In Vitro Rumen Fermentation Characteristics and Microbes of Thin Tail Sheep Given Sweet Potato Biomass

Sudarman A[1], Hayashida M[2], Miralestari M[1]

[1]*Department of Nutrition and Feed Technology, Faculty of Animal Science,*
Bogor Agricultural University, Bogor 16680, Indonesia
[2]*Department of Bioproduction Technology, Junior College*
Tokyo University of Agriculture, Japan
E-mail: a_sudarman@yahoo.com

ABSTRAK

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Tanaman ubi jalar (*Ipomoea batatas* L) diproduksi di Indonesia dalam jumlah besar. Daun dan batang ubi jalar dapat digunakan sebagai sumber protein dan umbinya dapat digunakan sebagai sumber energi. Penelitian ini bertujuan untuk mengkaji pengaruh pemberian biomasa ubi jalar pada karakteristik fermentasi rumen, kecernaan bahan kering dan bahan organic, serta populasi mikroba rumen domba ekor tipis. Penelitian ini menggunakan rancangan acak kelompok dengan menerapkan empat perlakuan pakan, yaitu, T0 (100% rumput gajah), T1 (70% dari rumput gajah + 30% konsentrat), T2 (50% dari rumput gajah + 50% daun ubi jalar), dan T3 (70% daun ubi jalar + 30% umbi ubi jalar) dengan tiga ulangan. Sampel cairan rumen diambil dengan metode *stomach tube* dengan menggunakan pompa vakum. Hasil penelitian menunjukkan bahwa perlakuan T3 memiliki kecernaan bahan kering dan bahan organik, konsentrasi NH3 dan VFA, dan populasi bakteri rumen lebih tinggi (P<0,05) daripada perlakuan T0 dan T1 tetapi tidak berbeda dengan perlakuan T2. Populasi protozoa dan pH rumen tidak berbeda antar perlakuan. Dapat disimpulkan bahwa penggunaan biomassa ubi jalar dapat meningkatkan kualitas fermentasi rumen domba.

Kata Kunci: Rumen, Kecernaan, Fermentasi, Domba, Biomassa Ubi Jalar

ABSTRACT

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Sweet potato plant (*Ipomoea batatas* L) is produced in Indonesia in large quantities. Sweet potato leaves and stems can be used as a source of protein and the tuber can be used as an energy source. *This* study was aimed to analyze the effect of feeding of sweet potato biomass on the rumen fermentation characteristics, digestibility of dry matter and organic matter as well as rumen microbial population of thin tail sheep. This study used a randomized block design by applying four feed treatments, i.e., T0 (100% Napier grass), T1 (70% of Napier grass + 30% concentrate), T2 (50% of Napier grass + 50% sweet potato leaves), and T3 (70% sweet potato leaves + 30% sweet potato tuber) with three replicates. Rumen fluid samples were taken with stomach tube method using a vacuum pump. Results showed that the T3 diet has higher (P<0.05) digestibility of dry matter and organic matter, concentration of NH_3 and VFA, and rumen bacterial population than those of T0 and T1diets but similar to that of T2 diet. Rumen pH and protozoa population was not different among the treatments. It can be concluded that the use of sweet potato biomass can improve the quality of rumen fermentation of sheep.

Key Words: Rumen, Digestibility, Fermentation, Sheep, Sweet Potato Biomass

INTRODUCTION

Low quality and fluctuated availability of feed may lead to low productivity of sheep. Most small holder farmers feed their sheep only by field grass regardless adequacy of the nutrients and nutrition required by sheep.

By-product of agriculture or plantations overflowing around the sheep farms may be used as an alternative good quality and cheap price feed. In Bogor, for example, are widely grown sweet potatoes producing waste that can be utilized by small holder farmers to feed their sheep. Sweet potato is widely grown by farmers because its relatively easy processing, have relatively short harvest period and resistant to drought.

In 2014, production of sweet potato in Indonesia amounted to 2,382,025 tonnes, while in West Java amounted to 471,737 tonnes and in Bogor amounted to 82,935 tonnes (CSA 2015). Sweet potato vines may be used as protein feed source containing 19.38% crude protein and 3720 Kcal/kg energy (Kebede et al. 2008), whereas the tubers can be used as an energy source with

energy content of 4156 Kcal/kg and crude protein content of 5.5% (Heuzé et al. 2015).

