

Degradability of Mulberry (*Morus alba*) and Rice Bran in the Rumen of Sheep Fed Different Diets

DWI YULISTIANI¹, Z.A. JELAN² and J.B. LIANG³

¹Balai Penelitian Ternak, PO Box 221, Bogor, Indonesia,

²Department of Animal Science, Faculty of Agriculture,

³Institute Bioscience, University Putra Malaysia, Serdang, Selangor 43400

(Diterima dewan redaksi 24 November 2008)

ABSTRAK

YULISTIANI, D., Z.A. JELAN dan J.B. LIANG. 2008. Degradasi hijauan murbei (*Morus alba*) dan dedak padi di dalam rumen domba yang diberi pakan yang berbeda. *JITV* 13(4): 264-272.

Penelitian dilakukan untuk mengetahui degradasi bahan kering (BK) dan protein kasar (PK) pada hijauan murbei dan dedak padi yang diinkubasikan pada beberapa periode waktu dalam kantong nilon di dalam rumen domba berfistula dalam lingkungan rumen yang berbeda. Tiga lingkungan rumen yang berbeda dibuat dengan cara domba berfistula diberi pakan dasar jerami padi terfermentasi dengan disuplementasi tiga perlakuan pakan tambahan yang berbeda yaitu: pakan kontrol (T0) (murbei dan molases); 50% dari murbei diganti dengan dedak padi dan urea (T1); dan 100% dari murbei diganti dengan dedak padi dan urea (T2). Pakan disusun secara iso protein dan iso energi. Pakan tambahan diberikan sebanyak 1,2% dari bobot hidup. Penelitian dilakukan dalam 3 periode. Untuk setiap periode, salah satu dari tiga domba fistula diberi pakan salah satu dari tiga perlakuan pakan tambahan. Setiap kantong nilon diisi sampel daun murbei yang sudah digiling atau diisi dedak padi yang kemudian diinkubasikan dalam rumen selama 48, 24, 12, 9, 6 and 3 jam dalam urutan yang terbalik. Karakteristik degradasi diperoleh dengan menganalisa data degradasi dengan menggunakan persamaan $p = a+b(1-e^{-ct})$ menggunakan program Neway. Data degradasi karakteristik BK dan PK, konsumsi pakan, NH_3-N rumen dan pH kemudian dianalisis menggunakan analisis varians (ANOVA) menggunakan program SAS. Hasil penelitian menunjukkan konsumsi bahan kering dan pH rumen tidak secara nyata dipengaruhi oleh pakan tambahan yang berbeda. Sedangkan konsentrasi amonia dalam rumen sangat dipengaruhi oleh pakan perlakuan. Pakan tambahan T1 dan T2 menghasilkan konsentrasi amonia rumen lebih tinggi dari T0. Namun konsentrasi amonia rumen dari semua pakan diatas konsentrasi minimal untuk sintesa mikroba rumen ($>5mg/100ml$). Kecepatan (konstanta c) degradasi BK dari murbei dan dedak padi pada T2 lebih rendah dari pada perlakuan yang lain. Degradasi PK hanya pada hijuan murbei saja yang dipengaruhi oleh perlakuan pakan. Degradasi PK hijuan murbei dan dedak padi termasuk tinggi ($>80\%$ sesudah 24 jam inkubasi) pada semua pakan perlakuan. Dari penelitian ini dapat disimpulkan bahwa tiga perlakuan pakan dapat menciptakan kondisi lingkungan rumen yang optimal untuk fermentasi. Suplementasi hijauan murbei ataupun dedak padi dan urea pada pakan dasar jerami padi terfermentasi memberikan pengaruh yang sama pada degradasi PK dedak padi, tetapi degradasi PK hijuan murbei menurun dalam rumen domba yang diberi pakan tambahan dedak padi dan urea (T2).

Kata Kunci: Hijuan Murbei, Dedak Padi, Degradasi, Domba

ABSTRACT

YULISTIANI, D., Z.A. JELAN and J.B. LIANG. 2008. Degradability of mulberry (*Morus alba*) and rice bran in the rumen of sheep fed different diets. *JITV* 13(4): 264-272.

The experiment was conducted to investigate degradation of dry matter (DM) and protein of mulberry and rice bran when incubated in nylon bag in the rumen at different incubation times and different rumen environments of rumen-cannulated adult sheep. Three different rumen conditions were created by feeding the three rumen-cannulated sheep with urea-treated rice straw as basal diet and offered with three supplemental treatment diets on different source of energy and nitrogen. Mulberry, urea and rice bran were used as source of fermentable energy and protein. Treatments consisted of control diet mulberry and molasses (T0); 50% mulberry was replaced by rice bran and urea (T1); and 100% of mulberry was replaced with rice bran and urea (T2). The diets were formulated in iso protein and iso energy. Supplemental diets were offered at 1.2% BW. The study was conducted in three periods. For each period, the sheep was offered with one of three supplemental treatment diets. The nylon bags each, contains sample of either mulberry or rice bran were incubated in the rumen of sheep at different incubation times in reverse order (48, 24, 12, 9, 6, and 3h). Degradation characteristic data were obtained by analyzing degradability data with the equation of $p = a+b(1-e^{-ct})$ using Neway computer package. Data of degradation characteristic, degradability of DM and CP, DMI, rumen NH_3-N and pH were subjected to analysis of variance (ANOVA) using a SAS software package. The results showed that the dry matter intake (DMI) and rumen pH were not significantly different between diets. The rumen ammonia concentration of T1 and T2 was significantly higher than that of T0. However, the rumen ammonia concentration was higher than that of critical value for rumen microbial synthesis ($>5mg/100ml$). The rate (c value) of DM degradability of mulberry and rice bran was affected by diet treatments, where T2 diet resulted in lower c of mulberry and rice bran. Only CP degradability of mulberry on the other hand was affected by diet treatments. But, both CP mulberry and rice bran had high degradability ($>80\%$ after 24 hs incubation) in all

