Intake and Digestibility of Untreated and Urea Treated Rice Straw Base Diet Fed to Sheep

D. YULISTIANI[1], J.R. GALLAGHER[2] and R.J. VAN BARNEVELD[3]

[1]*Research Institute for Animal Production, PO BOX 221, Bogor 16002*
[2]*Department of Animal Science, The University of Adelaide*
[3]*Pig and Poultry Production Institute, South Australia*

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ABSTRAK

YULISTIANI D, J.R. GALLAGHER and R.J. VAN BARNEVELD. 2003. Konsumsi dan kecernaan jerami padi tanpa perlakuan dan diberi perlakuan urea untuk pakan basal domba. *JITV* 8(1): 8-16.

Jerami padi merupakan salah satu limbah pertanian yang mempunyai kualitas rendah yang disebabkan karena rendahnya kandungan nutrisi esensial seperti protein, energi, mineral dan vitamin dan juga rendahnya kecernaan dan palatabilitasnya. Oleh karena itu kualitas jerami padi perlu ditingkatkan sehingga pemanfaatannya dalam saluran pencernaan ternak ruminansia bisa ditingkatkan. Tujuan dari penelitian ini adalah untuk membandingkan pakan basal jerami padi dan jerami padi yang diberi perlakuan dengan urea untuk pakan domba. Dua belas domba Merino jantan dewasa (rataan bobot hidup 53,62 ± 3,44 kg) dikelompokkan menjadi 4 kelompok berdasarkan bobot hidup, dan dari setiap kelompok diacak untuk mendapatkan salah satu dari tiga pakan perlakuan. Pakan perlakuan terdiri dari 3 macam yaitu: Pakan 1, terdiri dari jerami padi tanpa perlakuan; Pakan 2, jerami padi dengan perlakuan urea; dan Pakan 3, jerami padi disemprot dengan larutan urea sesaat sebelum diberikan pada domba. Rancangan percobaan yang dipakai adalah rancangan acak kelompok. Jerami padi yang diberi perlakuan urea dipersiapkan dengan menyiram jerami padi yang sudah dipotong-potong disemprot dengan larutan urea sehingga didapatkan kandungan urea 4% dan kadar air 40%. Selanjutnya campuran ini dimasukkan dalam plastik diikat dan disimpan selama 6 minggu. Jerami padi yang diberi perlakuan maupun yang tidak diberi perlakuan dicampur dengan bahan pakan lain untuk mendapatkan ransum isoenergi dan isoprotein. Ransum disusun berdasarkan kebutuhan untuk mencukupi kebutuhan pokok hidup dengan acuan dari NRC. Domba diadaptasikan dengan pakan perlakuan selama 15 hari, pengamatan kecernaan dilakukan pada akhir periode adaptasi. Hasil penelitian menunjukkan konsumsi bahan kering permetabolis berat badan (DMI/$W^{0,75}$), konsumsi energi tercerna (DE) dan kecernaan dinding sel tidak berbeda nyata antara perlakuan 1 dan 2. Sedangkan kecernaan bahan kering, bahan organik, serat deterjen asam (ADF), serta retensi nitrogen tidak berbeda nyata antar perlakuan. Hanya pakan perlakuan 2 yang menghasilkan retensi nitrogen positif, sedangkan perlakuan lain negatif. Dari hasil penelitian ini dapat disimpulkan bahwa pakan jerami padi yang disuplementasi dengan hijauan legum dapat dipergunakan sebagai alternatif pakan jerami padi yang diberi perlakuan urea.

Kata kunci: Jerami padi, perlakuan urea, kecernaan, dan domba

ABSTRACT

YULISTIANI D, J.R. GALLAGHER and R.J. VAN BARNEVELD. 2003. Intake and digestibility of untreated and urea treated rice straw base diet fed to sheep. *JITV* 8(1): 8-16.

