P-ISSN: 2304-3075; E-ISSN: 2305-4360

International Journal of Veterinary Science

www.ijvets.com; editor@ijvets.com

Research Article https://doi.org/10.47278/journal.ijvs/2024.129

Optimization *Indigofera zollingeriana* and Gambier (*Uncaria gambir*) Supplementation on Feed Consumption, Digestibility, Methane Production and Lactation Performance of Etawa Crossbreed Goats

Laily Rinda Ardani[1], Mardiati Zain[2*], Elihasridas[2], Erpomen[2], Roni Pazla[2], Yolani Utami[3], Rifa Ratna Sari[2], Muhammad Taufik Hadiwijaya[2], Ezi Masdia Putri[4] and Malik Makmur[2]

[1]Graduate Program, Faculty of Animal Science, Andalas University, Kampus Limau Manis, Padang, West Sumatra, Indonesia 25163
[2]Department of Animal Nutrition, Faculty of Animal Science, Andalas University, Kampus Limau Manis, Padang, West Sumatra, Indonesia 25163
[3]Animal Science Program, Kampus II Payakumbuh, Faculty of Animal Science, Andalas University, West Sumatra, Indonesia 262182
[4]Research Center for Animal Husbandry, National Research and Innovation Agency (BRIN) Indonesia, Jl. Raya Jakarta Bogor Cibinong 16915, Indonesia
***Corresponding author:** mardiati@ansci.unand.ac.id ; ardanilaily@gmail.com

Article History: 23-359 Received: 23-Nov-23 Revised: 16-Jan-24 Accepted: 17-Jan-24

ABSTRACT

The utilisation of *Indigofera zollingeriana* in rations as a replacement for high-protein concentrates can affect the nutritional quality of the feed. Gambier supplementation (*Uncaria 17gambir*) can shield the content protein from the breakdown process in the rumen so that post-rumen available amino acids are higher. This study explores the optimization of *I. zollingeriana* and *U. gambir* supplementation on feed consumption, digestibility, methane gas production, and lactation performance of Etawa Crossbreed goats. This experiment used a randomized block design with three groups and five replications. Fifteen Etawa Crossbreed goats were in their second lactation period with a body weight of 52±2 kg (n = 5 goats/group). The treatment in this study was as follows: A: field grass 60% + concentrate 40%; B: field grass 60% + concentrate 10% + *Indigofera zollingeriana* 30%; C: field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1%. The experiment lasted for 4 weeks including an adaptation period of 7 days. Treatment of 30% *I. zollingeriana* and 1% *U. gambir* in ration significantly affected nutrient digestibility, milk yield, and the content of PUFA, MUFA, CLA, omega-3, and omega-6. Besides, this treatment significantly reduced methane gas production. Meawhile the combination of *I. zollingeriana* and *U. gambir* decreased feed composition. The content of milk protein, milk fat, milk lactose, and omega-9 were not different among treatments. In conclusion, *I. zollingeriana* and *U. gambir* supplementation are able to optimize nutrient digestibility, methane reduction, and lactation performance including milk yield, PUFA, MUFA, CLA, omega-3, and omega-6. Meanwhile, this supplementation has no impact on feed consumption, fat, protein, lactose and omega-9 of milk.

Key words: Dairy goats, Etawa crossbreed, *Indigofera zollingeriana*, Lactation performance, Methane, *Uncaria gambir*

INTRODUCTION

Dairy goat farming contributes significantly to the national economy of countries in Asia, especially Indonesia. The need for milk which continues to increase every year shows that dairy goat farming has the potential to be developed (Rapetti et al. 2020). The Etawa Crossbreed goat is the result of crossbreeding the Etawa originating from India (Jamnapari) and a local goat from Indonesia, namely the Kacang Goat which resembles the Etawa goat but is smaller in size (Suranindyah et al. 2018). This goat has been able to adapt to the Indonesian environment and is dual-purpose, as a milk producer (dairy livestock) and meat producer (beef livestock) and accepted by the community as a producer of animal protein, especially in milk production (Fitriyanto and Utami 2013).