diet treatments. It is concluded that the three diets of this study were capable of creating the optimum condition for rumen fermentation. Supplementation of mulberry or urea-rice bran mixture had similar effect on protein degradability of rice bran. On the other hand, the rate of protein degradability of mulberry was reduced when it was incubated in the rumen of sheep fed urea rice bran mix supplement.

Key Words: Mulberry, Rice Bran, Rumen Degradability, Sheep

INTRODUCTION

The sustainability of livestock production is affected by the continuous supply in quality and quantity of feeds. On the other hand availability of land for forage planting is limited due to the priority of land use is for food crops. Therefore, livestock feeds must utilize agriculture or agroindustrial by-products. On the other these by products usually have low quality due to their high content of fibre and low digestibility. This low nutritive values restrict its utilization by rumen microorganisms and consequently by the host animal. An adequate supply of N to rumen microbes is crucial to obtain maximum rate of plant cell digestion as well as a high microbial protein synthesis. Supplementation with concentrate could improve the nutritional value of low quality roughage such as straws. This concentrate however, is expensive and unaffordable by smallholder farmers. The cheaper alternative of supplements is tree foliages which have high protein content (LENG, 1997) or concentrate from agricultural by products that locally available such as rice bran.

Mulberry is potential to be used as supplement to low quality roughage diets due to its high protein content (SANCHEZ, 2002) and degradability (SADDUL *et al.*, 2005). Beside its high protein content, the degradability of its organic matter was also high (JELAN and SADDUL, 2004) hence it can supply fermentable energy in the rumen. Therefore, it can create favorable condition in the rumen for plant cell wall degrading microorganisms.

The experiment was carried out to study the degradability of mulberry and rice bran in the rumen of sheep fed different diets.

MATERIALS AND METHODS

Preparation of urea-treated rice straw

Rice straw was obtained from rice field in Tanjung Karang, Selangor, Malaysia. The straw was chopped into 5 cm and stored in plastic bags. Rice straw (94% DM) weighing 100 kg was treated by spraying 5% urea solution (1 L/kg straw DM), thoroughly mixed and filled in the black plastic bag. The air was removed by careful trampling of the bag (5 kg treated straw/bag). The sacks were tightly sealed and stored for 3 weeks. After the curing period, the treated straw was evenly

spread on a concrete floor for 1 day to allow the excess ammonia to evaporate before feeding to the animals.

Mulberry

Mulberry grown at the experimental plot of the Department of Animal Science, University Putra Malaysia, Serdang, Selangor, Malaysia, was harvested 5-7 weeks after previous harvest. Foliage was air-dried under shed for 3 days, chopped to about 5 cm length using electric chopper, further air-dried for 2 days and stored in bags. At this stage the DM content of mulberry was approximately 90%.

Samples preparation

Mulberry foliage was harvested at 5-7 weeks after previous harvest, then was air dried under shed for 5 days before it was ground through 1mm sieve. The rice bran was purchased from animal feed shop. The rice bran and ground mulberry samples were used for *in situ* study.

Animals and feeding

Three Santa Ines crossbred rams with average body weight of 35.0 ± 5.0 kg were used to determine the *in situ* rumen degradability of mulberry and rice bran. All animals were fitted with a rumen fistula, housed in individual pen and fed twice daily (09:00 and 17:00 h) in equal portions. Three different rumen conditions were created by feeding the three rumen-cannulated sheep with urea-treated rice straw as basal diet and offered with three supplemental treatment diets in different source of energy and nitrogen. In this study mulberry, urea and rice bran were used as source of fermentable energy and protein. The 3 dietary treatments were: T0: treated rice straw (TRS) basal diet + mulberry and molasses supplements (as control); T1: TRS basal diet + 50% mulberry replacement with urea-rice bran mixture; and T2: TRS basal diet + total mulberry replacement with urea-rice bran mixture.

