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Effects of Using Gamal Leaf Flour as a Supplement on Feed Intake, Digestibility and Body Weight Gain of Goats

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Abstract: The research aims to determine the effect of supplementation of gamal leaf flour in feed on consumption, digestibility, feed conversion and body weight gain in goats. The research material used five male kacang goats aged 11-12 months with an average initial body weight of 13.39 ± 1.15 kg. The research used a 5 x 5 Latin Square Design (RBSL), the treatment consisted of 5 levels of gamal leaf flour supplementation in concentrate feed, namely; 0%, 3%, 7%, 12%, and 15%. Variables measured include: feed consumption, feed digestibility, PBBH, and feed conversion. The data obtained were analyzed using analysis of variance (ANOVA) and continued with the honest significant difference test (BNJ) on treatments that showed significant differences. The results showed that the level of supplementation of gamal leaf flour in feed had no significant effect (P>0.05) on the consumption of dry matter, organic matter and crude fiber but had a significant effect (P<0.05) on the consumption of crude protein. The treatment level of gamal leaf flour supplementation also had a significant effect (P<0.05) on feed ingredient digestibility but had no significant effect (P>0.05) on PBBB and feed conversion. It was concluded that gamal leaf flour could partially replace the use of conventional feed ingredients in concentrates.

I. INTRODUCTION

Goats are one of the popular ruminant animals raised by farmers in Indonesia. The choice of goats as livestock can be attributed to several factors, including the relatively affordable capital needed for their maintenance, especially since their feed is easily accessible. The common type of goat raised is the Kacang goat, which is a native Indonesian breed known for its meat production and is widely distributed across all provinces (Sodiq and Tawfik, 2003).

The main feed for goats and other ruminant livestock is forage, especially grass and some legumes or pulses. As stated by Suwignyo et al., (2012), forage is an essential requirement in the development of ruminant livestock. Forage can be obtained naturally by animals through grazing when they are herded or allowed to roam freely. If animals are kept in pens or enclosures, forage is obtained by cutting and carrying it to them, then feeding it after chopping it up. The feed for goats can also include crop residues from harvested crops (such as straw), especially crops from the legume group. According to Onyango et al., (2019), the limiting factor in the use of crop residues and agricultural byproducts is their high fiber content, coupled with low levels of metabolizable energy, crude protein, and minerals, resulting in low consumption, digestibility, and livestock performance.

The quantity and types of feed consumed by livestock will determine the level of nutrients and their utilization, as well as the response shown by the animals, particularly through their production performance (Boval and Dixon, 2012). To meet their basic living needs, goats and other ruminants will consume a certain amount of feed. Furthermore, feed consumption increases or changes as conditions and livestock production performance change. According to Mulyono and Sarwono (2010), the volume of feed required by goats largely depends on their total body weight and acceptability. However, the level of feed intake, according to Orskov (1988), is also greatly determined by the capacity or filling capacity of the rumen. Even if their nutritional needs are not met, animals will stop eating once their rumen is full.

The digestibility of feed ingredients will determine the amount of nutrients that can be utilized by livestock to meet their basic living needs and support their growth (Paramita et al., 2008). Therefore, digestibility can serve as an initial indicator of the availability of nutrients contained in feed ingredients. The digestion process of feed ingredients in the digestive tract involves a series of physical and chemical changes to the feed. This process will determine the feed's ability to supply nutrients to the animals.

The main challenge with forage availability, especially grass in tropical regions, is the inadequate nutritional value. Relying solely on low-nutrient feed guarantees suboptimal production performance for ruminant livestock. Providing supplementary feed in the form of concentrates is crucial to meet the nutritional needs of the animals and enhance their productivity. However, conventional commercial feed ingredients for making concentrates may not always be accessible to every farmer. Therefore, there is a need for alternative feed ingredients that are more affordable and accessible in terms of both price and availability.

