Rumen Parameters and Urea Kinetics in Goats and Sheep

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ABSTRACT : The effects of animal species and supplements on rumen fluid characteristics, plasma urea-N (PUN) concentration, plasma urea-N pool size, urea-N degradation in the gut and urea-N net flux (urea-N synthesis rate) were studied in goats and sheep, with some minor differences detected. The animals were fed either chopped rice straw *ad libitum*+200 g soybean meal (SBM), or chopped rice straw *ad libitum*+190 g soybean meal+300 g sago meal (SBM+SM) for 14 days. The supplements were isonitrogenous (80 g crude protein/animal/d). [^{14}C]-urea was used as the marker for urea metabolism studies. Two animals from each species were fed either supplement in a cross-over design in two periods. The results showed that rumen pH was significantly ($p<0.001$) lower in animals fed SBM+SM than those fed SBM supplement. The ammonia concentrations of rumen fluid were significantly ($p<0.01$) higher in sheep (382.9 mg N/L) than goats (363.1 mg N/L) when fed SBM supplement but lower (282.5 mg N/L) than that of goats (311.0 mg N/L) when fed SBM+SM supplement. Total VFA concentrations were significantly ($p<0.05$) higher in animals fed SBM+SM supplement than those fed SBM supplement. Goats had significantly ($p<0.01$) higher molar proportions of acetate (79.1, 77.7%, respectively) than sheep (75.8, 74.0%, respectively) in both supplements. The molar proportion of acetate was significantly ($p<0.05$) higher, while that of butyrate lower in animals fed SBM supplement than those fed SBM+SM supplement. In animals fed SBM supplement, the molar proportion of propionate was significantly ($p<0.01$) higher in sheep (18.0%) than in goats (15.6%), but in animals fed SBM+SM, the molar proportion of butyrate was significantly ($p<0.01$) higher (9.6%) in sheep than in goats (7.2%). Plasma urea-N concentration, plasma urea-N pool size, urea-N degradation in the gut, urea-N net flux and the fraction of urea-C from the blood entering the rumen were not significantly different between goats and sheep fed either supplement. However, PUN concentration was significantly ($p<0.05$) lower in animals fed SBM+SM supplement (average of 13.8 mg N/100 ml) than in those fed SBM supplement (average of 16.5 mg N/100 ml). The urea net flux was significantly ($p<0.05$) higher in goats (average of 14.5 g N/d) than sheep (average of 12.9 g N/d), and animals fed SBM supplement showed higher (average of 14.9 g N/d) urea net flux than animals fed SBM+SM supplement (average of 12.9 g N/d). A significant ($p<0.05$) positive correlation was observed between urea-N net flux and urea-N degradation; urea-N net flux and pool size; urea-N net flux and urea excretion in the urine; and PUN and rumen ammonia in goats. While in sheep, significant ($p<0.05$) positive correlation was observed between urea-N net flux and urea excretion in the urine; and PUN and rumen ammonia. (*Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 7 : 922-928*)

Key Words : Goats, Sheep, Rumen Parameters, Urea Kinetics

INTRODUCTION

Agricultural by-products typical in Malaysia, like rice straw, oil palm fronds and empty fruit bunches, are important sources of feed materials for ruminants, although they are usually low in nitrogen content. However, the animals are capable of survival even when fed these low nitrogen diets. This is possible because of the ability of the microbes within the rumen to synthesise protein required by the animals. In low nitrogen diets, endogenous urea recycling into the rumen may contribute a considerable proportion of the nitrogen required by the microbes to synthesise amino acids in the rumen (Nolan, 1993).

The indigenous goats (*Capra hircus*) and sheep (*Ovis aries*) in Malaysia are known as Kambing Katjang and Malin, respectively, and they are usually reared on small farms, primarily for mutton. It has been suggested that goats are better than sheep in digesting most of the nutrients, including fibre, when the animals are fed low-quality roughage diet (Devendra, 1978). There is little comparative information on nitrogen metabolism for goats and sheep in the tropical region. The information may contribute further understanding on the digestion and the relative use of feeds in the two animal species.