The diets were formulated in iso-nitrogenous and iso-energetic (containing a calculated CP of 11.4% and ME of about 8.32 MJ/kg, respectively). The supplements were offered at 1.2% of body weight (BW) while rice straw offered at *ad libitum*. Water and mineral licks were available at all time. Table 1 shows

Table 1 Ingredients and chemical composition of experimental diets

Feed ingredients	Diet		
	T0	T1	T2
Urea-treated rice straw (%)	57.1	57.1	57.1
Mulberry (%)	38.1	19.1	0
Molasses (%)	4.8	4.8	4.8
Urea (%)	0	0.7	1.3
Rice bran (%)	0	18.3	36.8
Calculated chemical composition			
Energy (ME MJ/kg)	8.4	8.3	8.3
Protein (%)	11.4	11.5	11.4

T0 = mulberry and molasses supplements

T1 = 50% of mulberry was replaced urea-rice bran mixture

T2 = all mulberry was replaced by urea-rice bran mixture

ME = Metabolisable energy

the ingredients and chemical composition of the three dietary treatments. The experiments were carried out for three consecutive periods. Three diets were assessed simultaneously in different animals for each period. Before samples were incubated in the rumen, the sheep were given two weeks adjustment period to stabilize intake of the diet and during this period its feed consumption was measured. During the incubation period, feed offered was reduced to 80% of the *ad libitum* intake to ensure that all feed were consumed.

Rumen *in situ* degradation

Approximately 5 g of mulberry and rice bran were weighed and transferred into nylon bag (size 6x12 cm) with an average pore size of 45 μ m (International Feed Resource Unit, Aberdeen, UK). The samples were prepared in duplicate. All nylon bags were dip into the water for 5 minutes to exclude air and then inserted into the rumen of each cannulated sheep in reverse order for 48, 24, 12, 9, 6, and 3h for each, rice bran and mulberry. After incubation, all the bags, including the 0 h bags were removed and immediately rinsed under running tap water, subsequently washed in a washing machine and dried in air-forced oven at 60°C for 72 h to determine DM disappearance. Duplicate samples were pooled for chemicals analysis. Rumen fluid from each animal was sampled from fistula at 0, 2, 4 and 6 h after morning feeding. Rumen fluid pH was measured immediately after sampling using a portable pH meter. One drop of concentrated sulfuric acid was then added (to stop microbial activity) and the fluid was later centrifuged at 3000 g for 10 min. After centrifugation,

10 ml of each supernatant was kept in air tight container and stored at -20°C pending analyses of NH₃-N.

Chemical analyses

The feed offered and residues of mulberry and rice bran after incubation were analyzed for DM and CP (AOAC, 1990). NH₃-N was determined by steam distillation and titration method.

Degradability calculation

In situ degradation for DM, NDF and CP was analyzed using the non-linear model (ORSKOV and MCDONALD, 1979). The equation was $p = a + b(1 - e^{-ct})$ where p is the amount of nutrient degraded (%) at time t , a is the intercept of the degradation curve at time zero and represent as degradability of soluble fraction (%), b is the rumen-insoluble, but slowly degradable fraction (%), c is the rate constant for degradation of the b fraction (%/h) and t is the incubation time (h). The calculation of the equation was carried out using the NEWAY program (CHEN, 1996).

Statistical analyses

Data on dry matter intake (DMI), rumen parameters and degradation constants from the *in situ* study was analysed using GLM procedure of Latin Square (SAS 1990 v 6.2). The model included effects of diets, animal and period.

RESULTS AND DISCUSSION

Dry matter intake and rumen parameters

Table 2 shows dry matter intake (DMI) of sheep fed on different supplements. It shows that different supplements did not affect DMI. The initial diet was formulated to contain rice straw 57.1% (Table 1) and the rest were supplements that consisted of either mulberry and molasses (T0) or partially mulberry (T1) or totally replaced by urea rice bran mix (T2) in iso-energetic and iso-nitrogenous composition (Table 1). However, in the feeding trial the straw was offered *ad libitum* but the supplements was offered in a fixed amount at 1.2% BW. This was carried out to study the effect of different dietary supplementations on the increasing intake of basal diet of urea-treated rice straw (TRS). Since the supplement was given before straw and in limited amount therefore the supplements were eaten in few minutes, hence the residue from the feeding was only from urea treated rice straw, which was in the form of tough stem or straw root.

Supplementation of either mulberry or mulberry replaced partially or totally with urea rice bran mix could stimulate intake of TRS by 20% higher. Total DMI or straw intake was not significantly different among supplementations, indicating that different protein sources have similar effect on DMI or rice straw intake. The implication of this finding is fermentable nitrogen supplementation can be derived from either urea or mulberry foliage that provides high degradable protein. Rumen degradable protein supplemented in a form of non protein nitrogen (NPN or urea) at a high level has been reported to increase forage intake of low quality prairie grass (KOSTER *et al.*, 1996) and forage sorghum hay (MATHIS *et al.*, 1997). However, these studies only supply rumen degradable protein (RDP), without supplementing source of fermentable carbohydrate. On the other hand, supplementation of

fermentable carbohydrate in a form of non fibre carbohydrate such as starch (NFC) at higher amount decreased forage intake (DEL CURTO *et al.*, 1990; OLSON *et al.*, 1999; KOZLOSKI *et al.*, 2007). In contrast, when the supplementation of NFC was combined with supplementation of RDP in a form of NPN or casein (true protein) the total intake and basal diet intake was not affected (KOZLOSKI *et al.*, 2007; DEL CURTO *et al.*, 1990; HELDT *et al.*, 1999b).