Feed crops from the legume group are known to have significantly better nutritional balance compared to non-legume group (Ianneta et al., 2016). Gliricidia (Gliricidia sp.) is one such leguminous tree that is easily accessible as it has long been recognized and cultivated for various purposes. With its high nutritional value, Gliricidia leaves have the potential to serve as an alternative concentrate feed ingredient for ruminant livestock, especially goats. The response of goats and other ruminants to the use of Gliricidia leaf meal as a supplement needs to be tested. Based on these considerations, research has been conducted on the utilization of Gliricidia leaves aiming to determine the effects of Gliricidia leaf meal supplementation in feed on feed consumption, digestibility, feed conversion, and changes in body weight of goats.

II. MATERIAL AND METHOD

The research was conducted from May 2021 to October 2021 in the experimental pens at the Agricultural Technology Assessment and Research Installation (IPPTP) Pandu, in Talawaan Bantik Village, Wori District, North Minahasa Regency. The animals used in this research were five male Kacang goats aged between 11 and 12 months, with initial body weights ranging from 11.9 to 15 kg and an average of 13.39 kg ± 1.15 kg, were used in the study. The age of each animal was determined based on birth records provided by the owner and further verified by examining the arrangement of their permanent incisor teeth. Initial body weights were obtained by weighing the goats after an acclimatization period before the start of the treatments. Subsequently, each goat was placed in individual pens that had been prepared beforehand.

Experimental Pens

The experimental pens consist of 1 unit of raised pens with individual compartments designed to be 100 cm long, 50 cm wide, and 70 cm high, equipped with feeding troughs. The individual compartments are made of wood, as is the flooring, which is constructed from slats spaced apart to facilitate the dropping of feces and the cleaning process of the pens.

Treatment Feed

The treatment feed consists of pasture grass obtained from fields around the research location. The ingredients composing the concentrate feed include coconut meal, rice bran, ground corn, fish meal, and Gliricidia leaf meal.

Application of Treatment

The research utilized a Latin square design of 5 x 5 (5 rows and 5 columns). The treatments consisted of five levels of Gliricidia leaf meal incorporation in the concentrate feed. The treatment feed was composed with a ratio of 85% pasture grass and 15% concentrate, with crude protein content ranging from 14 to 15%. The arrangement of treatment feeds is presented in Table 1.

Table 1. The arrangement of treatment feeds

Feed Ingredient	**Treatment**				
	P_0	P_1	P_2	P_3	P_4
Pasture grass (%)	85	85	85	85	85
Coconut meal (%)	1	1	1	1	0
Rice bran (%)	8	6	4	2	0
Ground corn (%)	4	3	2	1	0
Fish meal (%)	2	2	1	0	0
Gliricidia leaf meal (%)	0	3	7	11	15
Total	100	100	100	100	100

The formulation of the treatment feed was prepared based on the analysis of the nutritional content of the feed ingredients used. According to the formulation of the treatment feed, the nutrient content of the treatment feed is presented in Table 2.

Table 2. The nutrient content of each treatment feed

Nutrient Content	Treatment				
	P_0	P_1	P_2	P_3	P_4
Dry matter (%)	88.85	88.73	88.87	89.00	88.89
Organic matter (%)	80.32	80.80	81.65	82.50	82.93
Crude Protein (%)	14.45	14.80	15.14	15.48	15.97
Crude Fiber (%)	21.80	21.33	21.14	20.51	20.47

Measured Variables

The measured variables include:

-Nutrient intake (Dry Matter Consumption, Organic Matter Consumption, Crude Protein Consumption, Crude Fiber Consumption)

Nutrient intake from feed ingredients is calculated by subtracting the amount of feed given from the remaining feed that the animals did not eat. The feed to be given is weighed beforehand, while the remaining feed is weighed the next morning. The calculation of nutrient intake per kilogram of animal body weight is done by multiplying the proximate analysis results of the feed ingredients by the amount of feed given and then subtracting the proximate analysis results of the remaining feed. The result of this subtraction is then divided by the animal's body weight. The formula for calculating feed nutrient intake is as follows:

$$\text{DMC (g/kg BW}^{0.75}\text{/day)} = \frac{\text{[feed provided (g) x (\%DM) - remaining feed (g) x (\%DM)]}}{\text{Metabolic BW}}$$

