animals to ensure biological variation.

Table 1. Composition of experimental rations used for in vitro evaluation of gambier leaf extract on fiber digestibility and methane reduction

Feed ingredients	Treatment (%)			
Rice straw	20	20	20	20
Elephant grass	40	40	40	40
Bran	2	2	2	2
Corn	6	6	6	6
Palm kernel meal	15	15	15	15
Tofu dregs	16	16	16	16
Minerals	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5
Total	100	100	100	100
Gambier leaf extract	0	0.5	1	1.5

Table 2. Nutritional composition of experimental rations for sustainable ruminant farming

Nutrient content	Value of content (%)
Dry matter	90.01
Organic matter	90.08
Crude protein	12.59
Crude Fiber	25.79
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

Stage of the Study

Gambier leaf extract was prepared by drying and grinding and then analyzed for tannin content based on AOAC (2016). Rations were prepared based on predetermined formulations, then analyzed for nutritional content before treatment. Rumen fluid was taken using anaerobic technique to maintain microbial viability. The fermentation process was conducted using the method of Tilley and Terry (1963), where 2.5 g of ration sample was put into a fermentation tube along with 50 ml of rumen fluid and 200 ml of buffer solution. The samples were incubated at 39^{o}C for 48 hours. After fermentation, the residue was filtered and analyzed for fiber fraction (NDF, ADF, cellulose, hemicellulose). Methane gas production was measured using the method of Fieves (2005) during fermentation.

Parameters Observed

The main parameters observed were the digestibility of fiber fractions, including NDF, ADF, cellulose, and hemicellulose, as well as methane gas production expressed in gas volume (ml/g digested organic matter or DOM).

Data Analysis

Data were analyzed using analysis of variance (ANOVA) according to a randomized group design to evaluate the effect of treatment on the observed parameters. If there were significant differences ($P<0.05$), Duncan's Multiple Range Test (DMRT) was conducted to determine differences between treatments

RESULTS AND DISCUSSION

NDF and ADF Digestibility

The addition of gambier leaf extract significantly increased the digestibility of NDF and ADF compared to the control ($P<0.05$) (Table 3). In the T3 treatment (2% gambier extract), NDF digestibility reached 64.30%, an increase of 4.25% compared to the control (61.67%). ADF digestibility in the same treatment also increased to 63.77%, higher than the control of 61.56%. This increase was due to the ability of tannins in gambier extract to suppress protozoan populations in the rumen, which reduced competition between protozoa and fibroolytic microbes for fiber substrates. Tannins also interact with proteins, forming tannin-protein complexes that are stable at rumen pH, thus allowing fibroolytic microbes to work more efficiently in decomposing fiber (Pazla *et al*., 2024).

Furthermore, the catechin content in gambier extract is known to support the activity of fibroolytic enzymes such as cellulose and hemicellulose that are responsible for the breakdown of crude fiber. This is in line with the research of Antonius *et al*. (2024), which showed that bioactives such as tannins are able to increase crude fiber degradation in the rumen without interfering with the main fermentation. This increase in NDF and ADF digestibility has positive implications for feed efficiency, as better digested fiber fractions will increase energy availability for livestock.

Table 3. Effect of gambier leaf extract supplementation on fiber digestibility in ruminant rations

Treatment	Digestibility of NDF	Digestibility of ADF	Digestibility of Cellulose	Digestibility of Hemicellulose
T0	61.67^{c}±0.24	61.56^{c}±0.26	64.57^{c}±0.32	64.79^{c}±0.20
T1	63.46^{b}±0.28	62.91^{ab}±0.86	66.45^{b}±0.12	66.67^{ab}±0.18
T2	63.91^{ab}±0.23	63.37^{a}±0.78	66.43^{b}±0.21	66.94^{a}±0.17
T3	64.30^{a}±033	63.77^{a}±0.71	67.20^{a}±0.22	67.44^{a}±0.40

Description: T0 (control ration), T1 (ration + 0.5% gambier leaves extract), T2 (Ration+ 1% gambier leaves extract), T3 (ration + 2% gambier leaves extract), NDF : Neutral Detergent Fiber, ADF: Acid Detergent Fiber

Digestibility of Cellulose and Hemicellulose

The addition of gambier leaf extract also had a significant impact on cellulose and hemicellulose digestibility ($P<0.05$). In the T3 (2% gambier) treatment (Table 3), cellulose digestibility reached 67.20%, an increase of 4.07% compared to the control (64.57%).

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Hemicellulose showed a similar pattern with an increase in digestibility of 2.56% from 64.79% in the control to 67.44% in T3. This increase suggests that tannins in gambier extract play a role in creating a rumen environment that is more conducive to fibroolytic microbial activity. By decreasing the activity of protozoa competing for substrates, tannins favor specific microbes responsible for celluose and hemicellulose degradation.

