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Research Article
Ration Digestibility Based on Palm Oil Industry Byproducts, Tithonia (*Tithonia diversifolia*) and Corn Waste for Etawa Crossbred Dairy Goat

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Abstract

Background and Objective: The exploration of new and quality animal feed sources is very important for identifying supplements to the limited supply of grass. Palm oil processing industry byproducts, tithonia plants and corn waste have very good nutrient content for animal feed. The research objective was to study the potential of palm oil processing industry byproducts, tithonia (*Tithonia diversifolia*) and corn waste by *in vitro* digestion as feed ingredients for Etawa crossbred dairy goats (ECDGs). The long-term goal of this study was to obtain a concentrate ration formula by utilizing industrial byproducts of the palm oil industry, local forage of tithonia and corn waste, for ECDG with the ultimate goal of increasing the productivity of ECDGs to meet milk self-sufficiency by 2020. The theme of this study is in line with Andalas University's Master Plan Research with a focus on Food Security. **Materials and Methods:** This study used a randomized complete design consisting of three treatment groups; (A) Concentrate Ration (CR)+Tithonia, (B) CR+Tithonia+corn waste and © CR+corn waste. Five replicates were used per treatment. The CR consisted of 30% palm kernel cake (PKC), 20% rice bran, 9% corn, 40% tofu waste and 1% mineral. The protein and crude fiber content of the CR was 13.78 and 13.32%, respectively. The data were analyzed using one-way analysis of variance (ANOVA) and differences between treatments were tested using the Duncan multiple range test (DMRT) with 5% confidence intervals. The variables measured were dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD) and digestibility of fiber fractions (NDF, ADF and cellulose). **Results:** The results showed that DMD, OMD and digestibility of fiber fractions (NDF, ADF and cellulose) were greatest ($p<0.05$) in treatment B. However, treatments A, B and C did not affect the CPD and the results were significant. **Conclusion:** It was concluded that the combination of concentrate ration with tithonia and corn waste resulted in the highest *in vitro* digestibility.

Key words: Byproduct, corn waste, etawa crossbred dairy goat, palm oil, ration digestibility, tithonia

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Feed is an important factor that determines the performance of livestock production. The supply of sufficient and quality feed is needed so that livestock can produce well. Feed problems in the field of animal husbandry include the limited quantities of available feed, some of which are low quality and most of which are imported materials such as corn, soybean meal and fish meal. In the long term and to anticipate the increasing need for feed ingredients, alternative feed ingredients must be sought and the availability is quite large. Feed ingredients that fulfill the conditions above include a byproduct of the palm oil industry, tithonia (*Tithonia diversifolia*), which is a shrub and corn waste, representing agricultural waste, the latter two of which are promising sources of forage for livestock.

Indonesia is the largest palm oil producer in the world, with CPO production of 27 million t year^{-1} [1]andan oil palm plantation area reaching 11.7 million ha[2]. If every hectare of oil palm plants produces 4 t of CPO/year obtained from 16 t of fresh fruit bunches (FFB)[3], then every 1 t of FFB can produce 35 kg of palm kernel cake (PKC), which can be compared with 514 kg of PKC for every hectare.

In terms of production, 60% of the total palm oil production is byproducts, including PKC, which can be used as an alternative feed ingredient for livestock because it has a good nutrient content and has high potential as an animal feed ingredient[4,5]. If it is assumed that 60% of the total area of oil palm plantations is already producing plants, then the production of byproducts and oil palm plants can accommodate all beef cattle currently in Indonesia[6].

In addition to the palm oil industry's byproducts, goats can utilize tithonia (*Tithonia diversifolia*) and many corn wastes as substitutes for forages. Tithonia grow as shrub plants in unprocessed vacant land especially in West Sumatra, while corn waste is an agricultural waste that has potential as a source of forage for livestock. Tithonia is a potential source of forage for goats because it has good nutritional content and is a fast-growing plant. Titonia has a crude protein content of 22.98% and crude fiber of 18.17%[7]. In addition, tithonia has a balanced amino acid content[8]. Tithonia can also be used as a supplement for animal feed, especially in the dry season when the availability of forage is limited.

