Evaluation of *Leucaena leucocephala* and *Ziziphus mauritiana* as Sources of Tannins and their Interference with Nitrogen Utilisation in Goats

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ABSTRACT

Studies were undertaken to identify the roles of tannins in *Leucaena leucocephala* and *Ziziphus mauritiana* on ruminal degradability of sesame meal crude protein (CP) using nylon bags and on nutrient digestibility of nitrogen utilisation in goats. Four diets were used in an *in situ* study using a fistulated bull: S (sesame meal), S+L_1 (sesame meal and *Leucaena leucocephala* [25% of the diet]), S+L_2 (sesame meal and *Leucaena leucocephala* [50% of the diet]) and S+Z (sesame meal and *Ziziphus mauritiana* [50% of the diet]). Crude protein disappearance of S+L_1, S+L_2 and S+Z were significantly lower ($P < 0.001$) than that of S, indicating that supplementation with *Leucaena leucocephala* and *Ziziphus mauritiana* lowered degradation of sesame meal protein, thereby saving more protein. A digestion trial was carried out using four indigenous male goats allocated randomly to four dietary treatments using a 4 × 4 Latin Square design: RS (chopped rice straw and sesame meal), RSL_1 (chopped rice straw, sesame meal and *Leucaena leucocephala* at 25% of ration), RSL_2 (chopped rice straw, sesame meal and *Leucaena leucocephala* at 50% of ration) and RSZ (chopped rice straw, sesame meal and *Ziziphus mauritiana* at 50% of ration). Dry matter (DM) and organic matter (OM) intakes of all diets were relatively similar, but CP intakes of RSL_2, RSL_1 and RS were significantly higher ($P < 0.01$) than that of RSZ. Digestibilities of DM, OM, CP, neutral detergent fibre (NDF) and acid detergent fibre (ADF) for RSZ were significantly lower ($P < 0.01$) than those of other treatments. The proportion of faecal nitrogen:total nitrogen intake (Nf/NI, percentages) for RSZ was significantly higher ($P < 0.01$) than that of other diets while the proportion of nitrogen retention:total nitrogen intake (Nr/NI, percentages) for RSL_1 tended to be higher compared with RS, RSL_2 and RSZ. Supplementing the ration with 25% *Leucaena leucocephala* tended to promote nitrogen retention. The results suggest that tannins in *Leucaena leucocephala* interfere with protein degradation in the rumen and improve nitrogen retention.

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INTRODUCTION

Rice straw is a major feed source for ruminants in many tropical countries including Myanmar (Clark, 1982), especially during dry seasons. Like other fibrous residues, it is a poor quality feed but its nutritional limitations may be overcome by supplementation with concentrates, urea or green forage (Preston and Leng, 1984). Supplementation of rice straw with concentrate improves its utilisation (Trung et al., 1988). Supplementation using by-products may increase intake and/or digestion and/or utilisation of the basal diet by improving the microbial activity required to optimise rumen digestion when ammonia nitrogen in the rumen is adequate (Tin Ngwe et al., 1993).

In Myanmar, sesame meal is one of the common feed supplements for draught cattle and cross-bred dairy cows fed rice straw. However, since sesame meal is highly degradable (88.7%) in the rumen (Sampath and Sivaraman, 1987) several processing treatments (heat, tannins, formaldehyde, etc.) have been used to increase the proportion of dietary protein which is not degraded in the rumen (Chalupa, 1975). While protection of highly degradable feed protein by heat and formaldehyde treatment have already been reported, little information is available about the effect of including the tannins in tree foliages on protein protection.

Conventionally, tree foliages have been fed together with agricultural by-products (mainly crop-residues containing low levels of nitrogen) to enhance rumen microbial fermentation and hence animal productivity (Ni Ni Maw et al., 2002). Tanniferous trees and shrubs are important in animal production because they can provide significant protein supplements (Makkar, 1999). Forages containing tannins include *Leucaena leucocephala, Ziziphus mauritiana, Albizia chinensis, Manihot esculenta,* and *Terminalia oblongata* (Kumar, 1992), and tree legume forages offer a cheap alternative to concentrate diets in ruminant nutrition (Abdulrazak and Ondiek, 1998).

Among tanniferous trees and shrubs, *Leucaena leucocephala* and *Ziziphus mauritiana* are common feedstuffs for goats in Myanmar. *Leucaena leucocephala* is now widespread through most tropical and sub-tropical regions of the world and provides an important source of feed for ruminant livestock (Norton et al., 1994). It is a high quality fodder tree (Liu and Wang, 1998) with a crude protein content of 28.8% in Myanmar, and therefore with considerable potential to replace commercial protein feed resources in rations or be used as a supplementary feed (Abdulrazak and Ondiek, 1998).