$$\text{OMC (g/kg BW}^{0.75}\text{/day)} = \frac{\text{[feed provided (g)x\%DMx\%OM - remaining feed (g)x\%DMx\%OM]}}{\text{Metabolic BW}}$$

$$\text{CPC (g/kg BW}^{0.75}\text{/day)} = \frac{\text{[feed provided (g)x\%DMx\%CP - remaining feed (g)x\%DMx\%CP]}}{\text{Metabolic BW}}$$

$$\text{CFC (g/kg BW}^{0.75}\text{/day)} = \frac{\text{[feed provided (g)x\%DMx\%CF – remaining feed (g)x\%DMx\%CF]}}{\text{Metabolic BW}}$$

-Nutrient digestibility (Dry Matter Digestibility, Organic Matter Digestibility, Crude Protein Digestibility, Crude Fiber Digestibility)

Measurement of feed digestibility was determined by collecting feces over the last seven days. Feces produced within one day (24 hours) were collected using feces catchment nets installed at the bottom of the pens. The feces of each animal were weighed and recorded. Subsequently, the feces were dried under sunlight, then weighed and recorded for dry weight. Next, samples of 100 grams each were taken and placed in paper bags. On the final day of collection, all fecal samples from each animal were thoroughly mixed, and then 100 grams were taken for nutrient content analysis. Analysis of fecal nutrient content was conducted using proximate analysis according to AOAC (2000) standards. Nutrient digestibility of the feed was calculated using the equation as directed by McDonald et al., (2002) as follows:

$$\text{Nutrient digestibility} = \frac{[\Sigma \text{ nutrient consumed (g)} - \Sigma \text{ nutrient of feces (g)}]}{\Sigma \text{ nutrient consumed (g)}} \text{ X } 100\%$$

-Daily Weight Gain (DWG)

The increase in livestock body weight is determined through scheduled weighings every week during the research period. Weighing is done each week to monitor the pattern of body weight changes. Weighing is conducted in the morning before the animals are fed. The daily weight gain is obtained from the difference between the final body weight and the initial body weight divided by the observation time. The formula for daily weight gain is:

$$\text{DWG (g/goat/day)} = \frac{BW_2 - BW_1}{T_2 - T_1}$$

Note ;

DWG = daily weight gain (gr)

BW_1 = initial weighing body weight (kg)

BW_2 = final weighing body weight (kg)

W_1 = initial weighing time (dayi)

W_2 = final weighing time (day)

-Feed Conversion

Feed conversion is the efficiency ratio between feed intake and the resulting increase in livestock body weight. Feed conversion is obtained by dividing feed intake by the increase in body weight.

Data Analysis

The data obtained are tabulated and then analyzed using analysis of variance (ANOVA) according to the Latin Square Design (Hanafiah, 2010; Gomez and Gomez, 2010). Results showing significant differences in the analysis of variance are followed by honest significant difference (HSD) tests. The mathematical model of the design used is as follows:

$$Yij = \mu + \alpha i + \beta j + \varepsilon ij$$

Note:

Yij	= observation value for treatment i, group j
μ	= overall mean
αi	= effect of treatment i
βj	= effect of group j
εij	= random effect (experimental error) for treatment i, group j
i	= 1,2,3,4,5
j	= 1,2,3,4

III. RESULT AND DISCUSSION

Feed Consumption

Consumption of feed in livestock is influenced by various factors such as the animal's preference for the type of feed given, the amount of feed provided, the rearing system (grazing or confinement), the animal's age, sex, physiological condition, reproductive status, and its level of production. These factors also affect the level of feed consumption in goats. To meet their basic living needs, ruminant livestock consume a certain amount of feed, which increases as their conditions and production levels develop. The type and amount of feed consumed affect the amount of nutrients consumed and the animal's response to the feed provided.