Corn waste also has great potential to be used as a source of forage for ruminants, especially in the dry season when grass is difficult to obtain. Corn waste can be in the form of corn tebon, stover corn straw, corn husk and corn cobs[9].

The nutritional value of corn plant waste varies greatly. Corn husk has the highest *in vitro* digestibility value (68%), while corn stalk is the most difficult to digest in the rumen (51%). The digestibility value of corn husks and corn cobs is 60%, which is almost the same as elephant grass as a source of forage[10]. An important factor that must be taken into account in preparing rations using corn waste is total digestible nutrients (TDN) because dairy animals such as the Etawa crossbred dairy goat (ECDG) require high TDN.

ECDG goats represent livestock other than dairy cows that can be developed as milk-producing animals and they can adapt well to most parts of Indonesia[11]. ECDG goats, including dual-purpose goats, have good reproductive properties and have a milk nutritional content that is better than that of cow's milk. In addition to having a better nutritional content, compared to cow's milk, most goat's milk is higher in fluorine content (10-100 times). Fluorine is useful as a natural antiseptic that can suppress the growth of pathogenic bacteria in the body[12]. In addition, goat milk has medicinal properties that can cure various diseases such as asthma and tuberculosis[13].

This study aimed to determine the effects of concentrate ration formula by utilizing industrial byproducts of the palm oil industry, local forage of tithonia and corn waste on *in vitro* digestibility.

MATERIALS AND METHODS

For this study, analysis of the *in vitro* digestibility was conducted in the Laboratory of Ruminant Nutrition of Andalas University. The concentrate ration (CR) consisted of a mixture of PKC 30%, rice bran 20%, corn 9%, tofu waste 40% and mineral 1%. The protein content and crude fiber content of the CR were 13.78 and 13.32%, respectively. Samples of PKC were collected from the city of Payakumbuh, tithonia was collected from Agam Regency and corn waste was collected around the town of Padang. All samples were finely ground and mixed according to the treatment combinations. The parameters measured in this study were dry matter digestibility (DMD), organic matter digestibility (OMD), crude protein digestibility (CPD) and digestibility of fiber fractions (NDF, ADF and cellulose).

***In vitro* procedure:** The *in vitro* procedure in this study followed that of Tilley and Terry[14]. Rumen fluid was taken from a goat. The fermentation tube was filled with 2.5 g of sample and 250 mL of McDougall's solution was added. The tube was placed in a shaker bath at 39°C and fermented for 48 h. After 48 h, the fermentation activity was stopped by immersing the tubes in ice water to stop microbial activity. Next, the separation of the supernatant and residue was performed. The

precipitate of the supernatant mixture and the residue was filtered with Whatman no. 41filter paper and dried in a 60°C oven; then, the digestibility of the nutrient substances and fiber fraction were analyzed.

Experimental design and statistical analysis: The study was conducted using a randomized complete design (3×5) with 5 replications (levels of CR, Tithonia and corn waste as the treatments). The differences between the treatment means were analyzed using Duncan's multiple range tests (DMRT) with confidence intervals of 5%.

The treatments were as follows:

A = 50% CR +50% Tithonia
B = 50% CR +25% Tithonia +25% corn waste
C = 50% CR +50% corn waste

RESULTS AND DISCUSSION

Effects of treatments on dry matter, organic matter and crude protein digestibility: The effects of treatments on dry matter, organic matter and crude protein digestibility of each ration can be seen in Table 1.