Tannins are generally regarded as inhibitory to the growth of microorganisms but the mechanisms involved are poorly understood. Petroleum ether, chloroform, methanol, etc., are used to extract tan-

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nins sequentially from plant materials (Smith et al., 2001). However, detannification methods are very expensive and are not applicable in developing countries including Myanmar. Since tannins are widely distributed in tropical feedstuffs, if tree forages containing tannins were used to reduce protein degradability, savings on costs of providing dietary protein for ruminant production systems in developing countries may be expected.

Against this background, an experiment was undertaken to investigate the effect of tannins in *Leucaena leucocephala* and *Ziziphus mauritiana* on protein degradation of sesame meal using the nylon bag method in a fistulated bull. Another study examined the effect of *Leucaena leucocephala* and *Ziziphus mauritiana* on nutrient digestibility and nitrogen utilisation in goats.

MATERIALS AND METHODS

Experiment 1

Animals, Feed and Experimental Design

A fistulated bull (270 kg body weight [BWt]) was used to investigate the effect of *Leucaena leucocephala* and *Ziziphus mauritiana*, as sources of tannin on protein degradation. Four diets were used:

- Sesame meal (S)
- Sesame meal + *Leucaena leucocephala* 25% of the diet (S+L_1)
- Sesame meal + *Leucaena leucocephala* 50% of the diet (S+L_2)
- Sesame meal + *Ziziphus mauritiana* 50% of the diet (S+Z)

Before the study commenced a maintenance ration containing rice straw (4.75 kg), rice bran (220 g) and sesame meal (440 g) was fed 14 d. The experimental period for each diet lasted for 2 d. The experimental period lasted for 8 d.

Measurements

Dry matter, OM and protein degradation of each diet was measured by the nylon bag method (Orskov and McDonald, 1979). The sesame meal, *Leucaena leucocephala* and *Ziziphus mauritiana* were ground to pass through a 2 mm sieve. (Before incubation, the bags were dried in a hot air oven at 100°C for 4 h to a constant weight). Bags (13.5 cm × 8.5 cm; pore size 50 µm) were used in this study, with eight incubation times for each diet, and three nylon bags being introduced into the rumen for each incubation time. Thus, twenty four bags were required to complete incubation of each diet. About 5 g of ground sample were weighed into the bag which was closed with a plastic tie and tied with plastic string. The bags were then suspended in the rumen by tying the string to a bamboo stick placed outside the cannula. Bags were incubated in the rumen for 0.5, 1, 3, 6, 12, 18, 24 or 48 h., withdrawn and washed immediately with cold water for about 1 h under running tap water while rubbing gently between the thumb and fingers until the water was clear. They were then dried under sunlight for 5 h., and finally to constant weight at 60°C for 48 h in a hot air oven. After spreading on a table and allowed to equilibrate with the room temperature for 48 h the bags were weighed. Suitable amounts of residues were used to analyse for DM constituents.

Chemical Analysis

Dried residues were analysed for DM and OM as described by AOAC (1970). Nitrogen was determined using the Kjeldahl method (Foss 2020 digestor and Foss 2100 Kjeltec distillation unit), and CP calculated as 6.25×N (AOAC, 1970). All chemical analyses were carried out at the laboratory of Department of Physiology and Biochemistry, University of Veterinary Science, Yezin.

Statistical Analysis

The experimental results were subjected to one-way analysis of variance using ANOVA.

Experiment 2

Experimental Animals, their Management and Experimental Design

Four indigenous male goats aged about 5–7 months and BWt ranging from 19–29 kg were used to evaluate the effect of four dietary treatments on nutrient digestibility and nitrogen utilisation. Before starting the experiment, the goats were dewormed with Ivomec. During the study period, the goats were housed in individual metabolic stalls made of wood and an iron sieve and subjected to similar management practices. The feeding was done once daily at 09:00 h and the animals were given free access to water.

The experimental period for each dietary regime lasted 17 d. The goats were adapted to the test diet for the first 14 d and on the last 3 d of the experimental period samples of faeces and urine were collected from each goat for determination of nitrogen retention. The goats were randomly allocated to four dietary treatments using 4×4 Latin Square Design (**Table 1**). The dietary treatments were as follows:

- Chopped rice straw and sesame meal (RS);
- Chopped rice straw, sesame meal and *Leucaena leucocephala* 25% of ration (RSL_1);
- Chopped rice straw, sesame meal and *Leucaena leucocephala* 50% of ration (RSL_2);
- Chopped rice straw, sesame meal and *Ziziphus mauritiana* 50% of ration (RSZ)

All dietary treatments were adjusted to be isonitrogenous at the feeding level by calculating the crude protein content of each feedstuff contained in the diet. Dietary treatments were adjusted weekly by the supplement to levels of CP not less than 18% of the total diet.

Leucaena leucocephala and *Ziziphus mauritiana* (leaves and petioles) were harvested from the mature parts of the plant, collected, air dried and stored. The rice straws were also sun dried and chopped. Each diet was fed to goats at the level of 3.5% of BWt (as-fed basis). All feedstuffs used in the experiment were maintained as much as possible at a uniform composition throughout the trial period.