Rice straw as one of agricultural by-products has low quality due to low content of essensial nutrients like protein, energy, minerals and vitamin as well as poor palatability and digestibility. Therefore, the quality of rice straw needs to be improved in order to increase its utilization by gastrointestinal tract of ruminants. The purpose of this study is to compare untreated and urea treated rice straw as basal diets for sheep. Twelve mature Merino wethers (average body weight 53.62 ± 3.44 kg) were separated into 4 groups based on their live weight with each groups assigned three diets, that are: diet 1 untreated rice straw with high forage legume content, diet 2 urea ensiled rice straw and diet 3 rice straw sprayed with urea solution at feeding time. Diets were allocated based on a randomized complete block design. Urea ensiled rice straw was prepared by spraying chopped straw with urea solution to yield straw containing 4% urea and 40% moisture, then kept in air tight polythylene bags for 6 weeks. The untreated, ensiled and urea supplemented rice straw were mixed with other feed ingredients to provide isoenergetic and isonitrogenous diets. Diets were formulated to meet maintenance requirement according to NRC. Sheep were adapted to experimental diets for 15 days, and after adaptation period, a metabolism trial was conducted. Results reveal that dry matter intake permetabolic body weight (DMI/$W^{0.75}$), DE (digestible energi) intake and apparent digestibility of NDF (neutral detergent fibre) were not significantly different between diet 1 and diet 2. Apparent digestibility of DM (dry matter), OM (organic matter), and ADF (acid detergent fibre), as well as N retention were not significantly different between three diets. Positive result in N retention was only observed in diet 2, while others were negative. It may be concluded from this study that untreated rice straw basal diet supplemented with forage legume offer an alternative method other than urea ensiled for improving the nutritional value of rice straw as a ruminant feed on small farmer.

Key words: Rice straw, urea treated, digestibility, and sheep

INTRODUCTION

Rice straw is commonly used as a ruminants feed in tropical countries. This residues is available on most rice base farms in Indonesia and is an important source of fodder especially in the dry season. Rice straw is characterised by low protein content, mineral, and energy levels. The lower energy content of rice straw has been reported by RISTIANTO *et al*. (1998), they observed the average total digestible nutrient of rice straw were 39.13%, consequently rice straw have a poor nutritive value for ruminants (DOYLE *et al*., 1986). This low nutritive value can be improved by pre-treatment or supplementation with high quality feed.

Urea treatment is one of the various chemical treatment which has been found beneficial as it increased the nutritive value of rice straw by increasing the protein content and nutrient digestibility and palatability of rice straw, this in turn, may increase dry matter intake (WONGSRIKEAO and WANAPAT, 1985). However, the application of urea treatment by farmers in the village level may be limited due to the fact that it is labour intensive and time consuming and causes management problems (CHEVA and JAERACHI, 1987). WALLI *et al*. (1995) reported the feed back collected from farmers after field demonstartion and on-farm trials have been conducted with treatment technology the response has been positive, however the results not always sufficent for most farmer, despite the beneficial effect they observed, they also observed the constrains and the most cases the returns from this technology are marginal.

Rice straw sprayed with urea at feeding time might be an alternative means of treatment as it eliminates the long process associated with ensiling (CHEVA and JEERACHAI, 1987). In practice, supplementation with NPN (non protein nitrogen) can stimulate animal performance. However, care must be taken to avoid excessive intake of urea, as urea can be toxic when small amounts are consumed rapidly. At present, non protein supplements are not widely used by farmers in Asia because of the uncertainty surrounding the provision of urea (DOYLE *et al*., 1986). Since urea need to be fed slowly, several ways was explored to ensure an even intake of urea, one technical solution is the addition of urea in urea mollases mineral block (SHARMA *et al*., 1995). Supplementation of urea mollasses block in the rice straw basal diet increased feed intake (PURNOMOADI and RIANTO, 2002). ASTUTIK *et al*. (2002) reported that urea mollases mineral block together with rice bran and cassava supplemented to rice straw basal diet resulted in incrased body weight gain of ongole crossbred cattle at 740 g head^{-1} day^{-1}.