Cite This Article as: Ardani LR, Zain M, Elihasridas, Erpomen, Pazla R, Utami Y, Sari RR, Hadiwijaya MT, Putri EM and Makmur M, 2024. Optimization *Indigofera zollingeriana* and gambier (*Uncaria gambir*) 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

The production of dairy ruminants depends on the feed given properly in quality and quantity. So that in general dairy animal feed is given concentrates with high protein value to increase the efficiency of ruminant production (Wanapat et al. 2017; Arief et al. 2023). Of course, this strategy has high production costs and the potential for the competitiveness of feed ingredients. Therefore, increasing livestock production and optimizing the efficiency of utilization of feed nutrients can be achieved through high-protein feed supplementation (Mengistu and Hassen 2018). This feed supplementation strategy can reduce livestock production costs and increase the added value of poor-quality feed (Gunun et al. 2023).

Indigofera zollingeriana is a shrub legume in the Fabaceae family which has been used to increase the productivity of dairy goats in several regions in Indonesia (Hassen et al. 2008). Several studies reported *I. zollingeriana* has high protein and organic matter content (Pazla et al. 2023; Amanah et al. 2024). This forage has the potential to be a substitute for high-protein concentrates because of its high protein and mineral content (Evitayani et al. 2021). *I. zollingeriana* is cheap, high-quality, and easy to obtain because it is available all year round, grows tolerant to environmental conditions, and has fairly high palatability (Abdullah 2010). *I. zollingeriana* has a content of protein range between 26-31%, protein digestibility of 83-86%, fibre fraction (ADF 32-38%; NDF 49-57%) and high dry matter digestibility (72–81%) so that it has the potential as a protein source feed where the high protein content can stimulate the activity of rumen microorganisms to work better (Abdullah 2010; Abdullah 2014). Protein contributes 60-70% of the total nutritional needs of livestock and plays an important role in supporting livestock productivity (Owen et al. 2014; Putri et al. 2021). Therefore, the utilisation of *I. zollingeriana* in rations as a replacement for concentrate can affect the nutritional quality of feed and increase consumption and digestibility of feed nutrients thereby increasing daily body weight gain and productivity (Tarigan et al. 2017; Aidismen and Asturi 2018; Evitayani et al. 2021).

The application of *I. zollingeriana* as a replacement for high-content protein concentrate in the rations will increase the consumption of forage feed which has an impact on the high consumption of crude fibre so that it has the potential to decrease the efficiency of feed and enlarge methane gas production (Bharadwaj et al. 2021). A previous investigation by Putri et al. (2019), *I. zollingeriana* has a high rumen degradable protein (RDP) content of 74.72%. The degradation of protein content in the rumen will lessen feed protein value so it is important to protect feed protein so that the available amino acids in the post rumen are higher (Ramaiyulis et al. 2019). Even so, protein protection must still pay attention to the availability of ammonia for microbial synthesis protein in the act as the main protein source of ruminants livestock (Patra and Aschenbatch 2018). This study used additional supplementation of gambier leaves (*Uncaria gambir*) which are expected to bind to proteins so that they are resistant to degradation in the rumen and can reduce methane gas production. Previous studies reported that Gambier Leaves Waste and *Saccharomyces cerevisiae* supplementation can decrease the production of methane gas and improve the feed digestibility of Simmental Cattle (Ningrat et al. 2020). These study results are consistent with another study where Gambier leaves can be used as an animal feed supplement by reducing rumen protozoa populations and optimizing microbial protein synthesis (Ramaiyulis et al. 2019). Antonius et al. (2022) also reported that *U. gambir* leaves extract did not give a negative effect on Boerka goats crossbred, meanwhile increase intake nutrient, daily body weight, and meat quality.

U. gambir leaves contain phytochemical polyphenol fractions which mostly contain catechins (50-55%), pyrocatechol (20-30%), tannins (16-25%), red catechu (3-5%), quercetin (2-4%), alkaloids (2-5%), gambirin (1-3%) and wax (1-2%) (Yeni et al. 2014; Nurdin and Fitrimiwati 2018; Anggraini et al. 2019). Catechins are flavonoid compounds that have antioxidant activity and increase the endogenous antioxidant enzymes activity such as glutathione peroxidase, superoxide dismutase and catalase (Abd El-Aziz et al. 2012). Previous research on forage supplementation containing catechins can increase daily body weight gain in goats, meat quality and natural antioxidants (Tan et al. 2021). In addition, the tannin content in Gambier leaves protects the crude protein from microbial breakdown in the rumen of livestock. Tannins are able to form a kind of complex bond between tannins and proteins so that they are resistant to microbial breakdown at neutral pH (Bunglavan and Dutta 2013).