Amounts of all feedstuffs fed and refused were recorded daily for calculating intake levels. At the beginning of each period, animals were weighed before the morning feeding.

Measurements

Digestion trials were carried out by the conventional collection method. During collection periods samples of rice straw offered and refused and of sesame meal, *Leucaena leucocephala* and *Ziziphus mauritiana* were collected daily for chemical analysis. Residues were removed, weighed and sampled before the morning feeding.

Faeces voided and urine excreted were recorded daily during collection periods. The faeces from each goat were also weighed, sampled and put into a plastic bottle. After three consecutive d, 15% of faecal samples were dried under sunlight until constant weight was obtained. Urine was also measured, 10% sampled and stored in a refrigerator before chemical analysis. Five mL of 15% sulphuric acid was added to 200 g faecal samples before drying under sunlight and also added to the urine bucket before collection as preservative.

Table 1. Chemical composition (%) of diets incubated in the rumen of a fistulated bull.

Description	S	S+L_1	S+L_2	S+Z
DM[1]	91.8	92.2	92.0	92.3
OM	86.8	87.4	89.2	90.1
CP	40.8	34.4	33.4	25.7

S = sesame meal; S+L_1 = sesame meal + *Leucaena leucocephala* at 25% of diet; S+L_2 = sesame meal + *Leucaena leucocephala* at 50% of diet; S+Z = sesame meal + *Ziziphus mauritiana* at 50% of diet; [1] All values except DM are on DM basis.

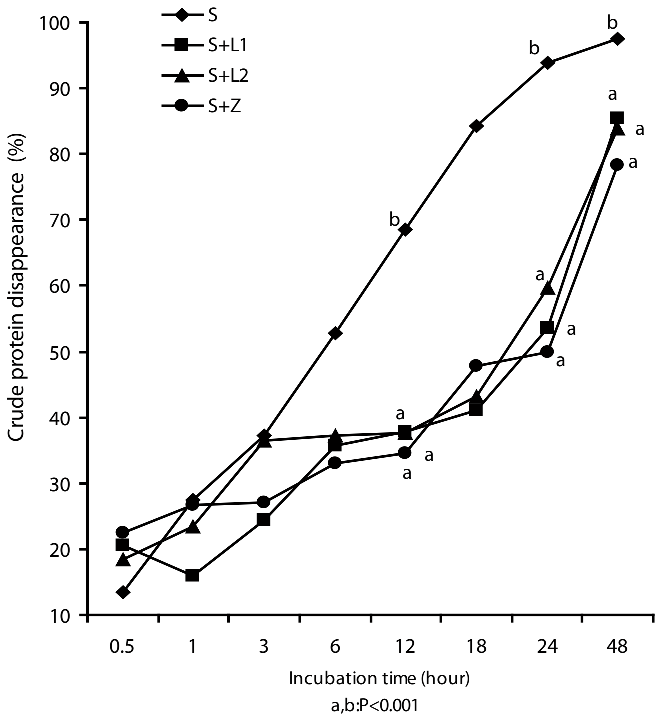

Figure 1. Disappearance of crude protein (%) of sesame meal supplemented with *Leucaena leucocephala* and *Ziziphus mauritiana* in the rumen of a fistulated bull

Chemical analysis

Ground samples of feed offered and of orts and faeces were analysed for dry matter (DM) and organic matter (OM) as described by AOAC (1970), and for neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and acid detergent insoluble nitrogen (ADIN) by the methods of Goering and Van Soest (1970). Faeces and urine were analysed for nitrogen using the Kjeldahl method (Foss 2020 digestor and Foss 2100 Kjeltec distillation unit) and crude protein (CP) was calculated as 6.25×N (AOAC, 1970). Estimates of tannin in *Leucaena leucocephala* and *Ziziphus mauritiana* were made by the sequential extraction of *Leucaena leucocephala* and *Ziziphus mauritiana* with acid detergent followed by neutral detergent.

Statistical analysis

Data were subjected to statistical analysis of ANOVA using Latin Square Design and the significance of differences between treatment means was compared by Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Experiment 1

Chemical Composition and CP Disappearance

Table 1 and **Figure 1** show the chemical composition of the diets and disappearance of CP from them. Dry matter and OM levels were similar in all diets, but CP content was highest in sesame meal and lowest where sesame meal was supplemented with *Ziziphus mauritiana* at 50% of in the diet.