In the present study, RDP and NFC were supplemented together to TRS basal diet. The source of RDP was either NPN (urea) or mulberry, whereas source of NFC was molasses, mulberry and rice bran. Protein and OM of mulberry were highly degradable in the rumen (SADDUL *et al.*, 2005). Therefore this forage is able to supply fermentable protein and energy in the rumen. Since RDP and NFC were supplied simultaneously, therefore there was no negative effect of different dietary supplementations on total DMI in the present study. This result is in agreement with the previous studies that supplementation of fermentable energy (starch, glucose of fibre) together with high degradable protein diet (DEL CURTO *et al.*, 1990; HELDT *et al.*, 1999) or cassava meal supplementation together with urea (KOZLOSKI *et al.*, 2007) did not decrease DMI. This result indicates that mulberry supplementation showed similar effect to urea and rice bran when it was supplemented at 1.2% BW or at 32% of total diet.

Table 3 shows the rumen pH and rumen NH₃-N concentration collected at 0, 2, 4 and 6 h post-feeding. The overall mean of rumen pH measured at 0, 2, 4, 6 h after feeding was not significantly different among dietary treatments, and the rumen pH range was 6.7-7.0 (Table 3), which is the optimum condition for cellulolysis (DURAND and KAWASHIMA, 1980) and greater than 5.7 for microbial protein synthesis (STEWART, 1977).

Table 2. Means of dry matter intake (DMI) and nutrients digestibility in sheep fed different supplements

Parameters	Supplements			S.E.M.
	T0	T1	T2	
Intake				
Total DMI (g/day)	727.8	768.3	773.2	38.8
Straw intake (% from total DMI)	66.4	71.0	68.6	2.22
DMI a (s % BW)	3.45	3.87	3.45	0.21
DMI (g/BW ^{0.75})	74.1	81.6	74.7	4.15

Means with different superscript in the same row are significantly different (P<0.05)

T0 : mulberry and molasses supplements

T1 : 50% of mulberry was replaced urea-rice bran mixture

T2 : all mulberry was replaced by urea-rice bran mixture

S.E.M : Standard error mean; DMI: dry matter intake

Table 3. Means of rumen ammonia nitrogen (NH₃-N) levels and rumen pH at different sampling times of sheep fed different dietary supplements

Variables	Sampling time (h)	Supplements			S.E.M.
		T0	T1	T2	
pH	0	7.0	7.0	6.8	0.05
	2	6.8	6.8	6.8	0.03
	4	6.8	6.8	6.7	0.07
	6	6.8	6.7	6.7	0.04
Average pH		6.8	6.8	6.7	0.004
NH ₃ -N (mg/100ml)	0	13.4	14.0	14.8	1.49
	2	24.5 ^b	24.1 ^b	34.2 ^a	1.78
	4	16.9 ^c	24.1 ^a	25.1 ^b	1.43
	6	16.3	18.7	18.1	1.44
Average NH ₃ -N		17.8 ^b	21.3 ^a	23.0 ^a	1.45

Means with different superscript in the same row is significantly different (P<0.05)

T0 = mulberry and molasses supplements

T1 = 50% of mulberry was replaced urea-rice bran mixture

T2 = all mulberry was replaced by urea-rice bran mixture

S.E.M = Standard error of mean.

Although mulberry was replaced by rice bran and urea, the rumen pH was similar, indicating that the replacement did not affect rumen pH. Similar result has been reported by KOZLOSKI *et al.* (2007) and MLAY *et al.* (2003) on NFC supplementation together with NPN on urea supplementation to low quality hay.

The rumen NH₃-N concentration at 0 h or before feeding was not significantly different among diets with an average of 14.0 mg N/100ml (Table 3). The NH₃-N concentration significantly increased 2 h post-feeding and that for diet T2 being the highest. Generally, ruminal NH₃-N concentration increased rapidly 1-3 h post-feeding (Arroquy *et al.*, 2004; HOOVER and STOKES, 1991). The NH₃-N concentration of T0 and T2 gradually decreased, whereas that of T1 did not decrease after 4 h post-feeding. The concentration of rumen NH₃-N in T2 was higher than that of T0 at all collection times. Previous studies have shown that NH₃-N was higher when true protein (casein and soy bean cake) was replaced by urea, which caused excess of NH₃-N concentration in few hours after feeding (ARROQUY *et al.*, 2004; MLAY *et al.*, 2003). This due to urea was rapidly degraded in the rumen up to 3 hrs post feeding. Although the recommended minimum rumen NH₃-N concentration for rumen microbial growth is 5 mg/100ml (SATTER and SLYTER, 1974), but higher values (10 – 20 mg/100ml) had been recommended (PRESTON and LENG, 1987; PERDOK and LENG, 1990) to optimize degradation of fibrous feed.

Ruminal degradability of mulberry and rice bran

Table 4 shows DM degradation characteristics of mulberry and rice bran incubated in the rumen of sheep fed different supplements. There was significant effect of different diets on dry matter degradability of mulberry, where diet T0 resulted in significantly higher (P<0.05) rate (c) of DM degradability. However, DM degradability of insoluble fraction (b) was significantly higher (P<0.05) in diet T2. The fastest DM degradability of mulberry occurred from 3 to 12 h incubation (Figure 1).

DM degradability of rice bran in the rumen of sheep was not significantly (P>0.05) affected by dietary treatments. However, the rate of degradation (c) of b fraction was significantly (P<0.05) lower in diet T2. The degradability of water-soluble fraction (a) was not affected by diet treatments and its degradability was higher than insoluble fraction (b) (Table 4). The effective degradability of DM of rice bran was not affected by the diet treatments. The fastest DM degradability of rice bran occurred at the first 3 h of incubation (Figure 1).