Feeding only rice straw generally does not provide suficient nutrient to maintain body weight of ruminant animals. Supplementation to rice straw basal diet can be done with either concentrates, roughage or both. Forage legumes supplementation have been found to be effective in improving the utilization of crop residues (RICHARD *et al*., 1994). Forage legume supplementation is more applicable, and legumes already are commonly fed to animals on small farms. This is because legumes are available near farms, are relatively cheap compared to concentrates, and, are easier to use compared to urea treatment. Forage legumes may provide useful supplements to cover the nutrient deficiencies of rice straws (VAN SOEST, 1988). NDEMANISHO *et al*. (1998) reported that dry *Leucana leucocephala* leaves can substitute up to two third of cotton seed cake as a protein source in to maize straw basal diet for weaner goat, this susbtittution did not reduce goat performance, this indicated that dry *Leucana leucocephala* leaves might reduce usage of expensive oil cakes as protein source.While sesbania supplementation to wheat straw diet for sheep at the level 20% resulted in better utilization of the diet by increasing nutriens digestibility (KHANDAKER *et al*., 1998).

An increase in protein content of the diet without balancing with energy could result in inefficient protein utilisation by animals (CLOETE *et al.,* 1983). Therefore, in the current experiment isoenergetic and isonitrogenous diets were formulated using untreated rice straw with high legume content, urea ensiled rice straw, and urea supplemented rice straw. Using these diets the objectives of this experiment were to compare these three diets in term of energy intake and apparent digestibility of nutrients, and nitrogen utilisation.

MATERIALS AND METHODS

Feeds preparations and treatments

Rice straw was chopped into 5 cm lengths prior to being subjected to various treatments. These included

Diet 1, untreated rice straw

Diet 2, urea ensiled rice straw

Diet 3, untreated rice straw supplemented with urea

Urea ensiled rice straw was prepared by spraying chopped straw with urea solution to yield treated straw containing 600g DM per kg straw and 40g urea/kg straw DM (WILLIAM *et al.*, 1984). The treated straw was then kept in air tight polyethylene bags for 6 weeks at ambient temperature (6-20°C). After 6 weeks the bags were opened and the treated straw was aerated on the floor for 24 hours prior to feeding (to reduce the smell of ammonia). The urea supplemented treatment was prepared by spraying 1 kg untreated rice straw with 200 ml urea solution 20% at feeding time.

The untreated, ensiled, and urea supplemented straws were mixed with other feed ingredients to provide isoenergetic and isonitrogenous diets. The rations were formulated using a "Take Away" computer program (BARBER, 1992). The diets were formulated to provide a maintenance ration for mature South Australian Merino wethers of 50 kg body weight. The metabolisable energy (ME) of untreated and ensiled rice straw was estimated using the following equation from MAFF (1984):

$$ME = 0.81\ (GE \times OMD)$$

where:

GE = gross energy (MJ/kgDM), and

OMD = *in vitro* organic matter digestibility

ME for other feed ingredients used in the diets was obtained from the "Take-Away" data base. The feed composition and the chemical composition of the diets is given in Table 1.

The untreated basal diet contained the highest proportion of legume compared to other diets in order to adjust the nitrogen and energy content and make it similar to the other diets. Urea was added in the urea supplemented diet to adjust nitrogen levels.

The nutrient composition, especially ME and N content of the experimental diets, (presented in table 1) were relatively similar.

Animals and management

Twelve mature Merino wethers (53.62 ± 3.44 kg) were separated into 4 groups based on their live weight with each group assigned to three diets (untreated; urea ensiled or urea supplemented diets). Diets were allocated based on a randomised complete block design. Before the experimental period, the wethers were drenched with a Valbezen-broad spectrum. During an adaptation period of 15 days, the sheep were placed in individual pens and gradually introduced to their experimental diets. Sheep were offered 1023 g DM daily of their allocated diets at 08.30 and 17.00 each day. At the conclusion of the adaptation period, the sheep were transferred to metabolism crates, designed to separately collect urine and faeces. Total faecal and urine output were collected for a seven day period. Water was available at all times.