The CP disappearances of all diets were relatively similar at 3 h incubation, but CP disappearances of S+L_1, S+L_2 and S+Z were lower than that of S at all times thereafter, significantly so ($P < 0.001$) after 12 h, 24 h and 48 h of incubation. This would indicate that supplementation with *Leucaena leucocephala* and *Ziziphus mauritiana* lowered the degradation of the sesame meal protein, and that this might be due to the presence of tannins in these foliages. This is consistent with the observation of Khin San Mu (2002) who reported that CP disappearance was reduced by incubating a concentrate with tamarind seed husk as a source of tannins to growing female calves. Also, Sampath and Sivaraman (1987) showed that the disappearances of DM and CP were reduced by incubating heat-treated sesame meal in the rumen, and Chalupa (1975) reported that several processing treatments (heat, tannin, formaldehyde, etc.) increased the proportion of dietary protein which is not degraded in the rumen.

Degradation Constants

The degradation constants of DM, OM and CP for S, S+L_1, S+L_2 and S+ Z are given in **Table 2**. Degradation rates (c) of DM, OM and CP for all diets were relatively similar but the values of b and a+b for S were found to be higher than those of S+L_1, S+L_2 and S+Z. The higher degradation constants of S would also indicate that tannins in these tree foliages protect the protein from degradation. The lower CP disappearance and degradation constants of the treatments that included *Leucaena leucocephala* and *Ziziphus mauritiana* suggest again that tannins contained in these tree foliages interfered with protein degradation in the rumen of the fistulated bull.

Experiment 2

Chemical Composition of Feedstuffs

The chemical composition of the feedstuffs are presented in **Table 3** (all values except DM expressed on DM basis). The CP content of *Leucaena leucocephala* used in this experiment was 28.8% which was higher than reported earlier (Smith, 1992; Wheeler et al., 1994; Ni Ni Maw et al., 2002; Lwin Naing Oo, 2002; Met Aung, 2002; Moe Moe Khaing, 2003), but similar to values reported by others (Jones, 1979; Abdulrazak and Ondiek, 1998; Aregheore and Yahaya, 2001).

The CP content of *Ziziphus mauritiana* was 13.9% which was similar to the value of 14% reported by Nath et al. (1969) and lower than the 18.39% recorded by Ni Ni Maw et al. (2002). The NDF and ADF values of *Ziziphus mauritiana* used were 35.8% and 25%

Table 2. Degradation constants of diets in the rumen of a fistulated bull.

DM [1]	Description			
	S	S+L_1	S+L_2	S+Z
a, %	5.0	16.0	12.0	2.0
b, %	88.0	54.0	60.0	56.0
c, h^{-1}	0.085	0.084	0.085	0.090
a+b, %	93.0	70.0	72.0	58.0
OM [1]				
a, %	7.0	10.0	9.0	1.0
b, %	87.0	58.0	61.0	57.0
c, h^{-1}	0.088	0.088	0.090	0.088
a+b, %	94.0	68.0	70.0	58.0
CP [1]				
a, %	5.0	1.0	9.0	10.0
b, %	93.0	63.0	58.0	51.0
c, h^{-1}	0.091	0.087	0.088	0.087
a+b, %	98.0	64.0	67.0	61.0

a — rapidly degradable fraction; b — slowly degradable fraction; a+b — potentially degradable fraction; c — rate of degradation; 1 as described in Table 1.

Exponential equation: $P=A+B\ (1-e^{-kdt})$.

Table 3. Chemical composition (%) of feedstuffs.

Description	Rice straw	Sesame meal	Leucaena leucocephala	Ziziphus mauritiana
DM	87.7	86.0	89.3	90.6
OM	81.4	84.8	91.0	92.2
CP	5.7	40.6	28.8	13.9
EE	1.7	10.5	8.2	4.2
NDF	68.3	17.4	22.7	35.8
ADF	41.2	9.6	13.7	25.0
ADL	—	—	3.7	8.3
Tannin	—	—	2.0	4.8
Silica	—	—	0.3	0.5

EE — ether extract; ADL— acid detergent lignin.

respectively, higher than the 30.0% and 19.78% reported by Ni Ni Maw et al. (2002).

The difference of 2.0% between ADF and NDF in the sequential analysis of *Leucaena leucocephala* for tannins was in agreement with 1.4 - 7.9% reported by Wheeler et al. (1994), while the difference of 4.8% between ADF and NDF in the sequential analysis of *Ziziphus mauritiana* for tannins agreed closely with the 5.3% reported by Bhatia et al. (1987).

The differences in chemical composition between *Leucaena leucocephala* and *Ziziphus mauritiana* used in this experiment and from other observations likely reflected differences between parts of the plants used, their maturity, soil, weather and environmental characteristics.

Digestibility coefficients

DM digestibility of RSL_2 was significantly higher ($P < 0.01$) than that of RS but CP digestibility was significantly lower ($P < 0.01$). This might be due to the greater amount of *Leucaena leucocephala* in the ration which resulted in an increased amount of the tannin. The OM digestibilities of RSL_1 and RSL_2 were not significantly different from that of RS (**Table 6**).