Results of previous studies show that the addition of sweet potato crops in napier grass-based diets may improve rate of degradation by rumen microbes and rumen fermentation which increases feed intake and animal productivity (Kariuki et al. 2001). This in vitro study was aimed to analyze effect of giving biomass sweet potato (*Ipomoea batatas* L.) on rumen fermentation characteristics and microbial rumen of sheep.

MATERIALS AND METHODS

Napier grass, sweet potato leaves, and sweet potato tubers flour were previously prepared by drying them for 2-3 days and then finely grounded. Concentrate were made by mixing coconut meal 30%, wheat pollard 15.29%, peanut meal 25%, cassava waste flour 27.08%, $CaCO_3$ 1.93%, salt 0.2%, and premix 0.5%. Treatment diets were T0: 100% grass, T1 = 70% of Napier grass + 30% concentrate, T2 = 50% Napier grass + 50% potato leaves, T3 = 70% leaf + 30% potato tubers. Nutrient content and composition of the treatments used are presented in Table 1.

Approximately 15-20 ml of rumen liquor were collected from three sheep before morning meal using a stomach tube with vaccum pump. Samples were filtered and analysed for protozoa and bacteria (Ogimoto & Imai 1981), ammonia concentration (Conway 1962), total volatile fatty acids (VFAs) using steam distillation method (GLP 1966), dry matter and organic matter digestibility (Tilley & Terry 1963), and rumen pH. Experimental design was based on a randomized complete block design using four treatments as describes above with three blocks for each treatment.

The blocks were based on three sheep that had been taken their rumen fluid. Data were analyzed using analysis of variance (ANOVA) (Steel & Torrie 1993). Any significant differences ($P<0.05$) of mean were further tested using Duncan's multiple range test. All statistical analysis were performed using SPSS software version 16.0.

RESULTS AND DISCUSSION

Rumen fermentation characteristics

Results on rumen fermentation characteristic variables were presented in Table 2. Those three treatments had no significant ($P>0.05$) effect on rumen pH. Rumen pH value has an important role in supporting rumen microbial growth. Proper rumen microbial growth leads to normal fermentation process producing VFA and NH_3 (Uhi et al. 2006). Rumen pH values in this study were in normal range around neutral, i.e., 6.93-7.00.

Those treatments significantly ($P<0.05$) affected VFA concentration. VFA value in treatment T3 (70% leaves and stems of sweet potatoes + 30% sweet potato tubers) did not differ from T2 treatment but was higher than the T1 and T0 treatment (Table 2). This is because of T3 treatment contained the highest NFE in the ration (58.91%) derived from feed energy source use, namely, sweet potato tubers. On the other hand due to the relatively low content of NFE in the ration (47.42%), T0 treatment had the lowest VFA concentration compared with other treatments (Table 2). NFE is an easily digestible carbohydrate that can be used as an energy source for livestock (Farida & Ridwan 2011). Easily digestible carbohydrates are in group of

Table 1. Chemical composition (% DM basis) of experimental diets

Nutrient	Treatment diets*			
	T0	T1	T2	T3
Dry matter (DM)	21.56	42.017	18.025	18.444
Crude protein (CP)	7.97	8.879	13.195	13.662
Ether extract (EE)	5.1	5.755	6.345	5.571
Crude fibre (CF)	26.9	22.001	21.28	11.841
Nitrogen free extract (NFE)	47.42	50.24	46.705	58.911
Ash	12.61	13.123	12.72	10.358
TDN**	54.97	58.207	62.29	74.161

Results of laboratory analyzes of Research Center for Biological Resources and Biotechnology of IPB (2015)
**Result of the calculation according to Hartadi et al. (1997)
*T0 = 100% Napier grass
T1 = 70% Napier grass + 30% concentrate
T2 = 50% Napier grass + 50% sweet potato leaves
T3 = 70% sweet potato leaves + 30% sweat potato tuber