The objective of this study was to compare the rumen fluid characteristics, plasma urea-N concentration, pool size, urea-N degradation in the gut (urea transfer into the gut), urea-N flux (urea-N synthesis rate) and urea-N excretion in urine between goats and sheep fed rice straw+soybean meal (*Glycine max.* Merr.) and rice straw+soybean meal+sago meal (*Metroxylon sagu*).

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Table 1. Chemical composition of soybean meal (SBM) and soybean meal+sago meal (SBM+SM) supplements offered (g/animal/day, unless otherwise stated)

Composition	SBM	SBM+SM
Dry matter	191	445
Crude protein	80	80
Organic matter	165	423
Crude fiber	11	25
Ether extract	8	11
Neutral detergent fiber	40	102
Acid detergent fiber	15	38
Gross energy (MJ/animal/d)	3.5	7.4

MATERIALS AND METHODS

Animals and diets

Four male local goats (Kambing Katjang) and four male local sheep (Malin), about one-year-old, weighing 25-35 kg were used. Each animal was fitted with a rumen fistula. The animals were housed in single pens and were dewormed (Dectomax) and given multivitamins (Stress-Vitam) by injection. Before the experiments, they were transferred to individual metabolism cages to facilitate faeces and urine collection. Each metabolism cage was fitted with food and water containers.

The animals were fed daily with chopped rice straw *ad libitum* at 110-120% of the previous day's intake. The amount consumed was monitored daily by weighing the amount of rice straw offered and the amount refused. The animals were supplemented with either 200 g (fresh weight) soybean meal (SBM) or 190 g (fresh weight) soybean meal+300 g (fresh weight) sago meal (SBM+SM) per day. Soybean meal was added to allow an adequate amount of protein for maintenance, while sago meal was included in the diet for studying the effect of soluble carbohydrate on nitrogen metabolism. The chemical composition of each diet is given in table 1.

The experiments were divided into two periods. Each period was 14 days. During the first period, two goats and two sheep were fed SBM supplement, while the other two goats and two sheep were fed SBM+SM supplement. The supplements were crossed over in the second period.

Experimental procedures

1) Rumen fluid characteristics

For the rumen fluid characteristics study (pH, VFA and ammonia concentrations), the rumen fluid was sampled before feeding (0 h) and at 3, 6, 9, 12 and 24 h after the onset of feeding.

2) Urea kinetics study

[^{14}C]-urea stock solution was prepared by dissolving 0.25 μCi ^{14}C-urea in 8 ml sterile saline solution (0.15 M NaCl) containing 50 mg urea (as carrier) to give a solution of 31 μCi : 6.25 mg urea/ml.

The animal was dosed once intravenously with [^{14}C]-urea (1.4 μCi : 0.28 mg urea/kg) in the morning before feeding. The tracer was injected directly into the right jugular vein. A catheter was inserted into the left jugular vein on the day before [^{14}C]-urea administration and maintained patent with sterile heparin solution.

Blood samples (15 ml) were withdrawn from the catheter at 0.5, 1, 2, 3, 5, 7, 10, 15 and 24 h after injection. The blood sample was injected directly into a 15 ml vacuumed Venoject tube containing 90 USP unit of sodium heparin and mixed well. The heparinised blood was centrifuged at 500× g for 30 min and the plasma stored at -20℃ until used.

Rumen fluid was withdrawn for the isolation of CO_2 at similar time intervals as the blood sampling times. Total urine was collected into acid (concentrated H_2SO_4) for three days for urea analysis.

3) Sample analyses

Total concentrations of volatile fatty acids (VFA) and molar concentrations of acetic, propionic and butyric acids were determined by Gas Chromatography (Shimadzu GC-14A) using a Thermo 3000 5%, Shincarbon A 60/80 column. Ammonia was determined by using the Gerdhardt Vapodest autodistillator.