Although all dietary treatments were adjusted to be isonitrogenous at the feeding level, a significant decrease was observed in CP intake of the RSZ diet (**Table 5**). This was due to underestimation of the CP content of *Leucaena leucocephala* and overestimation of CP content of *Ziziphus mauritiana*. Therefore, it could be assumed that all nutrient digestibilities were significantly ($P < 0.01$) reduced (**Table 6**) due to decreased CP intake in RSZ diet (**Table 5**). It is generally agreed that intake and digestion by ruminants is limited when the roughage contains less than 7% CP (Doyle, 1987). However, the CP content of RSZ constituted 15.7% of the diet, well above the CP content that may have limited nutrient digestibility. Therefore, the reduced nutrient digestibility might be due to ADIN content in *Ziziphus mauritiana* (**Table 4**).

Table 4. Content of acid detergent insoluble nitrogen in *Leucaena leucocephala* **and** *Ziziphus mauritiana.*

Description	Leucaena leucocephala	Ziziphus mauritiana
Total N %	4.6	2.2
ADIN %	1.7	1.5
ADIN/total N, %	37.0	68.0

N: = nitrogen; ADIN: = acid detergent insoluble nitrogen.

Table 5. Nutrient intakes (g/kg $^{0.75}$/d).

Description[1]	RS	RSL_1	RSL_2	RSZ
DM I	59.3	55.5	63.4	63.2
OMI	49.2	47.2	55.1	55.4
CPI	12.5	13.0	15.2	10.2

[1] DMI — dry matter intake; OMI — organic matter intake; CPI — crude protein intake.

Table 6. Digestibility of nutrients (%).

Description	RS	RSL_1	RSL_2	RSZ	SEM
DM digestibility	59.0^{B}	61.7^{Aa}	62.0^{Aa}	55.8^{C}	0.591
OM digestibility	66.6^{Aa}	67.7^{Aa}	66.8^{Aa}	60.2^{B}	0.533
CP digestibility	82.5^{Aa}	80.5^{ABa}	75.5^{Bb}	57.9^{C}	1.390
NDF digestibility	59.8^{Aa}	55.3^{ABb}	52.1^{Bb}	42.3^{C}	1.107
ADF digestibility	56.8^{Aa}	47.9^{ABb}	41.9^{Bb}	26.1^{C}	2.479

Significant differences between means over the whole experiment are indicated by dissimilar superscripts: $^{A,B,C}P < 0.01$ and $^{a,b}P < 0.05$.

Table 7. Nitrogen utilisation by goats fed different diets.

Description	RS	RSL_1	RSL_2	RSZ	SEM
Total NI, g/d	20.1^{Aa}	20.5^{Aa}	24.5^{B}	16.6^{C}	0.649
Faecal N, g/d	3.5^{Bc}	4.0^{Bc}	5.9^{Ab}	6.9^{Aa}	0.231
Urinary N, g/d	11.8^{ABa}	11.0^{ABa}	13.4^{Aa}	6.5^{Bb}	1.331
N retention, g/d	4.8	5.5	5.1	3.2	—
Nf/NI, %	17.5^{Aa}	19.5^{ABa}	24.5^{Bb}	42.1^{C}	1.327
Nu/NI, %	59.6	54.5	55.0	40.3	—
Nr/NI, %	22.9	26.0	20.5	17.6	
Nf/DNI, %	21.3^{Aa}	24.2^{Aa}	32.7^{Aa}	73.6^{B}	3.622
Nu/DNI, %	72.0	68.0	73.0	70.3	—
Nr/DNI, %	28.0	32.0	27.0	29.7	—

NI: = nitrogen intake; Nf: = faecal nitrogen; Nu: = urinary nitrogen; Nr: = nitrogen retention; DNI: = digestible nitrogen intake.

Significant differences between treatment means over the whole experiment indicated by dissimilar superscript: $^{A,B,C}P < 0.01$; $^{a,b,c}P < 0.05$

The NDF and ADF digestibilities of RSL_2 and RSZ were significantly lower ($P < 0.01$) than that of RS. Likewise, NDF and ADF digestibilities for RSL_1 were significantly lower ($P < 0.05$) than for RS, which is in accord with the report of Reed et al. (1990) that tannins have a negative effect on fibre digestibility (**Table 6**).

Nitrogen utilisation

Total nitrogen intakes of RS, RSL_1, RSL_2 and RSZ were 20.1, 20.5, 24.5 and 16.6 g/d, respectively (**Table 7)**. Total nitrogen intake of RSL_2 was significantly higher ($P < 0.01$) than those of other diets while total nitrogen intake of RSZ was significantly lower ($P <0.01$) than those of other diets.

The proportion of faecal nitrogen to total nitrogen intake (Nf/NI, %) of RSZ was significantly higher ($P < 0.01$) than RSL_2, RSL_1 and RS. This might be due to the high content of acid detergent insoluble nitrogen (ADIN) in *Ziziphus mauritiana* (68% of total nitrogen) compared with that of *Leucaena leucocephala* (37% of total nitrogen) (**Table 4**). This is in agreement with the report of Nakamura et al. (1994) who showed that ADIN and nitrogen digestibility were correlated ($r^2 = 0.66$) and that ADIN was completely indigestible leading to underestimation of nitrogen digestibility.