This study explores the optimization of *I. zollingeriana* and *U. gambir* supplementation on feed consumption, nutrient digestibility, production of methane gas, and lactation performance including milk yield and composition of milk of Etawa Crossbreed Goats.

MATERIALS AND METHODS

Animal Ethics

All research procedures carried out have been approved and monitored by the Research Ethics Committee of the Faculty of Medicine, Andalas University, Padang, West Sumatra with the following numbers 297/UN.16.2/KEP-FK/2023.

Study Location and Period

The experiment has been done at the "Toni Farm" Dairy Goat Farm located in West Payakumbuh, Payakumbuh City, West Sumatra, Indonesia. Laboratory analysis was carried out from January to June 2023 at the Laboratory of Ruminant Nutrition, Faculty of Animal Science, Andalas University, Padang, West Sumatra, Indonesia.

Animal, Experimental Design and Treatment

Fifteen Etawa crossbreed goats, which were in their second lactation period with a total body weight of 52 ± 2 kg, were carried out as an experiment for 4 weeks. Each animal was placed in an individual cage and obtained drinking water *ad-libitum*. The ration given was based on the dry matter requirement of 4% of the body weight of the animal in two feeds at 08.00 and 16.00. This experiment applied a randomized block design with five replications and three groups. The ration formulation and feed chemical content are shown in Table 1 and 2. The treatments in this study were as follows: A: field grass 60% + concentrate 40% concentrate; B: field grass 60% + concentrate 10% + *I. zollingeriana* 30%; C: field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1%.

Table 1: Nutritional content of basal and concentrated feed ingredients (%)

Nutritional content	Field grass	Tofu waste	Jackfruit skin	Cassava flour	*Uncaria gambir*	Mineral
				(%)		
Dry matter	23.29	16.2	98.36	96.95	56.43	100
Organic matter	91.43	97.01	95.00	98.78	53.51	0
Crude protein	10.23	23.00	12.06	11.66	11.84	0
Crude fibre	25.44	23.00	28.61	4.28	34.27	0
Crude fat	4.88	3.00	4.00	1.13	4.9	0
Nitrogen-free extracts	48.84	40.03	48.69	78.67	45.36	0
Total digestible nutrient	57.52	79.00	68.80	86.53	-	0
Lignin	4.2	1.80	8.54	6.49	-	0

Source: Laboratory of nutrition and feed engineering, Payakumbuh State Politany (2022).

Table 2: Rations formulation and nutritional content

Feed ingredients	Treatments (%)		
	A	B	C
Field grass	60	60	60
Concentrated	40	10	10
Indigofera zollingeriana	0	30	30
Total	100	100	100
Uncaria gambir supplementation	0	0	1
Chemical composition (%)			
Dry matter (DM)	28.23	23.91	24.47
Organic matter (OM)	93.22	91.62	92.15
Crude protein (CP)	14.18	15.74	15.85
Crude fibre (CF)	24.03	21.10	21.44
Crude fat	4.11	4.32	4.36
Nitrogen-free extracts (NFE)	46.59	45.78	46.23
Total digestible nutrient (TDN)	65.46	65.05	65.05
Lignin	3.81	3.33	3.33

Source: Laboratory of nutrition and feed engineering, Payakumbuh State Politany (2022).

Feed Preparation

The preparation of feed consists of providing field grass, providing concentrate consisting of tofu dregs, jackfruit skin, cassava flour and minerals and *I. zollingeriana* and *U. gambir* as a feed supplement. All ration ingredients used for this research were picked up from the local area in Payakumbuh City, West Sumatra, Indonesia. *U. gambir* leaves that were macerated for 12h continued with the process of filtering, pressing, and drying under the sun for 3-4d. Leaves then ground to a fine powder and ready to be used as a feed ingredient (Antonius et al. 2022).

Data Collection and Parameter Measurement

Feed consumption was calculated by weighing the total feed and the remaining consumed every day. Fifteen goats in the experiment were measured for their weight every week to rearrange the amount of given feed. Nutrient intake and digestibility determination followed the study of Ningrat et al. (2020). Measurement of methane gas production uses Jentsch's equation (Jentsch et al. 2007).