The mean consumption of dry matter (DMC), organic matter (OMC), crude protein (CPC), and crude fiber (CFC) of the treatment feed are presented in Table 3. In the table, it can be observed that the treatment had no significant effect ($P \geq 0.05$) on dry matter consumption, organic matter consumption, and crude fiber consumption, but had a significant effect ($P \leq 0.05$) on crude protein consumption

Table 3. Mean consumption of dry matter, organic matter, crude protein, and crude fiber of feed ingredients (g/kg $BW^{0.75}$/day)

Variabel	Treatment				
	P0	P1	P2	P3	P4
DMC	44.12 ± 4.65^{a}	43.77 ± 3.37^{a}	43.97 ± 3.07^{a}	42.10 ± 7.22^{a}	47.42 ± 5.79^{a}
OMC	35.40 ± 3.74^{a}	35.36 ± 2.72^{a}	35.91 ± 2.51^{a}	34.73 ± 5.96^{a}	39.33 ± 4.80^{a}
CPC	6.37 ± 0.67^{a}	6.48 ± 0.50^{a}	6.66 ± 0.46^{ab}	6.52 ± 1.12^{ab}	7.57 ± 0.92^{b}
CFC	9.02 ± 1.01^{a}	9.34 ± 0.72^{a}	9.30 ± 0.65^{a}	8.63 ± 1.48^{a}	9.71 ± 1.18^{a}

Note: numbers in the same row followed by different superscripts indicate significant differences ($P \leq 0.05$)

Statistically, only the consumption of crude protein shows a significant difference, while the other variables do not show significant differences. Nevertheless, comparing the effects of treatments in the table above indicates that the nutrient consumption when using Gliricidia leaf meal alone (P4) is higher in all variables compared to the levels of 11%, 7%, 3%, and 0% Gliricidia leaf meal supplementation. Based on these results, it can be stated that the level of nutrient consumption of Gliricidia leaf meal for all research goats is relatively the same across all supplementation levels. The supplementation level of Gliricidia leaf meal in the feed does not affect the ability and preference of goats in consuming the feed provided.

The results of this study illustrate that in terms of nutrient consumption, Gliricidia leaf meal can replace the use of concentrate formulated from several conventional feed ingredients such as coconut meal, rice bran, ground corn, and fish meal. As known, in addition to its high protein content, Gliricidia leaf meal also contains some phytochemicals such as tannins and saponins, which can act as anti-nutrients in feed (Ebrahim and Negussie, 2020). However, the use of Gliricidia leaf meal as a single supplement at 15% of the total feed requirement for goats has a relatively similar effect to using a supplement formulated from several feed ingredients.

Based on the facts above proves that up to the 15% level, the presence of anti-nutrients in Gliricidia leaf meal does not adversely affect feed consumption. The condensing bond of tannins actually provides protection for the protein contained in Gliricidia leaf meal, allowing it to bypass degradation in the rumen and proceed to the abomasum and partially to the duodenum (Asaolu et al., 2012). The low acidity level in the abomasum and duodenum (pH 2.5 - 3.5) causes the breakdown of the tannin-protein complex, allowing protein to degrade and amino acids to be utilized by the livestock. Similarly, Wiryawan et al., (1999) stated that tannin-protein complex bonds are stable at pH 4 - 7 (in the rumen) and then break down in the abomasum at pH 2.5 - 3.5, subsequently entering the small intestine, where the protein can be digested and absorbed. Thus, it can be stated that protein protection by tannins is highly beneficial because it increases the supply of feed protein, allowing more amino acids to be absorbed by the host animal.

Nutrient Digestibility of Feed

The mean digestibility of dry matter (DMD), organic matter (DOM), crude protein (CPD), and crude fiber (CFD) of the treatment feed are presented in Table 4. In the table, it can be observed that the treatment significantly affects ($P \leq 0.05$) the digestibility of dry matter, organic matter, crude protein, and crude fiber.