The results revealed that treatment B showed the highest digestibility of dry matter, organic matter and crude protein values ($p>0.05$). The digestibility value of the ration greatly influences the quality of the ration and a higher ration digestibility value means that the ration is of good quality for livestock consumption and for metabolic processes. According to Muhktarudin and Liman[15], a good ration has DMD and OMD values of up to 60%. The results of the current study were higher than the values for DMD (42.76%) and OMD (43.55%) obtained by Astuti[16] but lower than those obtained by Zain *et al.*[17]. Jamarun *et al.*[18] used tithonia combined with palm fronds and elephant grass in the study and obtained a DMD value of 58.23% and an OMD value of 57.35%. The CPD value of the combination of tithonia and elephant grass *in vitro* in a study by Pazla *et al.*[19] ranged from 50.18-70.31%. The results showed that the combination of forage in B rations consisting of tithonia and corn waste increased the DMD, OMD and CPD. The nutritional content of tithonia and corn waste is very good. A good nutrient content will make it easier for rumen microbes to degrade feed to increase digestibility. As explained by Winugroho *et al.*[20], increasing the digestibility value is closely related to the increased activity of microorganisms in the rumen and the increased digestibility of rumen microbes is closely related to the amount of rumen microbial population. Corn skin has a DMD value of 68%[9]. The DMD value of tithonia protein reaches 22.98%[7]. Tithonia leaves contain complex amino acids[8] and the plant also contains antinutrients such as phytic acid, saponins and tannins, which can have a positive effect on livestock[7,8]. Phytase enzymes in rumen microbes are able to break P bonds with phytate so that P can be absorbed and used as a phosphorus mineral source (P) for livestock. Mineral P is needed by rumen microbes for their growth, which ultimately has a positive effect on livestock productivity[21]. The rumen phytate can also form complex bonds with Zn and this Zn-phytate complex is

Table 1: Effects of treatments on dry matter digestibility (DMD), organic matter digestibility (OMD) and crude protein digestibility (CPD)

			Treatments		
No.	Nutrient digestibility (%)	Replication	A	B	C
1.	Dry matter digestibility (DMD)	1	72.36	74.81	65.42
		2	71.22	73.34	66.11
		3	71.58	75.29	66.88
		4	69.08	75.82	67.64
		5	68.12	72.41	67.36
		Average	70.47^{b}	74.33^{c}	66.68^{a}
2.	Organic matter digestibility (OMD)	1	70.06	71.42	61.89
		2	69.12	70.32	62.21
		3	69.57	71.84	63.54
		4	66.88	72.73	64.38
		5	68.02	69.20	64.17
		Average	68.73^{b}	71.10^{c}	63.24^{a}
3.	Crude protein digestibility (CPD)	1	65.45	70.43	62.22
		2	66.34	72.34	63.45
		3	65.12	71.01	63.22
		4	65.78	69.03	59.89
		5	64.56	68.08	59.87
		Average	65.45	70.18	61.73

^{a,b,c}Means in the same row with different superscripts were different ($p<0.05$)

Table 2: The average of digestibility of NDF, ADF and cellulose ration (%)

Treatment rations	NDF digestibility (%)	ADF digestibility (%)	Cellulose digestibility (%)
A	52.54[a]	49.59[a]	45.45[a]
B	64.01[b]	55.12[b]	61.52[b]
C	53.33[a]	50.40[a]	46.01[a]

[abc] Means in the same column with different superscripts were different ($p<0.05$)

likely to be degraded and release Zn slowly to be used for rumen microbial growth and to spur livestock growth[22]. Saponins in certain doses act as defaunation agents, thereby increasing the bacterial population and ultimately increasing the digestibility of feed ingredients in the rumen[23]. Tannin interacts with plant proteins to protect them from degradation in the rumen[24]. Henson *et al.*[25] stated that feeding a protein that is not degraded in the rumen can increase the amounts of protein and amino acids that are digested and absorbed in the small intestine, which can ultimately increase body protein synthesis. Widyobroto *et al.*[26] reported that protected proteins can directly experience the enzymatic digestion process in the abomasum and intestine.

Effects of treatments on digestibility of fiber fraction: The digestibility of the NDF, ADF and cellulose complete ration based on palm oil industry byproducts can be seen in Table 2.