Urea in plasma and urine samples was determined by using the Roche urea test kit. The isolation of CO_2 from the rumen fluid (in the form of bicarbonate) was carried out following the method described by IAEA (1985). The radioactivity in plasma and rumen samples (isolated bicarbonate) was counted in a liquid scintillation counter (LS-6000 Beckman) according to the procedures described by IAEA (1985).

4) Calculation

The specific radioactivities (SR) of urea-C and bicarbonate-C at various sampling times after tracer injections were plotted for each animal. The changes

Table 2. Nitrogen intake, rumen fluid characteristics of goats and sheep fed rice straw supplemented with either soybean meal (SBM) or soybean meal+sago meal (SBM+SM)

Parameter	SBM[1]		SBM+SM		S×S[2]	Main effects	
	Goat	Sheep	Goat	Sheep		Species	Supplements
N intake (g kg/LW)	0.6 (0.07)	0.5 (0.05)	0.6 (0.05)	0.6 (0.07)	NS	NS	NS
Rumen:pH	6.45 (0.34)	6.40 (0.25)	6.13 (0.36)	6.00 (0.55)	NS	NS	***
Ammonia (mg N/L)	363.1 (17.37)[a]	382.9 (20.23)[b]	311.0 (40.52)[a]	282.5 (28.42)[b]	*	NS	**
Total VFA (mM)	117.5 (17.34)	109.9 (20.23)	119.1 (18.42)	126.1 (12.79)	NS	NS	*
Acetate (%)	79.1 (2.95)[a]	75.8 (3.91)[b]	77.7 (3.22)[a]	74.0 (2.43)[b]	NS	***	**
Propionate (%)	15.6 (2.40)[a]	18.0 (2.72)[b]	15.1 (3.62)	16.4 (1.66)	NS	**	NS
Butyrate (%)	5.3 (0.99)	6.0 (1.45)	7.2 (1.02)[a]	10.0 (2.27)[b]	**	*	*

[1] Means with different superscripts in each supplement are significantly different ($p<0.01$).
[2] Interaction between animal species and supplements.
NS=Not significantly different; * Significantly different at 5% level ($p<0.05$); ** Significantly different at 1% level ($p<0.01$); *** Significantly different at 0.1% level ($p<0.001$).
Values in parentheses are standard deviations.

in SR over time were described by curves with two exponential components. The equations were developed by Noggle (1992).

The rate of transfer of plasma urea-C to the rumen was estimated by solving a two compartment model representing plasma urea-C and ruminal bicarbonate-C (Depocas & DeFreitas, 1970). The rate of urea movement into the gut (rate of urea degradation) was calculated by subtracting the rate of urinary urea excretion from the rate of endogenous urea synthesis (rate of irreversible loss).

5) Statistical analyses

Effects of sampling times, animal species, supplements and periods on feed intakes, rumen fermentation, concentration of plasma urea-N (PUN), urea pool size, urea-N excretion in the urine, fraction of urea-C from blood that enters the rumen and rate of urea degradation were analyzed by two way analysis of variance using the SAS computer program (SAS, 1989). Treatment means were compared by the least significant difference method. Regression analyses were also carried out with different pairs of parameters observed in the urea kinetics study. The effect of period was not significant for all the results obtained.

RESULTS

The nitrogen intake, rumen pH, ammonia and total VFA (acetate, propionate and butyrate) concentrations of goats and sheep are presented in table 2. Nitrogen intake was similar between animal species and between supplements.

Animals fed SBM+SM supplement showed significantly ($p<0.001$) lower rumen pH values than those fed SBM supplement. There was a significant interaction ($p<0.05$) between animal species and supplements for rumen ammonia. The ammonia concentrations of rumen fluid were significantly ($p<0.01$) different between goats and sheep fed each supplement. The ammonia levels of rumen fluid of sheep were higher (382.9 mg N/L) than that of goats (363.1 mg N/L) when fed SBM supplement but lower (282.5 mg N/L) than that of goats (311.0 mg N/L) when fed SBM+SM supplement. In the main effect analysis, animals fed SBM supplement had significantly ($p<0.01$) higher ammonia levels than those fed SBM+SM supplement.