Table 4. Average digestibility of dry matter, organic matter, crude protein and crude fiber of feed ingredients (%)

Variabel	Perlakuan				
	P0	P1	P2	P3	P4
DMD	64.21 ± 5.91^{ab}	60.13 ± 7.83^{b}	70.71 ± 6.32^{a}	60.29 ± 12.70^{b}	67.88 ± 8.11^{ab}
DOM	64.65 ± 5.84^{ab}	61.36 ± 7.59^{b}	71.82 ± 6.08^{a}	62.50 ± 11.98^{b}	69.64 ± 7.66^{ab}
CPD	80.16 ± 3.27^{ab}	76.91 ± 4.53^{ab}	82.24 ± 3.83^{a}	76.55 ± 7.50^{b}	81.89 ± 4.57^{ab}
CFD	57.98 ± 6.94^{ab}	57.67 ± 8.31^{ab}	65.33 ± 7.48^{a}	52.66 ± 15.13^{b}	63.25 ± 9.28^{ab}

Note: Numbers in the same row followed by different superscripts indicate significant differences ($P \leq 0.05$).

Comparison of the treatment effects on nutrient digestibility in Table 4 shows that the treatment effects significantly differ ($P \leq 0.05$) among the formulation levels of several feed ingredients containing Gliricidia leaf meal, specifically between the 7% level (P2) and the 11% level (P3), and the 3% level (P1). However, the supplementation effects from these formulations did not significantly differ from the use of Gliricidia leaf meal as a single supplement (P4). The nutrient digestibility values of the treatment using Gliricidia leaf meal as a single supplement (P4) in all variables (DMD, DOM, CPD, and CFD) did not significantly differ ($P \geq 0.05$) from the digestibility values of the other treatments. Although the digestibility percentage in treatment P2 is higher than that in treatment P4, this difference is statistically non-significant across all observation variables.

The nutrient digestibility of feed ingredients when using Gliricidia leaf meal as a single supplement appears to have a relatively similar effect to the nutrient digestibility of concentrate feed formulated from several feed ingredients without Gliricidia leaf meal or with varying levels of Gliricidia leaf meal. These results indicate that the nutrient content in feed ingredients supplemented with Gliricidia leaf meal alone is easily digestible. Rusdy et al. (2020) stated that supplementation of Gliricidia sepium can enhance dry matter digestibility due to the higher crude protein contents and fermentable energy, and the lower acid detergent fiber

(ADF) contents. According to Indriani et al. (2013), the higher the level of nutrient digestibility in feed, the greater the opportunity for livestock to utilize nutrients for their growth. Meanwhile, Soetanto and Kusmartono (2021) state that the tannin content found in leguminous plants such as Gliricidia leaves can provide nitrogen in higher quantities, thereby stimulating rumen microbes to increase feed digestibility.

Daily Weight Gain and Feed Conversion Value

The mean Daily Weight Gain (DWG) and Feed Conversion Ratio (FCR) values are presented in Table 5. In the table, it can be observed that the treatment does not have a significant effect ($P \geq 0.05$) on Daily Weight Gain (DWG), but it has a highly significant effect ($P \leq 0.01$) on the feed conversion ratio.

Table 5. Average daily weight gain and feed conversion ratio

Variabel	Treatment				
	P0	P1	P2	P3	P4
DWG (gr/goat/day)	46.98 ± 10.33^{a}	47.77 ± 10.80^{a}	49.42 ± 13.63^{a}	47.15 ± 9.75^{a}	49.91 ± 11.52^{a}
Feed Conversion	7.55 ± 1.17^{ab}	7.18 ± 1.15^{ab}	8.02 ± 11.95^{a}	6.69 ± 1.76^{b}	7.96 ± 1.78^{ab}

Note: Numbers in the same row followed by different superscripts indicate significant differences ($P \leq 0.05$).

Statistically, the effect of using Gliricidia leaf meal as a single supplement (P4) on the Daily Weight Gain (DWG) of goats shows no significant difference ($P \geq 0.05$) compared to the treatment using concentrate formulated from several feed ingredients with the addition of Gliricidia leaf meal or concentrate without Gliricidia leaf meal. Although not significant, the table above shows that the DWG of goats in treatment P4 is slightly higher than the DWG in other treatments. These results provide hope that concentrate formulated from several feed ingredients can be replaced with Gliricidia leaf meal. Considering the price of the feed ingredients used in the concentrate formulation, replacing them with Gliricidia leaf meal can potentially save on feed costs per kg of animal body weight. In larger-scale farming operations, these savings would be even more significant.