Table 1. Ingredient and chemical composition of the experimental diets (% dry matter basis)

Fractions	Diets		
	1	2	3
Ingredients:			
Untreated rice straw	48.96	-	48.48
Ensiled rice straw	-	54.61	-
Lucerne hay	31.61	10.63	18.04
Oaten hay	-	25.31	20.04
Wheat bran	15.10	5.08	10.13
Molasses	2.39	2.41	2.40
Urea	-	-	0.48
Rockphos	1.79	1.81	0.30
Salt	0.15	0.17	0.15
Chemical composition:			
OM	85.01	86.41	86.59
N	1.52	1.51	1.48
NDF	61.88	65.86	63.71
ADF	43.13	45.51	43.38
HC	18.75	20.35	20.33
Cellulose	30.94	33.20	31.32
ME (MJ/kg)	7.04	7.00	7.05

The composition was not 100% is due to the addition of rockphos to adjust the balance of the ratio of calcium to phospor
OM: organic matter; N: nitrogen; NDF: neutral detergent fibre; ADF: acid detergent fibre; HC: hemicellulose
ME: metabolisable energy

Sample collection

Feed

Feed ingredients were collected and analysed separately. Urea ensiled rice straw was sampled every day, after the ensiled straw has been aerated for 24 hours. Sub-samples were analysed for NDF, ADF, lignin and N. For the first three analyses, the sub-samples were dried in an forced-air oven at 60^0C for 48 hours before grinding to pass through a 1 mm sieve. Sub-samples were freeze-dried before grinding and sieving, prior to N analyses.

Refusals

Feed refusal samples for analysis were collected daily during the collection period, prior to the morning feed. The residues were sub-sampled and dried in an air-forced oven at 60^0C for 48 hours before being ground through a 1mm sieve. The samples were then kept in air tight plastic containers until required for chemical analysis.

Faeces

Ten percent of the total faeces from each animal were sampled daily and retained. At the end of the collection period, faecal samples from each animal were bulked and composited. Samples were then dried in an air-forced oven at 60^0C for 48 hours, before grinding to pass through a 1mm sieve. These samples were stored in plastic containers for NDF, ADF, and lignin analysis. Fresh faeces were dried in a freeze drier, then ground through a 1mm sieve and stored in air tight containers prior to nitrogen analysis.

Urine

Urine was collected in plastic containers containing 50 ml of glacial acetic acid (MC MENIMAN *et al*., 1988) to prevent nitrogen loss during collection and storage. Ten percent of the total urine collection was sub-sampled daily, pooled on an animal basis, and stored at -20^0 C until required for analysis.

Chemical analysis and measurements

Dry matter (DM), organic matter (OM) and nitrogen (N) analysis was determined by the method of AOAC (1991). Neutral detergent fibre (NDF), acid detergent fibre (ADF), permanganate lignin and silica (insoluble ash) were determined using the methods of GOERING and VAN SOEST (1970). Hemicellulose (HC) was calculated by the difference between NDF and ADF. Cellulose was obtained from the weight loss of ADF residue, after being treated with permanganate solution and ashed at 500^0 C (GOERING and VAN SOEST, 1970). Gross energy (GE) was measured using adiabatic bomb calorimeter.

Measurement of apparent digestibility of nutrients and nitrogen balance was facilitated by total urine and faeces collection. The apparent digestibility coefficients of the nutrients were calculated using the equation.

$$\% \text{ NAD} = \frac{\text{NI} - \text{NF}}{\text{NI}} \times 100\%$$

where:

NAD = nutrient apparent digestibility
NI = nutrient intake, and
NF = nutrient in faeces

The nitrogen balance was calculated by measuring the difference between total N intake and N excretion in faeces and urine.

Statistical analysis

Digestible energy intake, apparent nutrient digestibility coefficients, and nitrogen balance values were analysed using analysis of variance of a randomised complete block design (GENSTAT 5; LAWES AGRICULTURAL TRUST, 1994). Significant differences between treatments were determined using the least significant difference tests.

RESULTS

The chemical composition of untreated and urea treated straw in Table 2 shows that urea treatment increased the nitrogen content, but there were small differences in cell wall components between untreated and urea treated straw.