In addition, the presence of catechins in gambier extract can increase the activity of cellulose and hemicellulose enzymes that break down structural bonds in plant cell walls. Research by Elihasridas *et al*. (2024) also showed that polyphenolic compounds such as tannins have a synergistic effect with rumen microbes in decomposing complex fiber components. This effect is important because hemicellulose is usually more difficult to digest than cellulose, so a significant increase in this parameter indicates the great potential of gambier in increasing the efficiency of crude fiber use in livestock rations.

Methane Gas Production

Methane gas production decreased significantly with the addition of gambier leaf extract ($P<0.05$) (Figure 1). In the T3 treatment, methane gas production was recorded at 16.67 ml/g DOM, a decrease of 25.74% compared to the control (22.45 ml/g DOM). This decrease was due to the ability of tannins to suppress the methanogen population in the rumen, which is the main methane-producing microbe. Tannins work by reducing the availability of free hydrogen (H_2), which is an important substrate for the methanogenesis process.

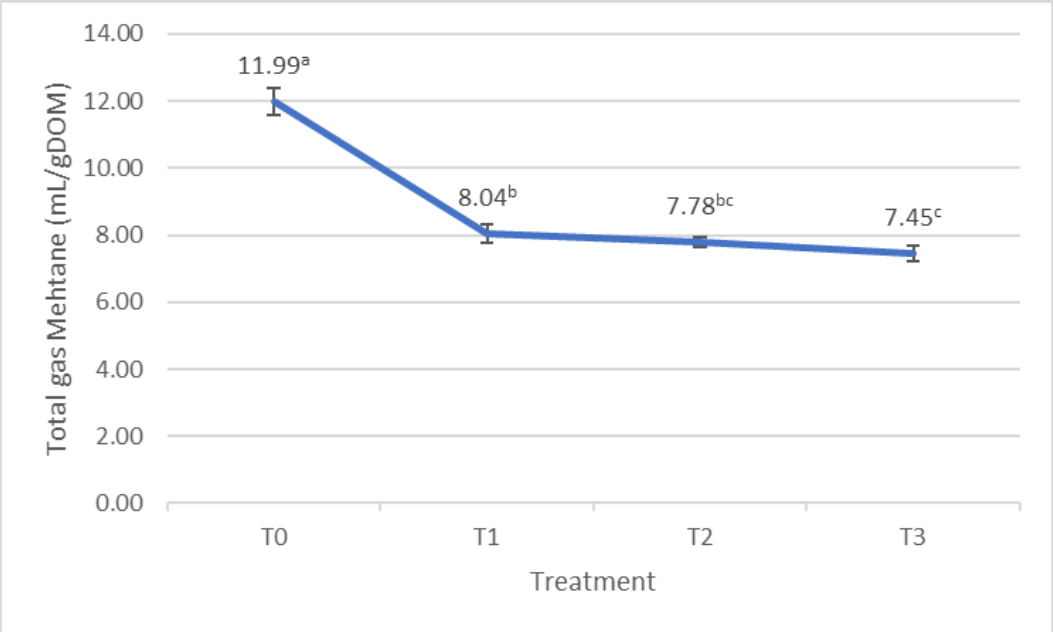


Figure 1. Methane gas production with gambier leaf extract supplementation in ruminant feed (T0 (control ration), T1 (ration + 0.5% gambier leaves extract), T2 (Ration+ 1% gambier leaves extract), T3 (ration + 2% gambier leaves extract), DOM: digestibility of organic matter)

The antimethanogenic effect of tannins is also related to the reduction of protozoan populations in the rumen, as protozoa often interact with methanogens through hydrogen transfer. By reducing the protozoan population, tannins indirectly suppress methane production. Research by Pazla *et al*. (2024) supports this finding, stating that tannins can reduce methane emissions without disrupting the production of volatile fatty acids (VFA), which are the main

source of energy for livestock. This suggests that gambier leaf extract not only plays a role in improving fiber fermentation efficiency, but also offers an environmentally friendly greenhouse gas emission mitigation solution.

CONCLUSION

The addition of 2% gambier leaf extract of Pangkalan origin increased fiber digestibility (NDF, ADF, cellulose, hemicellulose) and decreased methane gas production by 25.74%, making it a potential feed additive for feed efficiency and environmental impact mitigation.