The proportions of urinary nitrogen to total nitrogen intake (Nu/NI, %) of RS, RSL_1, RSL_2 and RSZ were not significantly different ($P > 0.05$). The Nu/NI, % of RSZ (40.3%) was numerically lower than those of RSL_1, RSL_2 and RS (59.6, 54.5 and 55.0% respectively), which might be due to the high content of tannins in the RSZ diet. However, the proportion of nitrogen retention to nitrogen intake (Nr/NI, %) of RSZ tended to decrease compared with other treatments which might be explained by an inadequate ammonia nitrogen concentration in the rumen for nitrogen utilisation because of the higher content of ADIN in *Ziziphus mauritiana* (68% total nitrogen) (**Table 4**). This was confirmed by the higher faecal excretion of nitrogen in RSZ diet (**Table 7**).

The proportion of nitrogen retention to nitrogen intake (Nr/NI, %) of RSL_2 was numerically lower than that of RSL_1, although the amount of tannin included in the RSL_2 was doubkle that of RSL_1. This would indicate an excessive amount of *Leucaena leucocephala* in the ration of RSL_2.

Although NDF and ADF digestibilities of RSL_1 were significantly lower than for RS ($P < 0.05$), the proportion of nitrogen retained to total nitrogen intake (Nr/NI, %) with the RSL_1 diet tended to be higher compared with other diets. Moreover, OM digestibility (**Table 6**) and the nutritive value of RSL_1 diet were also higher (**Table 7**). This observation is in agreement Dutta et al. (1999) who reported that the intakes (g/kg$W^{0.75}$) of DCP, TDN and the nitrogen balances of goats were significantly higher ($P < 0.05$) when *Leucaena* was fed. Norton (1994) also reported that nitrogen balance was apparently improved in animals that are fed low levels of tannins, although digestibility of forage fibre may be lowered.

No significant difference was observed in Nu/DNI, % and Nr/DNI, % among treatments suggesting that post ruminal nitrogen metabolism in goats fed on all diets was relatively similar.

Bhatta et al. (2000) reported decreased nitrogen excretion in urine with subsequent increased nitrogen retention in crossbred dairy cows fed with tamarind (*Tamarindus indica*) seed husks. Similar findings have been reported by Karda et al. (1998) in sheep fed with *Leucaena leucocephala,* by Barry et al. (1986) in sheep fed with *Lotus* and Pritchard et al. (1992) in sheep fed with *Acacia*, by Tin Ngwe (2003) in sheep supplemented with lablab bean (*Dlichos lablab*) husk, and by Lwin Naing Oo (2002) in goats supplemented with *Leucaena leucocephala.* In all these cases, the higher nitrogen retention was attributed to the tannin content of these legumes causing a reduction in protein fermentation in the rumen and an improvement in the efficiency of nitrogen utilisation.

Although tannins are regarded as antinutritional factors, certain types of tannins at low concentration are known to alter rumen fermentation of carbohydrates and protein (Barry and Duncan, 1984) and microbial protein synthesis (Makkar et al. 1995) to the benefit of ruminants. *Leucaena leucocephala* fed at the level of 25% of the ration used in the present experiment may have played roles favourable for nitrogen utilisation, while the higher level of ADIN content in *Ziziphus mauritiana* might have been a drawback as a ruminant feed.

CONCLUSIONS

Compared with other diets, the proportion of nitrogen retained to total nitrogen intake tended to be higher when the diet was supplemented with 25% of *Leucaena leucocephala*. The level of 25% of *Leucaena leucocephala* in the ration was found to be a good supplement to rice straw in terms of promoting nitrogen utilisation without reducing DM and OM digestibilities and could therefore be used as a source of tannins for protecting protein provided as concentrate from degradation in the rumen.

Ziziphus mauritiana reduced both fibre and protein digestibility because of its higher ADIN content and might therefore not be so suitable as a feed for goats.

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REFERENCES

Abdulrazak, S.A. & Ondiek, J.O., 1998. The effects of supplementating roughage diets with Leucaena leucocephala on intake, digestion and animal performance of goats and cattle in Kenya. *In*: Shelton, H.M., Gutteridge, R.C., Mullen, B.F. & Bray, R.A., eds. *Proc. Workshop on Leucaena: adaptation, quality and farming systems held in Hanoi*. Vietnam 9–14 February. ACIAR Proceedings No. 86, ACIAR, Australia. pp. 275–276.

Association of Official Analytical Chemists. 1970. *Official Methods of Analysis.* 11th Edn. AOAC.

Aregheore, E.M. & Yahaya, S.S. 2001. Nutritive values of some browses as supplements for goats. *Malaysian J. Anim. Sci.* 7: 29–36.