Table 2. Chemical analysis of untreated and urea ensiled rice straw (% dry matter basis)

Rice straw	N	NDF	ADF	cellulose	OM	HC
Ensiled	1.43	78.93	60.04	41.08	81.31	18.89
Untreated	0.53	77.71	59.48	39.40	80.98	18.23

N: nitrogen; NDF: neutral detergent fibre; ADF: acid detergent fibre; OM: organic matter; HC: hemicellulose

Dry matter intake, digestible energy intake and apparent digestibility of the diets

The voluntary dry matter intake per metabolic weight ($DMI/W^{0.75}$) of Diet 2 was significantly higher (P<0.05) than Diet 3 (Table 3). However, there was no significant difference in $DMI/W^{0.75}$ between Diet 2 and Diet 1. DE intake of Diet 2 was significantly higher compared to Diet 3, but not significantly different from Diet 2 (Table 3).

The crude protein digestibility of Diet 2 was significantly (P<0.05) lower compared to other diets (Table 3). The HC digestibility of Diet 2 (75.6%) was significantly higher (P<0.01) than the other diets (Table 3). The cellulose digestibility of Diet 2 (66.1%) was significantly higher (P<0.05) than the other diets. The NDF digestibility of Diet 2 was not significantly different to Diet 1, but was significantly different (P<0.05) to Diet 3 (Table 3). There were no significant difference in DM, OM and ADF digestibility between diets (Table 3).

Nitrogen balance of the diets

The N intake was not significantly different between Diet 1 and Diet 2 (Table 4). However, the N intake of both these diets was significantly greater (P<0.01) than Diet 3 (Table 4). The faecal nitrogen of Diet 2 was significantly (P<0.05) higher compared to the other diets. However, N excretion from urine in animals fed on Diet 2 was significantly (P<0.05) lower compared to other diets (Table 4). There was no significant difference between Diet 1 and Diet 3 in N excretion from urine. There was no significant difference in the nitrogen retention between diets (Table 4).

Table 3. Voluntary intake, DE intake and apparent digestibility of nutrients from untreated rice straw, urea ensiled rice straw and urea supplemented rice straw

Measurements	Diets			Significance	s.e.d.
	1	2	3		
Intake :					
DMI (g/day)	892^a	930^a	772^b	*	32.8
g $DMI/BW^{0.75}$/day	45.9^{ab}	47.3^a	40.1^b	*	2.53
DE intake (MJ/day)	7.76^a	7.28^a	6.32^b	*	0.441
Apparent digestibility (% DM):					
DM	50.4	52.0	50.1	N.S.	2.94
OM	58.1	59.6	56.9	N.S.	2.65
CP	62.9^a	50.2^b	64.7^a	**	2.86
NDF	47.5^b	54.1^a	44.3^b	*	3.87
ADF	40.9	44.1	38.3	N.S.	3.91
HC	62.4^b	75.6^a	56.0^b	**	3.23
Cellulose	59.8^b	66.1^a	56.7^b	*	2.26

s.e.d.: standard error of difference
N.S.: non significant; * P<0.05; ** P<0.01; Different letters in the same row indicate significant difference (LSD 5%)
DMI: dry matter intake; DE: digestible energy; DM: dry matter; OM: organic matter;
CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; HC: hemicellulose

Table 4. Nitrogen balanced of untreated rice straw, urea ensiled rice straw and urea supplemented rice straw diets (g/day)

Description	Diets			Significance	s.e.d.
	1	2	3		
N intake	14.25a	14.42a	12.13b	**	0.325
N faeces	5.32b	7.16a	4.29c	**	0.349
N urine	9.80a	5.73b	9.23a	*	1.267
N retention	-0.87	1.52	-1.38	N.S.	1.145

N = nitrogen
s.e.d. = standard error different
N.S. = non significant; * P<0.05; ** P<0.01 different letters in the same row indicate significant difference (LSD 5%)