Milk production was collected and recorded daily for 30 days during the milking morning and evening. Then, milk samples were put into milk bottles and placed in a cooler at 4°C to be analyzed in the laboratory for analysis of milk composition which includes total solid, solid non-fat, milk fat, milk protein and milk lactose using Lactoscan SP Analyzer (Germany). As for the analysis profile of milk fat, samples were kept at -20°C until analysis. Variables measured include saturated fatty acids (SFA), PUFA, MUFA, CLA, omega-3, omega-6 and omega-9. Fatty acid counts are identified by using the retention times in the standard fatty acids methyl ester gas chromatographic analysis at GC Shimadzu GC-2010, Japan).

Statistical Analysis

The data obtained were analyzed using analysis of variance. Data that had significant effect of each parameter ($P<0.05$) was continued testing with Duncan Test using SPSS version 26.0 (Statistical Package for the Social Sciences Statistics, Inc, USA).

RESULTS

Feed Consumption

The effect of *I. zollingeriana* and *U. gambir* supplementation on feed consumption is shown in Table 3. Table 3 shows the results of dry matter intake (DMI), DMI % of BW, DMI based on Metabolic BW which was significantly different ($P<0.05$) in group C compared to group A and B. This also happened to other nutrient intake, which is an organic matter where organic matter intake (OMI), OMI % of BW, and OMI based on Metabolic BW showed a significant different results in group C ($P<0.05$). The results of feed consumption in terms of dry matter (DM) and organic matter (OM) as a whole showed significantly more efficient results in the dairy goat group that was given 1% *U. gambir.*

Digestibility and Methane Gas Production

Results of the apparent digestibility and methane gas production from the various *I. zollingeriana* and *U. gambir* supplementation treatment groups are shown in Table 4. Group C showed higher and significantly different ($P<0.05$) digestibility results of DM, OM, and crude fibre (CF) compared to the other treatment groups. However, it was different in the crude protein digestibility where the highest yield was shown in group B ($P<0.05$), which was not significantly different from the treatment of group C. Nevertheless, the crude protein digestibility in Group B and C showed no significant difference. On the methane gas production parameters, the lowest result was shown in treatment group A which was not significantly different ($P>0.05$) from group C.

Lactation Performance

Lactation performance including milk yield and milk composition of Etawa crossbreed goats supplemented with *I. zollingeriana* and *U. gambir* are shown in Table 5. Supplementation in treatment group C had a significant treatment effect ($P<0.05$) on the milk yield. Meanwhile, the milk composition which includes milk protein, milk fat, and milk lactose was not impacted by the presence of the treatment ($P>0.05$). The profile of milk fat showed that group C had the highest results on PUFA and CLA ($P<0.05$), but the results were not significantly different

Table 3: Impact of supplementation *Indigofera zollingeriana* and *Uncaria gambir* on nutrient intake

Items	Treatments[1)]			SEM
	A	B	C	
DMI (kg/d)	2.07[b]	2.04[b]	1.83[a]	0.06
DMI % of BW (g/kg of BW)	3.97[b]	3.88[b]	3.44[a]	0.03
DMI based on Metabolic BW (g/kg $BW^{0,75}$)	106.63[b]	104.50[b]	93.03[a]	1.16
OMI (kg/d)	1.93[b]	1.87[b]	1.69[a]	0.05
OMI % of BW (g/kg of BW)	3.70[bc]	3.56[b]	3.17[a]	0.03
OMI based on Metabolic BW (g/kg $BW^{0,75}$)	99.40[bc]	95.74[b]	85.73[a]	1.07

SEM, standard error of mean; DMI, dry matter intake; OMI, organic matter intake; BW, body weight: [1)] A, field grass 60%+concentrate 40%; B, field grass 60%+concentrate 10% + *I. zollingeriana* 30%; C, field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1%: [a,b,c] Different superscripts in the treatment in rows are differently significant (P<0.05).