The use of Gliricidia leaf meal as a single feed supplement has proven to increase Daily Weight Gain (DWG) in livestock, with the rate of increase slightly higher than when using concentrate formulated from several conventional feed ingredients. With these research findings, it can be stated that Gliricidia, as one of the leguminous trees whose leaves can be used as goat feed, not only enhances DWG but also shows great potential as a supplement in concentrate or as a standalone supplement, while also being economically viable. Similarly, Rahman et al. (2015) stated that providing goat feed supplemented with tree forage increases body weight gain and feed digestibility.

Gliricidia leaves used as a single supplement or contained in concentrate feed contain tannin compounds, which can form complexes with proteins, cellulose, and hemicellulose. It's these complex tannin bonds that make the protein in the feed difficult to degrade in the rumen (Patra and Saxena, 2011). These complex bonds are temporary at rumen pH (around 5.7-7), so it is expected that when the concentrate feed reaches the abomasum and intestines with a pH of around 2.5-3.5, the bonds between tannin and protein will be released. With the release of these complex bonds, the protein in the feed can be digested into amino acids and utilized to increase goat body weight gain (Cao et al., 2021).

The feed conversion values obtained in this study, as seen in Table 5, range from 6.70 to 8.02. These results imply that for every 1 kg increase in goat body weight, it requires the consumption of 6.70 to 8.02 kg of dry matter feed. The treatment using 11% Gliricidia leaf meal (P3) as a substitution in the feed shows the smallest feed conversion ratio, which is 6.70. Basuki and Ngadiyono (2000) stated that the smaller the feed conversion ratio, the better. Therefore, among the treatments, the most efficient use of feed is treatment P3. Statistically, this ratio is significantly different ($P \leq 0.01$) from treatment P2, which resulted in a feed conversion ratio of 8.02. Meanwhile, the treatment using Gliricidia leaf meal as a single supplement (P4) did not significantly differ from the other treatments.

The high feed conversion ratio in treatment P2 is likely due to the high consumption and digestibility of nutrients in this treatment. Meanwhile, the lowest consumption and nutrient digestibility are observed in treatment P3. Folio Agtec (2021) reported that goats fed with high-quality concentrate have an average feed conversion ratio of 4.5-5.5, while those fed with low-quality roughage like straw have a feed conversion ratio of around 30. In another study by Hakim et al. (2019), where soybean hay was added to the diet of male PE goats, the feed conversion ratio was relatively high, ranging from 19.99 to 22.29. Meanwhile, a study by Aswanimiyuni et al. (2018) comparing the effects of feeding Napier grass and Guinea grass to male Jamnapari goats obtained a feed conversion ratio of 6.61 and 7.46, respectively.

The feed conversion values obtained in this study are slightly higher than those for high-quality concentrate diets but much lower than those for low-quality roughage diets as reported by Folio Agtec (2021). Additionally, the feed conversion ratio in this study is more efficient than that reported by Hakim et al. (2019) and roughly similar to that reported by Aswanimiyuni et al. (2018). Based on these reports, it can be concluded that the feed conversion ratio obtained in this study is relatively efficient.

IV. Conclusion

Based on the research findings and discussions, several conclusions can be drawn:

1. The use of gliricidia leaf meal as a supplement in concentrate has the potential to increase nutrient intake, which is comparable to using concentrate made from several feed ingredients. Moreover, the crude protein consumption when using gliricidia leaf meal as a sole supplement is significantly higher than when using concentrate made from multiple feed ingredients.
2. The nutrient digestibility of feed ingredients with the use of gliricidia leaf meal concentrate alone is as good as the digestibility of feed ingredients when using concentrate made from multiple feed ingredients.
3. The daily weight gain and feed conversion ratio, as performance indicators in goat production, for goats given gliricidia leaf meal concentrate alone are comparable to those for goats given concentrate made from multiple feed ingredients.

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