The degradability of soluble fraction of mulberry was affected by dietary supplementation, where diet T0 resulted in the highest rate of DM degradability. Similarly, the rate constant (c) of DM degradability of rice bran was also higher in diet T0 than that of T2. The rate of DM degradation of rice bran was much higher

Table 4. DM degradation characteristics of mulberry and rice bran incubated in the rumen of sheep fed different dietary supplements

Samples	Degradation constant	Supplements			S.E.M.
		T0	T1	T2	
Mulberry	<i>a</i> (%)	34.6 ^p	33.5 ^{pq}	30.9 ^q	0.371
	<i>b</i> (%)	45.9 ^q	48.3 ^q	55.6 ^p	0.577
	<i>c</i> (/h)	0.091 ^p	0.083 ^p	0.049 ^q	0.0033
Rice bran	<i>a</i> (%)	59.1	58.7	60.4	0.256
	<i>b</i> (%)	31.6	32.0	33.3	0.375
	<i>c</i> (/h)	0.286 ^p	0.258 ^{pq}	0.130 ^q	0.017

Means with different superscript in the same row is significantly different (P<0.05)

T0 = mulberry and molasses supplements

T1 = 50% of mulberry was replaced urea-rice bran mixture

T2 = all mulberry was replaced by urea-rice bran mixture

a, b, c are degradation constant which reflected: *a*, degradation of water soluble fraction; *b*, degradation of insoluble fraction; and *c*, rate of degradation of *b* fraction

S.E.M.= standard error of mean; ns, non significant;

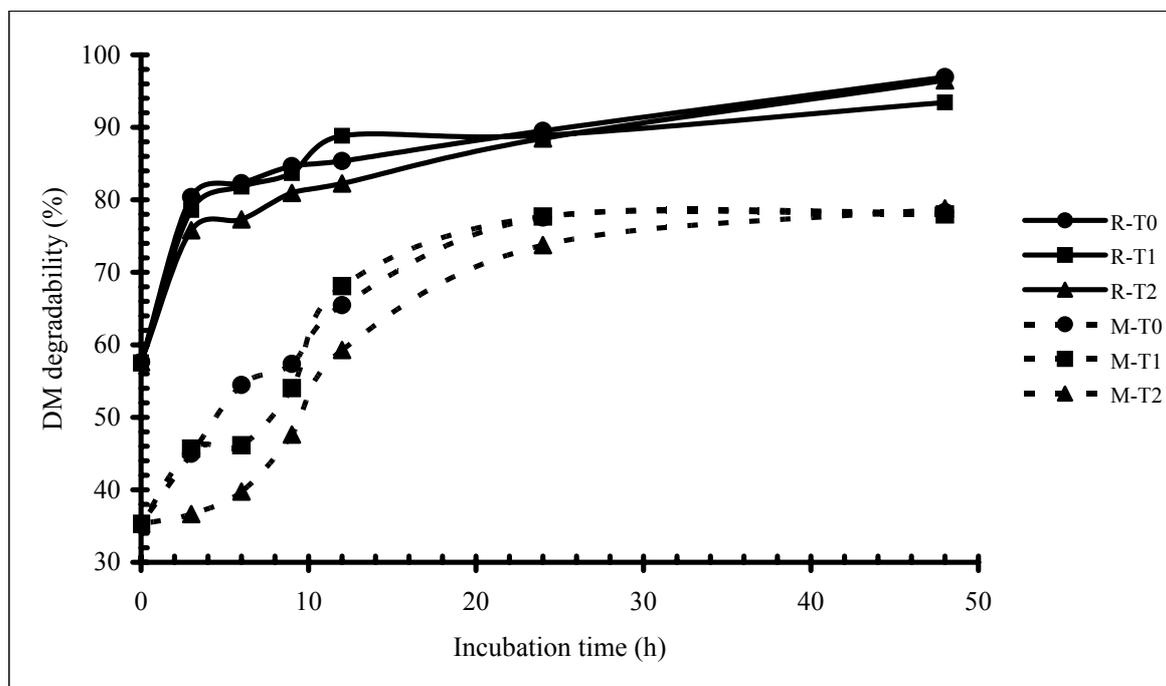


Figure 1. DM degradability of mulberry (M) and rice bran (R) incubated in the rumen of sheep fed mulberry supplement (●) 50% mulberry were replaced by urea-rice bran mixture (■) and all mulberry were replaced by urea-rice bran mixture (▲)

than that of mulberry (13-28 against 4.9-9 %/h; refer Table 4). Rice bran had higher water-soluble fraction (*a*) than insoluble fraction. This indicates that rice bran supplies immediately fermentable fraction (CONE *et al.*, 1997). This was probably caused by the lower NDF content (27%) of rice bran used in this study. The high rate of DM degradation resulted in short time (12 h) of all DM of rice bran to be degraded in the rumen (Figure

1). Similar result was also reported by ZHAO *et al.* (1996).