Total VFA concentrations were not significantly different between the two animal species fed either supplement. However, total VFA concentration was significantly ($p<0.05$) higher in animals fed SBM+SM than in those fed SBM supplement.

Goats fed either SBM or SBM+SM supplement had significantly ($p<0.01$) higher molar proportions of acetate (79.1, 77.7%, respectively) than sheep (75.8, 74.0%, respectively). The molar proportion of acetate was also affected by supplements. Animals fed SBM supplement produced significantly ($p<0.01$) higher concentrations of acetate than those fed SBM+SM supplement. The molar proportion of propionate was significantly ($p<0.01$) higher in sheep (18.0%) than in goats (15.6%) when fed SBM supplement, but there was no significant difference between animal species when fed SBM+SM supplement. There was a significant ($p<0.01$) interaction between animal species and molar percentage of butyrate. The molar proportion of butyrate was significantly ($p<0.01$) higher in sheep (10.0%) than in goats (7.2%) when fed SBM+SM supplement, while the difference in molar proportion of butyrate between animal species was not significant when fed SBM supplement. In the main effect analysis, sheep had significantly ($p<0.05$) higher molar proportion of butyrate than goats, and animals fed SBM+SM had higher molar proportion of butyrate

Table 3. Urea metabolism in goats and sheep fed rice straw supplemented with either soybean meal (SBM) or soybean meal+sago meal (SBM+SM)

Parameter	SBM[1]		SBM+SM		SxS[2]	Main effects	
	Goat	Sheep	Goat	Sheep		Species	Supplements
Plasma urea (mg N/100 ml)	15.90 (2.21)	17.07 (1.59)	13.74 (1.39)	13.78 (2.18)	NS	NS	*
Pool size (g N)	2.86 (0.73)	3.35 (0.81)	2.74 (0.36)	2.61 (0.54)	NS	NS	NS
Net flux (g N/d)	15.00 (1.41)	13.89 0.92)	13.88 (1.08)	11.83 (2.28)	NS	*	*
Urea excretion in urine (g N/d)	4.13 (0.98)	5.00 (0.97)	4.14 (0.84)	3.14 (1.50)	NS	NS	NS
Urea degradation (g N/d)	10.87 (1.41)	8.89 (0.92)	9.75 (1.38)	8.69 (1.71)	NS	NS	NS
Fraction of urea from blood to rumen (% N)	3.88 (0.28)	3.56 (0.89)	3.47 (0.44)	2.84 (0.49)	NS	NS	NS

[1] Means with different superscripts in each supplement are significantly different ($p<0.01$).

[2] Interaction between animal species and supplements.

NS=Not significantly different; * Significantly different at 5% level ($p<0.05$).

Values in parentheses are standard deviations.