DISCUSSION

Urea treatment of rice straw (Table 2) resulted in increase nitrogen content by 2.7 times, this result slightly higher compared to previous experiment reported by PRASAD *et al*. (1998) which is 2.34 for urea treatment kept in bale and 2.43 kept in stack. However the increase of nitrogen content in the expriment currently reported was slightly lower compared to the result reported by AHMED *et al*. (2002). This differences could be due to method of the ensiling or the variety of rice straw as well as the nitrogen content of rice straw. YULISTIANI *et al*. (2000) reported that rice straw with low nitrogen content could benefit more from urea treatment to improve nutritive value especially nitrogen content. Urea treatment decreased slightly cell wall component previous study reported by YULISTIANI *et al*. (2000) showed that effect of urea treatment on cell wall component was not consistent.

Dry matter intake, digestible energy intake and apparent digestibility of the diets

The urea ensiled straw diet (Diet 2) and the untreated rice straw diet (Diet 1) had similar effects on DMI/metabolic weight. The apparent digestibility of cell wall components, particularly cellulose and hemicellulose, was improved in the urea ensiled straw diet. The DMI of Diet 3 was lower compared to Diet 2 in this experiment (40.1 *vs* 47.3 g/$W^{0.75}$). The greater DMI in Diet 2 may have been associated with improved palatability of urea ensiled straw (LAWLOR and O'SHEA, 1979). A similar result was obtained with wheat straw by CLOETE *et al*. (1983) and PRASAD *et al*. (1998).

Legume supplementation may have promoted an increase in the DMI of Diet 1. In the current study, total DMI and DE intake of Diet 1 (892 g/day and 7.76 MJ/day respectively) was significantly higher ($P<0.05$) than Diet 3 (772 g/day and 6.32 MJ/day respectively). This is due to the legume supplementation providing to the rumen fermentable energy (in addition to protein) in the form of available cellulose and hemicellulose, both of which are known to stimulate fibre digestion (SILVA and ORSKOV, 1988). Furthermore SILVA and ORSKOV (1988) reported that the rate of fibre digestion was significantly faster in sheep fed on supplemented legume straw. This straw could have stimulated DMI (MCMENIMAN *et al.*, 1988). MCMENIMAN *et al.* (1988) also observed that supplementation with NPN did not stimulate the rate of rumen degradability of rice straw to the extent achieved with legume straw supplementation, even though the rumen ammonia concentration may be similar in sheep fed on rice straw supplemented with urea, compared to those fed with rice straw supplemented with legumes.

In the current study the DM digestibility of Diet 2 (52.0 *vs* 50.1%) was not significantly different to Diet 1. Despite this, urea ensiled rice straw may have the advantage of greater fibre digestibility. The NDF, ADF, cellulose and hemicellulose content of the three diets were relatively similar (Table 1), however the digestibility of NDF, cellulose and hemicellulose in Diet 2 was higher than the other diets (Table 3). This is because the ammonium hydroxide which is released following ensiling with urea causes a cleavage of the alkali-labile linkages between lignin and the structural carbohydrates (HARTLEY and JONES, 1978), and such a cleavage increases the fibre degradability. Data from the current study suggest that the digestibility of cell wall constituents of urea ensiled rice straw increased. This result is comparable to the result obtained by DIAS-DA-SILVA and SUNDSTOL (1986) who obtained a hemicellulose digestibility in urea ensiled wheat straw of 726 g/kg. In the current experiment a hemicellulose digestibility of 756 g/kg was obtained. The increased fibre digestibility could have increased the dry matter intake of Diet 2 which was 18% higher than that of Diet 3. Urea treatment may cause the structural carbohydrate of the cell wall to become more accessible to rumen micro organisms. Hence urea treatment may increase the digestibility of organic matter and cell wall components. Comparable results with ammoniated wheat straw have also been reported by CLOETE *et al*. (1983).