Table 5 shows degradation characteristics of protein of mulberry and rice bran incubated in the rumen of sheep fed different dietary supplements. Protein degradability of mulberry in the rumen of sheep was affected by type of supplements. The rate (*c*) of protein degradability of insoluble fraction was significantly

($P < 0.05$) higher in T0 than T2, but was not significantly different from T1. Degradation of protein of rice bran was not affected by dietary supplements this could be due to the higher water soluble of protein in rice bran (a) than insoluble fraction (b), where the degradation of water soluble was not affected by the enzymatic or microbial activity in the rumen which influenced by type of the diet. Protein degradability of soluble fraction was higher in rice bran than in mulberry. Protein of rice bran was almost completely degraded in the first 3 h of incubation (Figure 2).

Similar to DM degradability, protein degradability of water soluble fraction, (a) of rice bran was also higher than insoluble fraction, (b). The degradability of soluble, (a) and insoluble fraction, (b) of rice bran was not affected by the different dietary supplements. However, the rate of protein degradability was significantly higher in the T0 diet. Almost all the protein was degraded in the rumen within 12 h incubation (Figure 2). This value was higher than that obtained by KRISHNAMOORTY *et al.* (1995) who reported that protein degradability of rice bran in the rumen was 44%. This difference could be due to the differences in chemical composition or the processing of rice bran. As reported by AROSENEA *et al.* (1995), the variability of nutrient composition of by-products feedstuff selected from different areas of USA was related to the handling during processing or after

processing. Rice bran which was evaluated by KRISHNAMOORTY *et al.* (1995) was processed by solvent extraction which caused high NDF content (68.5%). The rice bran used in the present study was unprocessed and had low NDF content (27%).

Protein degradation of soluble fraction of mulberry was higher in T0 than T2 diet. However, the degradation of insoluble fraction was higher in T2 diet than other diets. On the other hand, the rate of protein degradation of insoluble fraction was faster in T0 than T2 diet (Table 5). This indicates that mulberry supplementation in the diet caused faster protein degradability of rice bran and mulberry when they were incubated in the rumen. The high rate of protein degradation in mulberry supplementation may be due to the endogenous plant protease from mulberry enriching the proteolytic bacteria and stimulates the activity of the rumen contents (THEODOROU, 1995; NUGENT *et al.*, 1983). The protein degradability of water soluble fraction of mulberry in this study was lower, whereas the degradability of insoluble fraction was higher than reported by KABI and BAREEBA (2008). These differences could be due to the differences in age of the plant, variety and cutting frequency. However, degradability of protein mulberry in T0 and T1 was similar to the value obtained by SADDUL *et al.* (2005), where mulberry was incubated in rumen-cannulated cow that was fed mulberry as the supplement.

Table 5. CP degradation characteristics of mulberry and rice bran incubated in the rumen of sheep fed different supplements

Samples	Degradation constant (%)	Supplements			S.E.M.
		T0	T1	T2	
Mulberry	a (%)	37.0 ^p	35.2 ^{pq}	31.2 ^q	0.64
	b (%)	60.5 ^q	66.0 ^q	74.5 ^p	0.89
	c (/h)	0.079 ^p	0.069 ^{pq}	0.045 ^q	0.0034
Rice bran	a (%)	61.2	61.3	61.8	0.10
	b (%)	31.4	30.7	32.5	0.40
	c (/h)	0.99	0.54	0.37	0.1027

Means with different superscripts in the same row are significantly different ($P < 0.05$)