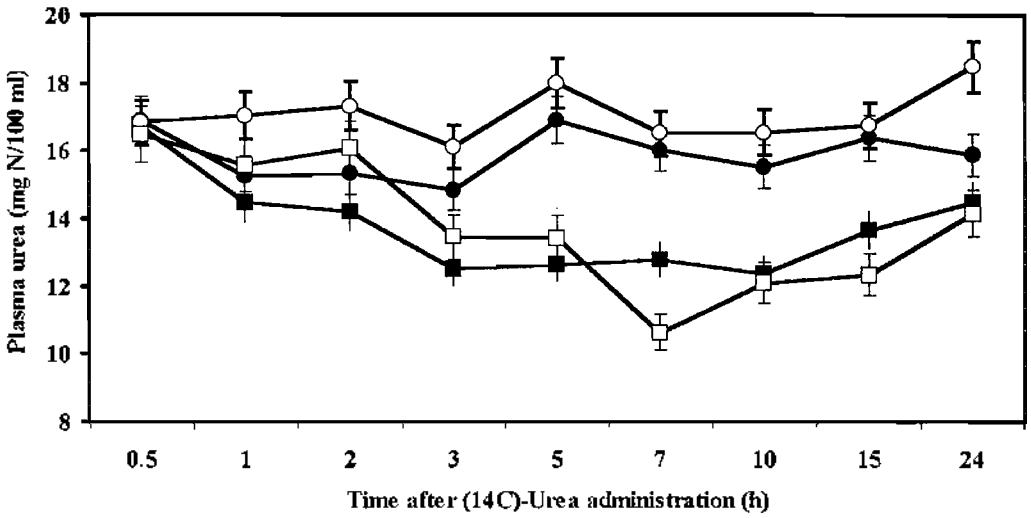

Figure 1. Plasma urea-N concentration in goats and sheep fed either SBM (● and ○ for goats and sheep, respectively) or SBM+SM (■ and □ for goats and sheep, respectively) supplement at different sampling time after (^{14}C)-urea administration

than those fed SBM supplement.

The results on the concentration of urea-N in the plasma (PUN), urea-N pool size, net flux (estimates of urea synthesis rate), urea-N excretion in the urine, urea-N degradation in the gut and the fraction of urea-C from the blood entering the rumen are presented in table 3. There were no significant differences between goats and sheep fed either supplements in all these parameters. However, in the main effects analyses, PUN concentration was significantly ($p<0.05$) affected by supplement. Animals fed SBM+SM supplement had significantly ($p<0.05$) lower PUN concentrations (average of 13.8 mg N/100 ml) than animals fed SBM supplement (average of 16.5 mg N/100 ml). Figure 1 shows the changes in PUN concentrations of both goats and sheep fed either supplement. Animals fed SBM+SM supplement showed a steady decrease in PUN concentrations until 10 h, and then an increase at 15 and 24 h of sampling. Animals fed SBM supplement, showed less variations in PUN concentrations with time.

The net flux was significantly ($p<0.05$) affected by species and supplements. Goats seemed to synthesise more urea (average of 14.5 g N/d) than sheep (average of 12.9 g N/d), and animals fed SBM showed higher (average of 14.9 g N/d) urea synthesis rate than animals fed SBM+SM supplement (average of 12.9 g N/d).

Regression analysis was carried out by using data from each animal species. Table 4 shows the correlation coefficients of various urea kinetic parameters observed in goats and sheep. A significant

Table 4. Correlation coefficients (r) for combined data of urea kinetic parameters for goats and sheep fed rice straw supplemented with either soybean meal (SBM) or soybean meal+sago meal (SBM+SM)

Relationships	r	
	Goat	Sheep
Net flux *vs* urea degradation	0.92*	0.67
Net flux *vs* PUN[1]	0.22	0.05
Net flux *vs* pool size	0.75*	0.31
Net flux *vs* urea excretion in the urine	0.76*	0.81*
Net flux *vs* rumen ammonia	0.51	0.53
Urea degradation *vs* PUN	-0.16	-0.44
Urea degradation *vs* urea excretion in the urine	0.16	-0.02
PUN *vs* pool size	-0.23	0.27
PUN *vs* rumen ammonia	0.73*	0.76*
PUN *vs* urea excretion in the urine	-0.18	0.11
PUN *vs* N intake	0.34	0.79

[1] Plasma urea-nitrogen; * Significantly different at 5% level ($p<0.05$).

($p<0.05$) positive correlation was observed between urea-N net flux and urea-N degradation; urea-N net flux and pool size; urea-N net flux and urea excretion in the urine; and PUN and rumen ammonia in goats. While in sheep, significant ($p<0.05$) positive correlation was observed between urea-N net flux and urea excretion in the urine; and PUN and rumen ammonia. The other pairs of parameters analysed were not significantly correlated.

DISCUSSION

There was no significant difference in the rumen pH between goats and sheep. However, the rumen pH was affected by the supplements. When animals were fed SBM supplement, rumen pH was maintained within a narrower range (6.2-6.7). On the other hand, when sago meal was included in the ration, the rumen pH was maintained within a broader pH range (5.6-6.7). The addition of sago meal into the diet probably enhanced the rate of fermentation because of the rapid breakdown of soluble carbohydrate (mainly starch) from sago. According to Dixon (1985), the rumen pH tends to decrease if fermentation occurs more rapidly than absorption of end-products from the rumen. The lower rumen pH was also attributed to the higher levels of VFA in the rumen of animals fed SBM+SM supplement.