Table 4: Impact of supplementation *Indigofera zollingeriana* and *Uncaria gambir* on digestibility (%) and methane gas production

Items	Treatments[1)]			SEM
	A	B	C	
DM	67.28[a]	68.59[a]	78.50[b]	9.56
OM	66.38[a]	65.97[a]	75.60[b]	6.45
CP	66.31[a]	75.42[b]	73.75[b]	3.70
CF	55.02[a]	59.40[a]	67.80[b]	8.42
Methane gas production (J/d)	1.26[b]	1.45[a]	1.27[b]	0.05

SEM, standard error of mean; DM, dry matter; OM, organic matter; CF, crude fibre; CP, crude protein: [1)] A, field grass 60%+concentrate 40%; B, field grass 60%+concentrate 10% + *I. zollingeriana* 30%; C, field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1%: [a,b,c] Different superscripts in the treatment in rows are differently significant (P<0.05).

Table 5: Impact of supplementation *Indigofera zollingeriana* and *Uncaria gambir* on lactation performance

Items	Treatments[1)]			SEM
	A	B	C	
Milk yield (kg/d)	1.20[a]	1.32[a]	1.95[b]	0.13
Milk composition (%)				
Protein	3.26	3.18	2.99	0.12
Fat	5.59	4.62	5.34	0.62
Lactose	4.93	4.8	4.53	0.18
PUFA	28.55[a]	30.71[b]	30.76[b]	10.2
CLA	0.64[a]	0.93[c]	1.24[c]	0.7
SFA	47.70[b]	44.07[b]	38.51[a]	3.4
MUFA	24.05[a]	25.04[a]	30.73[b]	5.2
Omega-3	2.68[a]	3.38[b]	4.51[c]	1.2
Omega-6	8.03[a]	7.03[b]	6.25[b]	1.4
Omega-9	20.45	22.26	22.14	2.7

SEM, standard error of mean; CLA, conjugated linoleic acid; PUFA, poly-unsaturated fatty acid; SFA, saturated fatty acid; MUFA, mono-unsaturated fatty acid: [1)] A, field grass 60%+concentrate 40%; B, field grass 60%+concentrate 10% + *I. zollingeriana* 30%; C, field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1%: [a,b,c] Different superscripts in the treatment in rows are differently significant (P<0.05).

from group B. Group C has shown the result lowest and significantly different on SFA (P<0.05). As for the MUFA profile, group C differed significantly higher than the other treatments (P<0.05). In addition, the content of the highest omega-3 in milk was shown by the treatment in group C (P<0.05) and the highest omega-6 in milk was shown in group A (P<0.05), followed by group B and group C which were not significantly different. Meanwhile, the omega-9 content of milk did not show a significant effect in the presence of *I. zollingeriana* and *U. gambir* supplementation (P>0.05).

DISCUSSION

Feed Consumption

In our findings, giving the treatment group C with field grass 60% + concentrate 10% + *I. zollingeriana* 30% + *U. gambir* 1% reduced nutrient intake including DM and OM. It is assumed that the feed given contains higher energy and nutrients compared to other treatments. Palupi et al. (2018) stated that feed with a higher content of crude protein, dry matter, and fibre fraction including NDF tends to decrease livestock consumption due to adjustments to energy requirements that are able to fill the rumen. We hypotized that the decrease of nutrient intake was caused by tannin in *U. gambir.* Tannin has bitter taste that might be responsible for decreasing the intake of nutrient in Etawa crossbred goat (Elihasridas et al. 2023). Hydrolyzed tannins (HT) are treacherous, but condensed tannins (CT) are still safe to use if the amount is less than 5% of DM in feed (Mueller-Harvey 2005). In addition, low tannin levels can increase ruminants utilizing nitrogen because they can change the place of protein digestion thereby increasing the absorption of amino acids in the body (Van 2006). This mechanism is called rumen escape protein which has an impact on milk productivity and also improves the performance (Mueller-Harvey 2005). Tannins at a pH of 3.5-7.0 can form a stable and insoluble complex bond with proteins, but these complexes are able to dissociate at a pH below 3.5 so that the proteins contained in food bound to tannins will be free from degradation of the rumen and then released into the abomasum (Makkar 2003). Absorption of the content of amino acids in the small intestine will possibly increase the efficiency of using nitrogen (N) and have an impact on livestock productivity (Van 2006). Some legumes with tannin content are used to increase protein bypass (Makkar 2003).