Table 2. Effect of treatment on the rumen fermentation characteristics

Parameters	Treatment diets*			
	T0	T1	T2	T3
pH	6.97±0.06	7.00±0.00	6.93±0.06	7.00±0.00
VFA (mM)	99.94±6.46[c]	107.42±6.90[bc]	116.39±11.69[ab]	125.27±6.77[a]
NH_3 (mM)	6.89±0.44[c]	7.80±1.30[bc]	9.01±1.53[ab]	10.41±1.42[a]
IVDMD (%)	45.23±3.92[c]	47.90±1.88[c]	62.50±1.39[b]	72.29±4.60[a]
IVOMD (%)	40.25±5.95[c]	45.81±1.69[c]	61.55±1.88[b]	72.10±5.58[a]

*T0 = 100% Napier grass
T1 = 70% Napier grass + 30% concentrate
T2 = 50% Napier grass + 50% sweet potato leaves
T3 = 70% sweet potato leaves + 30% sweat potato tuber
Different superscript within the same row shows significant (P<0.05) difference

polysaccharide starch. Starch in rumen will be hydrolyzed into monosaccharide by rumen microbial enzymes and further fermented into VFA such as acetate, propionate, and butyrate, and gases of CH_4 and CO_2. Total VFA concentration in this study was slightly lower than that of the finding of Puastuti et al. (2012) that was 122.5-190.3 mM. VFA production of a feedstuff reflects its fermentability level. VFA produced was higher along with higher fermentability level of a feedstuff.

Those three treatment also had a significant effect (P<0.05) on the concentration of NH_3. Concentration of NH_3 result had the same pattern as the VFA result. Concentration of NH_3 in treatment T3 (70% leaves and stems of sweet potatoes + 30% sweet potato tubers) did not differ from that of T2, but was higher than those of T1 and T0 treatments (Table 2). This figure caused by protein content in rations T3 was the highest (13.66%) compared to other treatments (Table 1). Feed protein undergoes hydrolyisis into oligopeptide by proteolytic enzymes. Oligopeptides were then undergo deamination and converted into an amino acid producing NH_3. High crude protein content in feed will produce high NH_3. Concentration of ammonia in the rumen depends on protein content of feed. Quality of protein in the diet may also affect the concentration of ammonia. Large quantities of low quality protein would not be beneficial, because most of the protein would be degraded by rumen microbes into ammonia. Excess of ammonia will be discarded through urine causing low efficiency of protein utilization. T0 treatment contained the lowest crude protein (7.97%), therefore produced the lowest NH_3 concentration compared to other treatments. NH_3 concentration of all treatments in this study were comparable with the results of Puastuti et al. (2012) showing that NH_3 concentration of sheep fed napier grass and supplemented with rumen undegradable protein ranged from 7.4 to 9.4 mM.

Digestibility of dry matter and organic matter

Those three treatments significantly (P<0.01) affected digestibility of dry matter and organic matter. Digestibility of dry matter and organic matter of T3 treatment (70% leaves and stems of sweet potatoes + 30% sweet potato tubers) was the highest compared to those T0, T1 and T2 treatment. Digestibility value of feeds was in contrast to their crude fibre content. The lower crude fiber content, the higher digestibility value of feed. Crude fibre content of T3 treatment was the lowest followed by treatment of T2, T1, and T0, i.e., 11.8%, 21.3%, 22.0% and 26.9%, respectively. Results were in line with the results of Aregheore (2004) showing that sweet potato had digestibility more than 62%.

Digestibility value of T1 treatment was not significantly different from the digestibility value of T0 treatment (Table 2). This clearly shows that the addition of 30% concentrate on the treatment T1 could not increase digestibility value of feed. Digestibility value in T0 treatment (fed only grass) was the lowest compared to that of other treatments (Table 2). It was caused by the high crude fiber content of elephant grass in the T0 ration, i.e., 26.9%, where the crude fiber is a component that is difficult to be digested.

Rumen microbial population

Population of ruminal bacteria and protozoa in this study were presented in Table 3. High number of bacterial populations on T3 treatment was followed by increase of concentration of VFA and NH_3. This indicates that bacteria on the T3 treatment were capable in utilizing VFA and ammonia from feed degradation for their growth. In turn, it produces more bacterial population that may accelerate fermentation process of feed. So that, VFA and NH3 results will also increase.