The results also showed that the concentration of ammonia in the rumen was lower in goats (363.1 ± 43.42 mg N/L) than in sheep (382.9 ± 33.76 mg N/L) when fed SBM supplement, but was higher (311.0 ± 40.52 mg N/L) in goats than in sheep (282.5 ± 28.42 mg N/L) when fed SBM+SM supplement, although the amount of N intake was the same (table 2). It is not clear why ammonia concentrations differ between animal species in different diets, but the ammonia pool in the rumen depends on the inflows (dietary and endogenous sources, including the degradation of endogenous urea) and outflows (assimilation by microorganisms and absorption and removal in digesta) of ammonia. Differences in magnitude of any of these components would result in differences in ammonia concentration (Nolan et al., 1995). The ammonia levels were also affected by supplements. The concentrations were significantly ($p<0.05$) lower in animals fed SBM+SM supplement when compared to those fed SBM supplement. This may be due to the ratio of protein and carbohydrate in the diet. A diet rich in easily available carbohydrate decreases the concentration of ammonia present in the rumen (Phillipson, 1970). The additional carbohydrate may result in a better synchrony between the availability of energy and ammonia-N for microbial protein synthesis.

Molar proportions of acetate were significantly affected by animal species and supplements (table 2). In both supplements, goats had higher molar proportions of acetate than sheep, but both animal species had lower molar proportions of acetate, and higher molar proportions of butyrate when fed SBM+SM supplement. The reason for the differences between animal species is not clear, but goats have been observed to show significantly ($p<0.05$) higher potential degradability of dry matter (*in situ*) and acid detergent fibre (*in vivo*) of rice straw when fed SBM and SBM+SM supplements (Darlis et al., 1999). This would result in a higher acetate production in goats as acetate production is associated with roughage fermentation. The shift in ruminal fermentation pattern towards higher butyrate with a concomitant decrease in acetate proportion has been associated with readily available carbohydrate fermentation (Abdullah et al., 1991). Higher rumen molar proportions of butyrate had been associated with high ciliate populations in cattle fed barley-based diets at a restricted intake (Eadie et al., 1970). Significantly ($p<0.01$) higher rumen

protozoal populations were observed in goats and sheep fed rice straw and SBM+SM supplement than those fed rice straw and SBM supplement (Darlis et al., 1998).

The differences in PUN concentration between goats and sheep on SBM supplement (15.90±2.21 mg N/100 ml vs 17.07±1.59 mg N/100 ml) and on SBM+SM supplement (13.74±1.39 mg N/100 ml vs 13.78±2.18 mg N/100 ml) were not significantly different. This is expected as PUN concentration is influenced by N intake of the animals (Hunt et al., 1987) and the N intakes of goats and sheep were found to be very similar (table 2), However, the addition of sago meal decreased the PUN concentration for both goats and sheep by 13.6% and 19.3%, respectively. As illustrated in figure 1, a marked decrease in PUN concentration was observed in animals fed SBM+SM supplement. Harmeyer and Martens (1980) had also reported a decrease in PUN concentration of animals fed a high energy diet. In the present study, a significant correlation ($p<0.05$) was found between PUN and rumen ammonia concentration ($r=0.73$ and 0.76 for goats and sheep, respectively). Ogundala (1983) had also reported a high correlation between PUN concentration and rumen ammonia concentration. The lower concentration of rumen ammonia in animals fed SBM+SM supplement may result in a lower PUN concentration. Lower rumen ammonia concentration may increase the permeability of rumen wall to transfer of urea to the rumen (Ørskov, 1992). The decrease in PUN concentration may also be the result of a higher concentration of butyrate in the rumen of animals fed this diet (table 2). Eskeland et al. (1974) reported that higher butyrate concentration in the rumen could depress PUN concentration in lambs given a high concentrate diet (218.4 g CP/kg and 2.95 Mcal/kg). High butyrate concentration may stimulate microbial activity in the keratinised layer of the rumen wall and the increase in disruption of this cell layer can result in higher rates of urea entering into the rumen fluid (Norton et al., 1982).