T0 = Mulberry and molasses supplements

T1 = 50% of mulberry was replaced urea-rice bran mixture

T2 = All mulberry was replaced by urea-rice bran mixture

S.E.M = Standard error of mean

a, b, c are degradation constant which reflected

a = degradation of water soluble fraction

b = degradation of insoluble fraction

c = rate of degradation of b fraction

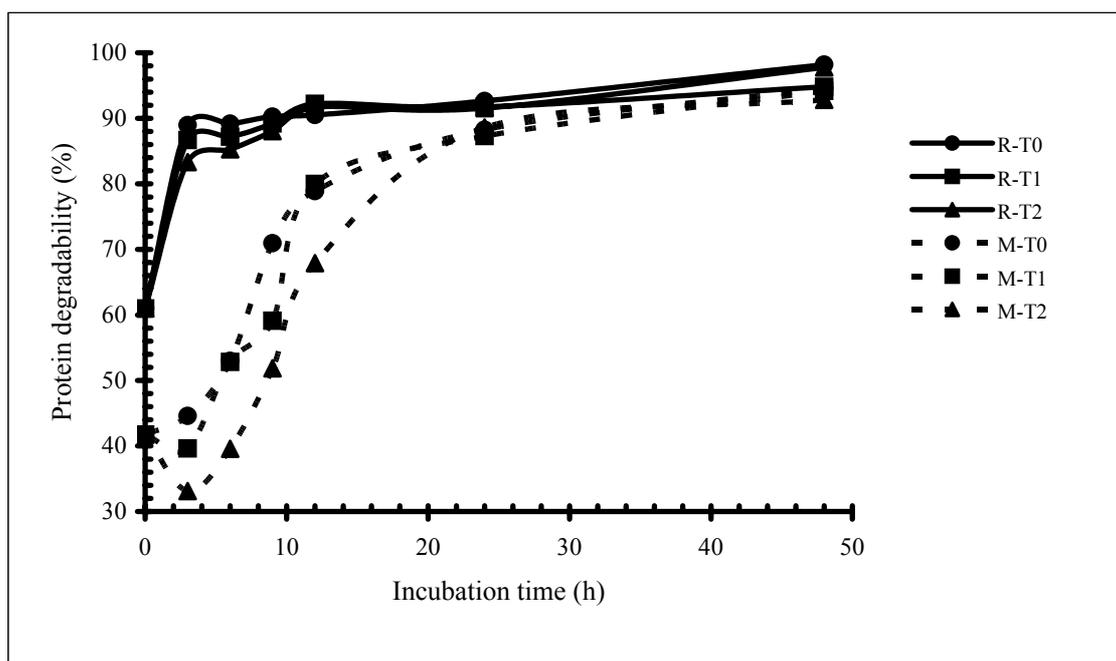


Figure 2. Protein degradability of mulberry (M) and rice bran (R) incubated in the rumen of sheep fed mulberry supplement (●) 50% mulberry were replaced by urea-rice bran mixture (■) and all mulberry were replaced by urea-rice bran mixture (▲)

The degradation of protein mulberry was high (88%; Figure 2) after 24 h incubation in the rumen of sheep regardless of the differences in feeding supplement. However, the rate of mulberry protein fermentation decreased when it was incubated in the rumen of sheep fed T2 (urea rice bran mix) supplement. It has been reported that mulberry contained high amino acid (YAO *et al.*, 2000). The high degradation of protein mulberry in the rumen is a disadvantage because it will loss of its essential amino acids which are needed for tissue synthesis in high producing ruminants (growing, pregnancy, and lactating). In addition, fermentation of readily digestible feeds result in the loss of 20% metabolisable energy as heat and methane (PRESTON and LENG, 1987). The current study shows that N requirement for effective rumen environment can be supplied from urea (T2) or mulberry (T0). Therefore attempt to reduce protein degradability in the rumen is needed without sacrificing the efficiency of rumen ecosystem.

CONCLUSIONS

Mulberry foliage supplementation in urea-treated rice straw based diet provides fermentable energy and fermentable protein as indicated by similar effect of rice bran and urea supplementation on the DMI and creating efficiency of rumen ecosystem.

Supplementation of mulberry or urea-rice bran mixture had similar effect on protein degradability of rice bran. On the other hand, the rate of protein degradability of mulberry was reduced when it was incubated in the rumen of sheep fed urea rice bran mix supplement.

REFERENCES

- AOAC. 1990. Association of Official Analytical Chemist, Official Method of Analysis. 12th Edition. AOAC, Washington. USA.
- AROSEMENA, A., E.J. DEPETERS and J.G. FADEL 1995. Extent of variability in nutrient composition within selected by-product feedstuffs. *Anim. Feed Sci. Technol.* 54: 103-120.
- ARROQUY, J.I., R.C. COCHRAN, T.A. WICKERSHAM, D.A. LLEWELLYN, E.C. TITGEMEYER, T.G. NAGARAJA and D.E. JOHNSON. 2004. Effects of type of supplemental carbohydrate and source of supplemental rumen degradable protein on low quality forage utilization by steers. *Anim. Feed Sci. Technol.* 115: 247-263.
- CHEN, X.B. 1996. An Excel Application Program for Processing Feed Degradability Data. User Manual, Rowett Research Institute, Buchsburn, Aberdeen, UK.
- CONE, J.W., A.H. VAN GELDER and F. DREIHUIS. 1997. Description of gas production profiles with a three-phasic model. *Anim. Feed Sci. Technol.* 66: 31-45.