Barry, T.N. & Duncan, S.J. 1984. The role of condensed tannins in the nutritional value of Lotus pedunculatus for sheep. 1. Voluntary intake. *Br. J. Nutr.* 54: 485–491.

Barry, T.N., Manley, T.R. & Duncan, S.J. 1986. The role of condensed tannins in the nutritional value of Lotus pedunculatus for sheep. 4. Sites of carbohydrate and protein digestion as influenced by dietary reactive tannin concentration. *Br. J. Nutr*. 55: 123–137.

Bhatia, D.R., Kumar, R. & Patnayak, B.C. 1987. Annual Report CSWRI, Avikanagar, Cited by Kumar, R. & Vaithiyanathan, S. (1990): Occurrence, nutritional significance and effect on animal productivity of tannins in tree leaves. *Anim. Feed Sci. and Technol.* 30: 21–38.

Bhatta, R., Krishnamoorthy, U. & Mohammed, F. 2000. Effect of feeding tamarind (Tamarindus indica) seed husk as a source of tannin on dry matter intake, digestibility of nutrients and production performance of crossbred dairy cows in mid-lactation. *Anim. Feed Sci. and Technol.* 83: 67–74.

Chalupa, W. 1975: Rumen bypass and protection of protein and amino acids. *J. Dairy Sci.* 58: 1198–1218.

Clarke, J.P. 1982. *Roughages and fodders in Myanmar.* Field Document No.23. FAO, Rome.

Doyle, P.T. 1987. Supplements other than forages. *In* Hacker, J.B. & J.H., Ternouth, eds. *The Nutrition of Herbivores*. Academic Press, Australia: 429–464.

Dutta, N., Sharma, K. & Hasan, Q.Z. 1999. Effect of supplementation of rice straw with Leucaena leucocephala and Prosopis cineraria leaves on nutrient utilization by goats. Asian-Aus. *J. Anim. Sci.* 12: 742–746.

Goering, H.K. & Van Soest, P.J. 1970. Forage Fibre Analysis. *Agricultural Handbook* No. 379. ARS–USDA, Washinton, D.C.

Jones, R.J. 1979. The value of Leucaena leucocephala as a feed for ruminants in the tropics. *World Anim. Rev.* 31: 13–23.

Karda, I.W., McL, G., Dryden & Gutteridge, R.C. 1998. The effect of supplementation with Leucaena leucocephala and urea or sucrose on the voluntary feed intake and digestibility of Rhodes Grass hay by sheep. *In* Shelton, H.M., Gutteridge, R.C., Mullen, B.F. & Bray, R.A., eds. *Proc. Workshop on Leucaena: adaptation, quality and farming systems held in Hanoi*. Vietnam 9–14 February. ACIAR Proceedings No. 86. ACIAR, Australia: 280–281.

Khin San Mu. 2002. *Studies on the Physiological Responses of Growing Bulls Fed on Urea-treated Rice Straw Supplemented with Untreated or Heat-treated Sesame Meal and Two Rates of Chickpea (Cicer arietinum) Husk*. MVSc. Thesis submitted to the Department of Physiology and Biochemistry, University of Veterinary Science, Yezin.

Kumar, R. 1992. Antinutritional factors the potential risks of toxicity and methods to alleviate them. *Animal Production and Health Paper* 102. FAO, Rome: 145–160.

Liu, G. & Wang, D., 1998. Preliminary study of Leucaena leucocephala as feed for livestock. *In* Shelton, H.M., Gutteridge, R.C., Mullen, B.F. & Bray, R.A., eds. *Proc. Workshop on Leucaena: adaptation, quality and farming systems.* Hanoi, Vietnam 9–14 February. ACIAR Proceedings No. 86. ACIAR, Australia: 284–286.

Lwin Naing Oo. 2002. *Effect of Feeding Tree Forages as Partial Replacement of Concentrates in Rice Straw Based Diets of Goats on Voluntary Intake, Digestibility and Nitrogen Balance.* MVSc. Thesis submitted to the Department of Physiology and Biochemistry, University of Veterinary Science, Yezin, Myanmar.

Makkar, H.P.S. 1999. *Quantification of Tannins in Tree Foliage.* IAEA Working Document. IAEA, Vienna.

Makkar, H.P.S., Barowy, N.K., Becker, K. & Degen, A. 1995. Some problems in fibre determination of a tannin rich forage (Acacia saligna leaves) and their implications in vitro. *Anim. Feed Sci. Technol.* 55: 67–76.

Met Aung. 2002. *The Effect of Feeding Tree Forages as Partial Replacement of Concentrates in Rice Straw Based Diets in Goats on Feed Intake and Physiological Responses.* MVSc. Thesis submitted to the Department of Physiology and Biochemistry, University of Veterinary Science, Yezin.