The finding of this study is in line with a previous study which reported that gambier supplementation had a positive effect by increasing the average daily weight and synthesis of microbial protein (Ramaiyulis et al. 2019; Ningrat et al. 2020). The impact of tannins on the digestive tract could be related to the bounds complexes of tannin with protein and tannin with carbohydrates which are deficient degraded by rumen microbes (Gemeda and Hassen 2015). Makkar (2003) stated that the phenolic hydraulic group of tannins is able to form bound complexes especially with the proteins and at a lower level bind polysaccharides, nucleic acids and metal ions. Nonetheless, Kumar et al. (2005) reported that the phytochemicals in the form of catechins, tannins, flavonoids or saponins found in plants have physiological functions in the form of antioxidants and increase body weight gain. In addition, *I. zollingeriana* and *U. gambir* supplementation does not cause changes in the consumption of the palatability of treated livestock (Abdullah 2014; Ningrat et al. 2020). Feed consumption can be affected by the available energy in the ration. Ration with sufficient energy content causes a decrease in feed consumption when compared to rations with lower energy (Palupi et al. 2018). The use of *I. zoolingeriana* in various previous studies can replace some or even all of the concentrate feed without reducing the digestibility or performance and productivity of goats (Gunun et al. 2023; Evitayani et al. 2021; Aidismen and Asturim 2018).

Digestibility and Methane Gas Production

Increased digestibility including DM, OM and crude fibre due to *I. zollingeriana* and *U. gambir* 1% supplementation shows the effectiveness of the phytochemical content like flavonoids and phenol so that the process of fermentation in the rumen takes place optimally. This study is supported by previous findings by Aguiar et al. (2014) and Paula et al. (2016) who reported that increasing feed containing flavonoid compounds was significantly positively correlated with increasing the digestibility of DM, crude protein (CP), crude fibre and NDF. The effect of this study indicates that flavonoid compounds can affect the nutrient digestibility and the utilization of feed ingredients, but their effectiveness depends on the concentration and classification of the plant given (Zhan et al. 2017). Zhan et al. (2017) added that flavonoid compounds are able to regulate rumen microflora including those related to microorganisms that play a role in degrading food substances.

An increase in feed digestibility can occur due to the regulation mechanism of microorganisms in the rumen due to the flavonoid compounds contained (Zhan et al. 2017; Antonius et al. 2023). Catechin compounds which are included in the flavonoid compounds in Gambier have a contribution that is relatively the same as tannins in livestock by binding to proteins, binding to hydrogen so as to prevent methane formation and inhibit methanogenic archaea (Becker et al. 2014; Antonius et al. 2022; Ardani et al. 2023). A study by Antonius et al. (2022) reported that the catechins in gambier leaves in their research were around 62.46% and were believed to contribute significantly to increasing the daily weight of livestock. Previous studies reported that flavonoid compounds were able to increase the population of *Megasphaera elsdenii* and *Streptococcus bovis* in the rumen digestion tract, while the population of methanogenic microorganism decreased (Seradj et al. 2014). Zhan et al. (2017) added that flavonoids have antimicrobial substances that can have positive or negative impacts on livestock rumen microorganisms. In his study, supplementation of feed containing flavonoids can enhance the degradation of protein and cellulose by increasing the population of proteolytic microorganisms including *Butyrivibrio fibrisolvens, Streptococcus bovis, Ruminobacter amylophilus, Prevotella sp.*, as well as cellulolytic microorganisms such as *Ruminobacter flavefaciens* and *Fibrobacter succinogen* (Kim et al. 2015).

The production of methane gas from ruminants depends on the quality and quantity of feed given because it affects digestion in the rumen (Beauchemin et al. 2008). Feed containing phenolic compounds such as tannins can reduce methane production without having a negative effect on rumen fermentation (Hassanat and Benchaar 2013). From the results of this study, the reduction of methane gas occurred in the treatment group with 1% Gambier supplementation (group C). This finding is consistent with another report that the phenolic content in the plant generally produces lower methane gas regardless of the protein content, fibre fraction and lignin of the plant (Gemeda and Hassen 2015). Tannins in feed can reduce the production of ammonia (NH_3) by reducing rumen protein degradation which results in a decrease in nitrogen excretion in the urine (Zain et al. 2020). Gemeda and Hassen (2015) also reported that the effect of tannin compounds on rumen methanogenic microorganisms was greater than the degradation of feed substrates. However, it should be underlined that these impacts based on the type of content chemical structure of the tannins and the concentrations contained (Beauchemin et al. 2008). Tannin acts as a toxin for methanogens in the rumen (Gemeda and Hassen 2015).