- DEL CURTO, T., R.C. COCHRAN, D.L. HARMON, A.A. BEHARKA, K.A. JACQUES, G. TOWNE and E.S. VANZANT. 1990. Supplementation of dormant tall grass-prairie forage: I. Influence of varying supplemental protein and (or) energy levels on forage utilization characteristics of beef steers in confinement. *J. Anim. Sci.* 68: 515-531.
- DURAND, M. and R. KAWASHIMA. 1980. Influence of minerals in rumen microbial digestion. *In: Digestive Physiology and Metabolism In Ruminants*. Y. Ruckebusch and P. Thivend (Eds.). MTP Press, Lancaster UK. pp. 375-408.
- HELDT, J.S., R.C. COCHRAN, C.P. MATHIS, B.C. WOODS, K.C. OLSON, E.C. TITGEMEYER, T.G. NAGARAJA, E.S. VANZANT and D.E. JOHNSON. 1999. Effects of level and source of carbohydrate and level of degradable intake protein on low-quality tall-grass prairie hay by beef steers. *J. Anim. Sci.* 77: 2846-2854.
- HOOVER, W.H. and S.R. STOKES. 1991. Balancing carbohydrate and proteins for optimum rumen microbial yield. *J. Dairy Sci.* 74: 3630-3644.
- JELAN, Z.A. and D. SADDUL. 2004. Mulberry as feed for ruminant. Proc. International Symposium on Recent Advances in Animal Nutrition. Kuala Lumpur, Malaysia September 7, 2004. pp. 110-115.
- KABI, F. BAREEBA. 2008. Herbage biomass production and nutritive value of mulberry (*Morus alba*) and *Calliandra calothyrsus* harvested at different cutting frequencies. *Anim. Feed Sci. Technol.* 140: 178 – 190.
- KÖSTER, H.H., R.C. COCHRAN, E.C. TITGEMEYER, E.S. VANZANT, I. ABDELGADIR and G. ST-JEAN. 1996. Effect of increasing degradable intake protein on intake and digestion of low quality, tall grass-prairie forage by beef cows. *J. Anim. Sci.* 74: 2473-2481.
- KOZLOSKI, G.V., M.V. REFFATTI, L.M. BONNECARRÈRE, L.D. LIMA, R.L. CADORIN JR, C.J. HÄRTER and G. FIORENTINI. 2007. Intake and digestion by lamb as fed a low-quality grass hay supplemented or not with urea, casein or cassava meal. *Anim. Feed. Sci. Technol.* 136: 191-202.
- KRISHNAMOORTHY, U., H. SOLLER, H. STEINGASS and K.H. MENKE. 1995. Energy and protein evaluation of tropical feedstuff for whole tract and ruminal digestion by chemical analyses and rumen inoculum studies *in vitro*. *Anim. Feed Sci. Technol.* 52: 177-188.
- LENG, R.A. 1997. *Tree Foliage in Ruminant Nutrition*. Animal Production and Health Paper. No. 139. FAO.
- MATHIS, C.P., R.C. COCHRAN, B.C. WOODS, J.S. HELDT, K.C. OLSON, E.C. TITGEMEYER and E.S. VANZANT. 1997. Effects of supplemental degradable intake protein on intake and digestibility of forage sorghum hay. *J. Anim. Sci.* 75 (Suppl. 1): 94 (Abstr.).
- MLAY, P.S., A.E. PEREKA, M.R. WEISBJERG, T. HVELPLUND and J. MADSEN. 2003. Digestion and passage kinetics in fiber in mature dairy heifers maintained on poor quality hay as affected by the source and level of nitrogen supplementation. *Anim. Feed Sci. Technol.* 109: 19-33.
- NUGENT, J.H.A., W.T. JONES, D.J. JORDAN and J.L. MANGAN. 1983. Rates of proteolysis in the rumen of the soluble protein casein, fraction I (18S) leaf protein, bovine serum albumin and bovine submaxillary mucoprotein. *Br. J. Nutr.* 50: 357-368.
- OLSON, K.C., R.C. COCHRAN, T.J. JONES, E.S. VANZANT, E.C. TITGEMEYER and D.E. JOHNSON. 1999. Effects of ruminal administration of supplemental degradable intake protein and starch on utilization of low-quality warm-season grass hay by beef steers. *J. Anim. Sci.* 77: 1016-1025.
- ORSKOV, E.R. and I. McDONALD. 1979. The estimation of protein degradability in the rumen from incubation measurements weighed according to the rate passage. *J. Agric. Sci. Camb.* 92: 499-503.
- PERDOK, H.B. and R.A. LENG. 1990. Effect of supplementation with protein meal on the growth of cattle given a basal diet of untreated or ammoniated rice straw. *Asian-Aust. J. Agric. Sci.* 3: 269-279.
- PRESTON, T.R. and R.A. LENG. 1987. Matching Ruminant Production Systems with Available Resources in The Tropics and Sub-Tropics. Penambul Books, Armidale, New South Wales, Australia.
- SAS. 1989. SAS/STAT User's Guide (Release 6.12) SAS Inst, Inc. Carry, NC, USA.
- SADDUL, D., Z.A. JELAN, J.B. LIANG and R.A. HALIM. 2005. Evaluation of mulberry (*Morus alba*) as potential feed supplement for ruminants: The effect of plant maturity on *in situ* disappearance and *in vitro* intestinal digestibility of plant fractions. *Asian-Aust. J. Anim. Sci.* 18: 1569-1574.
- SANCHEZ, M.D. 2002. Annex1. Mulberry, an exceptional forage available almost worldwide. In *Mulberry for Animal Production*, ed. M.D. Sanchez. Animal Production and Health Paper. No. 147. FAO Rome, Italy. pp. 271-290.
- SATTER, L.D. and L.L. SLYTER. 1974. Effect of ammonia concentration on rumen microbial protein production *in vitro*. *Br. J. Nutr.* 32: 199-208.
- STEWART, C.S. 1977. Factors affecting the cellulolytic activity of rumen contents. *Appl. Environ. Microbiol.* 33: 497-502.
- THEODOROU, M.K. 1995. Digestion kinetics of ruminant feeds and plant enzyme mediated proteolysis in ruminants. In *Conference on Rumen Function*. 23. Chicago, Illinois November 14-16.
- YAO, J., B. YAN, X.Q. WANG and J.X. LIU. 2000. Nutritional Evaluation of Mulberry leaves as feed for ruminants. *Livest. Res. Rural Dev.* 12 (2). Available at: <http://www.cipav.org.co/lrrd/lrrd12/2/yao122.htm>. [18 juli 2007]
- ZHAO, Y., K. TANIGUCHI and T. OBITSU. 1996. Effects of different processing procedures for rice bran on dietary nutrient digestion in each segment of the digestive tract of steers. *Anim. Feed Sci. Technol.* 59: 265-277.