Moe Moe Khaing. 2003. *Study on the Effects of Supplementation with Leucaena Leaves and Urea Molasses Multinutrient Blocks of Rice Straw Based Diet in Goats on their Voluntary Intake and Digestibility.* MVSc. Thesis, Department of Physiology and Biochemistry, University of Veterinary Science, Yezin, Myanmar.

Nakamura, T., Klopfenstein, T.J. & Britton, R.A. 1994. Evaluation of acid detergent insoluble nitrogen as an indicator of protein quality in non-forage proteins. *J. Anim. Sci.* 72: 1043–1048.

Nath, K., Malik, N.S. & Singh, O.N. 1969. Utilization of Ziziphus nummularia leaves by three breeds of sheep. *Aust. J. Agric. Res.* 20: 1137–1142.

Ni Ni Maw, Khin San Mu, Aung Aung & Moe Thida Htun. 2002. *Preliminary report of nutritive value of tree foliages available in Yezin area.* Proceedings of the Annual Research Conference, June 28–30, Yangong, Myanmar.

Norton, B.W. 1994. The nutritive value of tree legumes. *In* Gutteridge, R.C. & Shelton, H.M., eds. *Forage Tree Legumes in Tropical Agriculture*. CAB International, Wallingford, Oxford: 177–191.

Norton, B.W., Lowry, B. & McSweeney, C. 1994. The nutritive value of Leucaena species. *In* Shelton, H.M., Piggin, C.M. & Brewbaker, J.L., eds. *Proc. Workshop held in 24–29 January, Bogor, Indonesia.* ACIAR Proceedings No. 57. ACIAR, Australia: 103– 111.

Orskov, E.R. & McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. *J. Agric. Sci. Camb.* 92: 499–503.

Preston, T. R. & Leng, R.A. 1984. Supplementation of diets based on fibrous residues and by-products. *In* Sunstol, R.F. & Owen, E., eds. *Straw and Other Fibrous By-products as Feed.* Elsevier, Amsterdam: 373–413.

Pritchard, D.A., Martin, P.R. & O'Rourke, P.K. 1992. The role of condensed tannins in the nutritional value of Mulga (Acacia aneura) for sheep. *Aus. J. Agric. Res.* 43: 1739–1746.

Reed, J.D., Soller, H. & Woodward, A. 1990. Fodder tree and straw diets for sheep: intake, growth, digestibility and the effect of phenolics on nitrogen utilization. *Anim. Feed Sci. Technol.* 30: 39–50.

Sampath, K.T. & Sivaraman, E. 1987. Ruminal degradability of heat treated and formaldehyde treated groundnut cake, gingelly cake and rubberseed cake. *Indian J. Dairy Sci.* 40: 163–168.

Smith, O.B. 1992. Fodder trees and shrubs in range and farming systems in tropical humid *Africa.Animal Production and Health Paper* 102. FAO, Rome: 43–59.

Smith, A.H., Odenyo, A.A., Osuji, P.P., Wallig, M.A., Kandil, F.E., Seigler, D.S. & Mackie, R.I. 2001. Evaluation of toxicity of Acacia angustassima in a rat bioassay. *Anim. Feed Sci. Technol.* 91: 41–57.

Steel, R.G. & Torrie, J.H. 1980. *Principles and Procedures of Statistics. A Biometrical Approach.* 2nd Edn. Mc Graw-Hill Book Company, New York.

Tin Ngwe. 2003. *Study on Effects of Chickpea (Cicer arietinum) Husk and Lablab Bean (Dolichos lablab) Husk as Sources of Easily Digestible Fibre, on Rice Straw Digestion and Ruminal Characteristics in Sheep.* Ph.D. Thesis, Graduate School of Agriculture, Hokkaido University, Japan.

Tin Ngwe, Mar Mar Kyi, Cho Cho Thein & Zaw Win Maung. 1993. Study on ustilization of rice straw by ruminants supplemented with agricultural by-products available in Myanmar. II. Effect of groundnut meal or sesame meal with or without chickpea husk on voluntary intake of rice straw and digestibility of rice straw diet in growing bulls. *Myanmar J. Agric. Sci.* 5: 83–95.

Trung, L.T., Palo, L.P., Atega, T.A. & Lapinid, R.R. 1988. *Urea treated rice straw with copra meal or fish meal in concentrate supplemented at two rates for dairy replacement heifers.* Paper presented at the 25th Philippine Society of Animal Science Annual Convention, November 17–18, University of the Philippines Los Banos, Laguna.

Wheeler, R.A., Norton, B.W. & Shelton, H.M. 1994. Condensed tannins in Leucaena species and hybrids and implications for nutritive value. *In* Shelton, H.M., Piggin, C.M. & Brewbaker, J.L., eds. *Proc. Workshop on Leucaena- Opportunities and Limitations.* 24–29 January, Bogor, Indonesia. ACIAR Proceedings No.57, ACIAR, Australia.