From the Table 2, it can be seen that the average digestibility of NDF in the rations was 52.54-64.01%, ADF digestibility was 49.59-55.12% and cellulose digestibility was 45.45-61.52%. The greatest digestibility of NDF, ADF and cellulose was in the B ration, likely because of the low crude fiber content in the B ration. Treatment B was more digestible ($p<0.05$) compared to treatments A and C and the difference was significant. Moreover, treatments A and B were not significantly different ($p>0.05$) and the composition of the rations was similar as well. The high digestibility of NDF in treatment B was due to the low content of crude fiber and lignin contained in the ration. The lignin levels were low in the B treatment as a result of a reduced use of oil sludge, representing a positive impact with improved ration digestibility. Lignin is a limiting factor in the digestion process because it contains components of cell walls that are difficult to digest; thus, its presence in the diet will affect digestibility. This observation is consistent with that put forward by Parakkasi[27], who stated that the components of the fiber in the diet are closely linked to the level of consumption and digestibility and that increasing the level of fiber in the diet will decrease the digestibility of the ration. The increased level of PKC in treatment B also had a positive impact on digestibility. An increased amount of PKC provided an increased level of dietary protein in treatment B. Additionally, PKC is a better quality protein source than other sources such as corn. Several international studies on goats have reported varying ADF digestibility results that are generally higher than the digestibility of the rations in this study. In India, Anbarasu *et al.*[28] observed an ADF digestibility of 45.50% by using rations containing 22% protein. In Spain, Abebe *et al.*[29] reported an ADF digestibility of 54.70% with rations containing 19.40% protein. These results show that the protein content of the diet is closely related to the digestibility of the fiber fraction.

Duncan's tests on the ADF digestibility values indicate that the treatment gives a significantly different effect ($p<0.05$) on the digestibility of ADF. This result may have been caused by differences in the level of provision of PKC but the levels are relatively equal, so it does not affect the nutritional composition of the ration.

The low digestibility of NDF, ADF and cellulose in treatments A and C was due to the lignin content and high crude fiber rations that inhibit the digestion process. High lignin content in the feed is a limiting factor in the digestion process and may cause decreased fermentability and low digestibility of the ration. Additionally, the use of high PKC in ration B affects the nutrient content of the ration, affecting the adequacy of nutrients for rumen microbial growth.

Table 2 shows that the higher digestibility of NDF compared to that of ADF is caused by the increased degradation of NDF in the rumen compared to ADF. This result occurs because NDF has a more soluble fraction in the form of hemicellulose. In addition, the low digestibility of ADF occurred because ADF contains components that are difficult to digest, especially cellulose and lignin. Greenhalgh *et al.*[30] stated that the ADF content of the ration will affect the digestibility of the ration, where a higher ADF indicates that a ration has many components that are difficult to digest such as cellulose, lignin and silica, decreasing the digestibility.

The above results also indicate that bacterial activity that increases with increasing dose of supplementation will increase the activity of the digestibility fraction of the fiber; as stated by Winugroho *et al.*[20], the level of digestibility of nutrients in ruminants is not dependent on the quality of dietary protein or quality of materials food but on the crude fiber content and activity of rumen microorganisms, especially cellulolytic bacteria. Wallace and Newbold[31] reported that administration of probiotics will improve the rumen microbial

population so that the digestibility of feed will increase. Thus, the administration of BioPlus can increase the population of cellulolytic bacteria and allow feed digestibility to be increased.

This study revealed the combination of the best rations from byproducts based on palm oil processing industries, tithonia plants and corn waste. This study can be used in the formulation of milk goat rations and is recommended in areas that have an oil palm industry, which includes areas with many tithonia and corn plantations. The limitations of this study are that these represent preliminary laboratory testing results; thus, it is very necessary to perform direct *in vivo* tests in livestock.

CONCLUSION

The results showed that the mixture of PKC concentrate (30%), rice bran (20%), tofu waste (40%), corn (9%) and minerals (1%) with forage sources from tithonia and corn waste showed the best results with respect to dry matter digestibility, organic matter digestibility and crude protein digestibility, with values of 74.33, 71.10 and 70.18%, respectively. The digestibility of the fiber fraction was 64.01, 55.12 and 61.52% for NDF, ADF and cellulose digestibility, respectively.

SIGNIFICANCE STATEMENT

The effect of a CR based on PKC combined with tithonia and corn waste on *in vitro* digestibility was evaluated in this study. The results indicated that the combination of 50% CR +25% tithonia +25% corn waste was highly effective in rations derived from plantation waste products, such as oil palm fronds. This study will help researchers to recognize that a CR based on PKC combined with tithonia and corn waste is beneficial for supporting *in vitro* digestibility. Thus, this study could lead to a new theory regarding the importance of feed material combinations in rations derived from plantation waste.

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