Lactation Performance

The findings of our study, supplementation of 1% *U. gambir* can increase the milk yield of Etawa goats. The increase in milk production can occur due to the increased digestibility of feed ingredients and the content of various flavonoids and phenols in Gambier. Even though there was a decrease in DMI in the group of cattle that were given 1% Gambier supplementation, milk production actually increased ($P<0.05$). These results were confirmed by several other studies which reported that a diet rich in flavonoids could increase cow's milk production, but there were no reports of an increase in dry matter consumption in livestock (Gessner et al. 2015; Winkler et al. 2015). Zhan et al. (2017), in their research, reported that giving alfalfa flavonoids can increase nutrient digestibility, change the composition of milk and regulate the rumen microbial population. Zhan et al. (2017) added that feed ingredients containing different flavonoid compounds can have different effects on the performance of dairy ruminants. Supplementation of 1% *U. gambir* (treatment group C) was able to improve the presentation of rumen undegradable protein (RUDP) feed because it prevented the breakdown of protein in the rumen by binding mechanism of tannins compounds. Leondro et al. (2019) reported that higher levels of RUDP in feed resulted in better production performance and milk quality. This is due to the optimization of microbial protein synthesis through the balance of energy and protein and also the availability of by-pass protein through gastrointestinal tract. Previous studies reported that supplementation of balanced feed ingredients was able to improve milk yield causing the accessibility of various precursors in the process of milk biosynthesis (Leondro et al. 2019).

U. gambir 1% supplementation can impact the milk composition by enhancing the content of PUFA, CLA, MUFA, omega-3, omega-6 and also decreasing the SFA. Meanwhile, the content of milk protein, milk fat and milk lactose were not impacted by supplementation. Our results are in line with a previous study that stated that increasing the PUFA content and decreasing SFA in milk could occur due to the reduced biohydrogenation process composition of unsaturated fatty acids in the rumen (Si et al. 2018; Saleh et al. 2023). The content from catechin and tannin compounds in gambier which can be antimicrobial agents (Zhan et al. 2017; Antonius et al. 2022) is thought to be able to influence population regulation in the digestive rumen tract which functions to decrease the hydrogenation process of fatty acids in the rumen (Si et al. 2018). The content of milk fat is related to the level profile of acetate and butyrate which are fatty acid precursors. The study by Pegolo et al. (2016) reported that the milk fat composition was impacted by the herbal mixture supplementation containing various compounds in them. This is supported by previous studies that the composition of milk fat can be increased through the manipulation of polyphenol components for the rumen biohydrogenation process (Butler et al. 2011). The polyphenolic compounds present in gambier can modulate specific microorganisms in the digestive rumen, reducing the biohydrogenation process of absorbed fatty acids and increasing unsaturated fatty acid (UFA) fractions including PUFA and MUFA (Zheng et al. 2022). In another study, this shows that there is a direct correlation between the abundance of *Butyrivibrio* and the level of milk fatty acids which had an impact on increasing UFA levels in milk (Saleh et al. 2023).

Conclusion

The optimization *I. zollingeriana* 30% and Gambier 1% supplementation can cause an increase in nutrient digestibility, methane reduction, and lactation performance including milk yield, PUFA, MUFA, CLA, omega-3, and omega-6. Meanwhile, this supplementation has no impact on feed consumption, fat, protein, lactose and omega-9 of milk of the Etawa Crossbreed Goats.

Conflict of Interest

There is no conflict of interest with any organization about the discussed in this manuscript.

Acknowledgments

The experiment was funded through the Publication Riset Grant provided by Andalas University for 2023, as per the "Decision of the Research and Community Service Institute with contract No: T/33/UN16.19/PT.01.03/ Pangan-RPT/2023". The study was conducted with the support of the staff technical assistance at the Ruminant Nutrition Laboratory, Faculty of Animal Science, Andalas University, Padang, West Sumatra.

Author's Contribution

Mardiati Zain, Elihasridas, and Erpomen designed the concept of this study and searched for funding. Rifa Ratna Sari, and Muhammad Taufik Hadiwijaya conducted field and laboratory work. Laily Rinda Ardani and Yolani Utami collected and analyzed the data. Roni Pazla, Ezi Masdia Putri, and Malik Makmur drafted the manucript. All authors have read and approved the final manuscript.

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