The crude protein digestibility of Diet 2 was significantly ($P<0.05$) lower compared to Diet 1 and Diet 3 (50.2 *vs* 62.9 and 64.7%, respectively). This indicates that ammonia treatment reduced CP digestibility. CLOETE and KRITZINGER (1984) suggested that supplemental urea is more easily degraded by rumen microbes, and hence is associated with a high digestibility of protein compared with urea ammoniated straw. DIAS-DA-SILVA and SUNDSTOL (1986) and RATH *et al.* (2001) also observed the lower nitrogen digestibility of ammoniated straw compared to straw supplemented with urea at feeding time. As ammonia is more readily absorbed in the hindgut, this could partly account for the high level of faecal nitrogen observed on the ammoniated diet and the enhancement of protein synthesis by microflora in the rumen, caecum and colon. Moreover, CANN *et al.* (1991) found significantly higher total rectal bacterial counts in sheep fed on ammoniated rice straw diet compared to untreated rice straw (which could contribute to the higher faecal nitrogen). This finding was supported by HASSEN and CHENOST (1992), who observed faecal nitrogen to be composed mostly of bacterial nitrogen and nitrogen bound to undegraded cell walls. More nitrogen was bound to cell walls in ammoniated straw compared to untreated straw (HASSEN and CHENOST, 1992). The cell walls that are not degraded in the rumen are fermented in the large intestine. This condition may be responsible, in the current study, for the higher faecal nitrogen excretion from sheep fed on Diet 2 rather than on Diet 1. HASSEN and CHENOST (1992) suggested that the higher excretion of faecal nitrogen in sheep fed on an ammoniated straw diet, might be due to phenolic nitrogenous compounds generated from the ammonia treatment which could be incorporated into the microbes in the rumen, but which are lost in the faeces in a soluble form. A reduction in CP digestibility on urea ensiled straw diets compared to untreated straw was also reported by CLOETE *et al.* (1983) and compared to urea supplemented straw by CHEVA and JEERACHAI (1987), CLOETE and KRITZINGER (1984) and SAHOO *et al*. (2000). CLOETE and KRITZINGER (1984) obtained a 22.1% decrease in crude protein digestibility when urea ensiled wheat straw was compared with urea supplemented wheat straw. In the current study, the reduction was 22.4%.

Nitrogen balance of the diets

In the current study the nitrogen retention was not significant different between treatments. Lack of significance in nitrogen retention could have been due to the high individual variations recorded in the feeding trial, as indicated by the high standard error (Table 4). If the replication was increased and the variation reduced, the nitrogen retention of the urea ensiled diet could be improved. The evidence for this is provided by the fact that N retention of Diet 2 was improved from -1.38 to +1.52 g/day. Higher N retention resulting from a urea ensilage diet might be attributed to the urea treatment increasing the protein, as well as the energy supply, in the diet, as structural carbohydrates of the cell wall become more accessible to micro organisms in the rumen. This was indicated by the significantly higher DE intake in sheep fed Diet 2 than those fed Diet 3 (7.28 *vs* 6.31 MJ/day). In the urea ensiled diet (when the ration was balanced for energy and protein content) the utilisation of nitrogen by rumen microbes was more efficient because of a more synchronous availability of energy and nitrogen (ZORRILA-RIOS *et al.*, 1989). Results in the current study are also supported by CLOETE *et al.* (1983), who showed that when diets contained equal protein, the nitrogen retention of ammoniated wheat straw was lower than that of untreated straw. This was due to a lower energy content of the diets resulting in the utilisation of muscle protein to fulfil energy requirements. Similar results have been reported by CANN *et al.* (1991).

CONCLUSIONS

Formulating isoenergetic and isonitrogenous rations using urea ensiled and untreated rice straws supplemented with legumes had similar effects on DMI, DE intake and digestible cell wall components. This suggests that untreated rice straw basal diets supplemented with legume straws or forage legumes offer an alternative method of improving the nutritional value of rice straw as a ruminant feed on small farms.

Urea ensiled rice straw resulted in higher DMI, DE intake, and digestible cell wall components compared to rice straw which was supplemented with urea at feeding time. This suggests that the urea ensiled rice straw is a superior choice for use in ruminant diets. Although ensiled rice straw had a longer preparation time (42 days in temperate weather) compared to urea supplemented rice straw, the former had a 15% higher DE intake and resulted in a positive N balance.

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