Table 3. Effect of treatment on the rumen microbial population

Parameters	Treatment diets*			
	T0	T1	T2	T3
Bacteria (Log CFU ml^{-1})	8.29±0.02^c	8.35±0.01^b	8.37±0.04^{ab}	8.42±0.02^a
Protozoa (Log cell ml^{-1})	6.39±0.09	6.36±0.09	6.35±0.10	6.30±0.09

*T0 = 100% Napier grass
T1 = 70% Napier grass + 30% concentrate
T2 = 50% Napier grass + 50% sweet potato leaves
T3 = 70% sweet potato leaves + 30% sweat potato tuber
Different superscript within the same row shows significant (P<0.05) difference

The results was supported by Siwaporn et al. (2010) who reported that in cattle producing high VFA and in buffalo producing high N-NH$_3$, the ruminal bacteria population was high. Increase of VFA amount may be caused by the presence of amylolytic and cellulolytic bacterial population that is capable to degrade fiber and starch in feed into VFA. Bacterial population of T0 (100% grass) was the lowest compared to that of the other treatments. This may be due to the protozoa populations of T0 treatment tend to be highest. It is well known that high population of protozoa may prey on population of cellulolytic and amylolytic bacteria. As a consequent, the VFA produced is low. The present results proved that low population of bacteria of the T0 treatment was accompanied by the low concentration of the VFA. Protozoa population in T3 treatment tended to be lower, so that T3 treatment bacterial population increased. In the T3 treatment, sweet potato leaves with its saponin content (Anthoney & Omwenga 2014) was able to lysis protozoa cell causing them to death, but saponin had no effect on bacterial cells.

Total bacteria in this experiment (19.50 x 10^7/ml - 26.30 x 10^7/ml) were lower that reported by Singh & Kundu (2011) (8.53 x 10^8/ml - 16.05 x 10^8/ml) for the sheep fed by *Dicanthium annulatum* grass based diet and supplemented with *Leucaena leucocephala* and *Hardwickia binata*. This discrepancy probably due to that many of bacteria in this experiment were eaten by protozoa, as shown by the number of protozoa in this study was higher than the protozoa reported by Singh & Kundu (2011).

The treatments did not significantly (P>0.05) affect protozoa population (Table 3). T2 and T3 treatments containing sweet potato leaves tended to have lower protozoa population than T0 and T1. There was a tendency showing that with increasing level of sweet potato leves, the protozoa population increased. This may indicate that sweet potato leaves have an anti protozoa agent. Eventhough the effect was not so strong. Sweet potato plant is known to contain anti-nutrients of saponin (Anthoney & Omwenga 2014). Saponin usually used as defaunating agents being capable to lysis protozoa cell (Wang et al. 2011). Thus higher sweet potato leaves given produces higher saponin content in the feed that is able to lysis protozoa cell in greater numbers. Sweet potato leaves contain saponin (Pochapski et al. 2011) as defaunating agent being capable in reducing protozoa population. Protozoa population of the T0 (100% elephant grass) and T1 (70% of elephant grass + 30% concentrate) tended to be higher than that of T2 and T3 treatments. T0 and T1 treatmnets did not use sweet potato leaves, so it did not contain saponin that may reduce population of protozoa. Lower rumen protozoa populations of sheep were reported by Singh & Kundu (2011) as 5.34 and 3.95 x 10^5/ml in rumen of sheep fed by *Dicanthium annulatum* grass based diet and supplemented with *Leucaena leucocephala* and *Hardwickia binata* in 75:25 ratio, respectively. Lower protozoa population of Singh & Kundu (2011) than that in this study probably due to that *Leucaena leucocephala* and *Hardwickia binata* had higher secondary compound (condensed tannin and saponin) that capable in reducing protozoa population.

CONCLUSION

Use of sweet potato biomass may improve quality of ruminal fermentation of sheep. Providing of 30% tubers and 70% leaves (T3 diet) of sweet potato afeected dry and organic matters digestibility concentration of NH$_3$ and VFA as well as bacterial population were higher than other treatments. Moreover, it had no siginifical effect on protozoa population.

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