The net flux (urea synthesis rate) was significantly ($p<0.05$) affected by animal species. Goats synthesised significantly higher amounts of urea (average of 14.5g N/d) than sheep (average of 12.9 g N/d). The amount of urea synthesised by goats in this study was much higher than that reported by Obara and Shimbayashi (1980) for goats (8.5 g N/d) fed hay plus concentrate containing 110 g CP/kg DM and injected intravenously with ammonia. On the other hand, the values obtained from sheep in this study were lower than that (14.5 g N/d) reported by Nolan and Leng (1972), where the sheep were injected intravenously with ^{14}C-urea and fed lucerne containing 20-26% CP.

The ability of goats to synthesise higher amounts of urea than sheep would offer an advantage to the animal for urea recycling to the gut. Although the difference was not significant, goats seemed to transfer higher amounts of urea into the gut (urea degradation) than sheep (table 3). A positive significant correlation ($r=0.92$, $p<0.05$) was also observed between urea degradation rate and net flux in goats.

Harmeyer and Martens (1980) found that the quantity of urea transferred to the rumen in goats was the same as that in sheep fed a similar diet. They concluded that the quantity of urea hydrolysed in the rumen of animals fed *ad libitum* was modified by dietary factors, particularly by the crude protein content of the feed. Urea transferred to the rumen appeared to decrease when the content of crude protein in the diet was above 12%.

In this study, the urea-N net flux was significantly ($p<0.05$) higher in animals fed SBM supplement. Although the protein content of the diets was similar, the rumen ammonia of animals fed SBM supplement was significantly ($p<0.05$) higher than animals fed SBM+SM supplement. However, there was no significant correlation between net flux and rumen ammonia. Abdullah et al. (1992) had also found that urea synthesis rate (net flux) was not correlated to the rumen ammonia concentration in cattle and buffaloes fed rice straw or rice straw+molasses.

There was no significant correlation between urea degradation in the gut and PUN concentration. Similar result was also obtained by Kennedy and Milligan (1978) who reported that urea degradation in sheep fed brome grass was not correlated with concentration of plasma urea in the range of 145-250 mg N/L.

In the present study, the fraction of urea C from blood that entered the rumen was not significantly different between goats and sheep and the values were within the range observed for other ruminants fed rice straw or rice straw+molasses diets (Abdullah et al., 1992).

Urea which is synthesised within the body tissues is also excreted in the urine. Verma and Singh (1978) found that the fraction of urea synthesised that was excreted in the urine was associated closely with PUN concentration and also to a large extent with the flow rate of urine. Synthesis rate (net flux) was not correlated to PUN concentration but was significantly ($p<0.05$) correlated to urea excretion in the urine ($r=0.76$ and 0.81 for goats and sheep, respectively). The amount of urea excreted by goats and sheep (average values of 4.13 and 4.07 g N/d, respectively) was lower than that found by Nolan and Leng (1972), where 10.8 g N/d was excreted by sheep fed lucerne (20-26% CP). The difference in the results was probably due to the different N intake as it has been reported by Lindberg (1989) that higher N intake can increase urea excretion in the urine of the animals.

The results showed that only molar proportions of VFA were affected by animal species, where goats had higher molar proportions of acetate, but lower propionate and butyrate than sheep. Rumen fluid characteristics were more influenced by diets. Animals fed SBM+SM supplement showed lower rumen pH, ammonia levels and molar proportion of acetate than those fed SBM supplement, while molar proportion of butyrate was higher. Urea synthesis rate (net flux) was higher in goats than in sheep, whereas plasma urea-N and synthesis rate were reduced in animals fed SBM+SM supplement. A positive linear correlation between urea synthesis rate and urea degradation in the gut was observed in goats, but not in sheep.

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