REFERENCES

Antonius, A., Pazla, R., Putri, E. M., Alma'i, M. I., Laconi, E. B., Diapari, D., ... & Negoro, P. S. (2024). Effects of herbal plant supplementation on rumen fermentation profiles and protozoan population in vitro. *Veterinary World, 17*(5), 1139–1148. https://doi.org/10.14202/vetworld.2024.1139-1148

Antonius, A., Pazla, R., Putri, E. M., Negara, W., Laia, N., Ridla, M., Suharti, S., Jayanegara, A., Asmairicen, S., Marlina, L., & Marta, Y. (2023). Effectiveness of herbal plants on rumen fermentation, methane gas emissions, in vitro nutrient digestibility, and population of protozoa. *Veterinary World, 16*(8), 1477–1488. https://doi.org/10.14202/vetworld.2023.1477-1488

Ardani, L. R., Zain, M., Elihasridas, E., Erpomen, E., Pazla, R., Utami, Y., ... & Makmur, M. (2024). Optimization Indigofera zollingeriana and Gambier (*Uncaria gambier*) supplementation on feed consumption, digestibility, methane production, and lactation performance of Etawa crossbreed goats. *International Journal of Veterinary Science, 13*(5), 537–544. https://doi.org/10.47278/journal.ijvs/2024.129

Association of Official Analytical Chemists (AOAC). (2016). Appendix F: Guidelines for standard method performance requirements. *AOAC Official Method of Analysis,* 1–18. Gaithersburg, MD: AOAC International.

Black, J., Davison, T., & Box, I. (2021). Methane emissions from ruminants in Australia: Mitigation potential and applicability of mitigation strategies. *Animals, 11*(4). https://doi.org/10.3390/ani11040951

Elihasridas, E., Pazla, R., Jamarun, N., Yanti, G., Asmairicen, S., Marlina, L., ... & Zelinea, F. (2024). Effect of tannin degradation of mangrove (*Sonneratia alba*) fruit on nutrient digestibility, protozoa population and methane gas production. *Czech Journal of Animal Science, 69*(7), 292–301. https://doi.org/10.17221/38/2024-CJAS

Fievez, V., Babayemi, O. J., & Demeyer, D. (2005). Estimation of direct and indirect gas production in syringes: A tool to estimate short-chain fatty acid production that requires minimal laboratory facilities. *Animal Feed Science and Technology, 123–124,* 197–210. https://doi.org/10.1016/j.anifeedsci.2005.05.001

Laura, E., Zain, M., & Agustin, F. (2024). Enhancing sheep rations: Optimal ammoniated palm fronds utilization with lerak fruit (*Sapindus rarak*) and probiotic supplementation. *Andalasian Livestock, 1*(1), 59–69. https://doi.org/10.25077/alive.v1.n1.p59-69.2024

 DOI: 10.25077/alive.v1.n2.p114-120.2024

Malik, P., Singhal, K., Deshpande, S., & Siddique, R. (2012). Mitigation strategies for enteric methane emission with special emphasis on biological approaches: A review. *Indian Journal of Animal Sciences, 82,* 794–804.

Pazla, R. (2024). Strategi pengurangan metana: Peran tanin dalam nutrisi ternak dan pengelolaan lingkungan (*Strategies for methane reduction: The role of tannins in livestock nutrition and environmental management*). Purbalingga, Indonesia: CV. Eureka Media Aksara. https://repository.penerbiteureka.com/publications/569002/strategi-pengurangan-metana-peran-tanin-dalam-nutrisi-ternak-dan-pengelolaan-lin

Pazla, R., Antonius, Erpomen, & Sari, D. N. I. (2022). Upaya mengurangi gas metan dari sektor peternakan [Efforts to reduce methane gas from the livestock sector]. Indramayu: Penerbit Adab. ISBN: 978-623-497-149-1. https://penerbitadab.id/upaya-mengurangi-gas-metan-dari-sektor-peternakan/

Pazla, R., Elihasridas, E., Jamarun, N., Yanti, G., Antonius, A., Putri, E. M., ... & Efendi, Z. (2024). Optimizing nutrient digestibility through fermentation of mangrove (*Sonneratia alba*) fruit with *Aspergillus niger*: Implications for livestock feed quality improvement. *International Journal of Veterinary Science, 13*(6), 862–869. https://doi.org/10.47278/journal.ijvs/2024.182

Putri, E. M., Pazla, R., Jamarun, N., Agustin, F., Yanti, G., Ikhlas, Z., Arief, A., Negara, W., Khan, F. A., Surachman, M., Darmawan, I. W. A., Akhadiarto, S., Herdis, H., Priyatno, T. P., & Lestari, P. (2024). Optimizing ruminant feed efficiency: The synergistic effects of BMR sorghum and *Tithonia diversifolia* on nutrient digestibility, rumen function, and methane mitigation. *Journal of Animal Behavior and Biometeorology, 12,* e2024022. https://doi.org/10.31893/jabb.2024022

Tilley, J. M. A., & Terry, R. A. (1963). A two-stage technique for the in vitro digestion of forage crops. *Grass and Forage Science, 18*(2), 104–111. https://doi.org/10.1111/j.1365-2494.1963.tb00335.x

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74*(10), 3583–3597. https://doi.org/10.3168/jds.S0022-0302(91)78551-2