Effect of Supplementation of Rice Straw with *Leucaena leucocephala* and *Prosopis cineraria* Leaves on Nutrient Utilization by Goats

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ABSTRACT : The potential of *Leucaena leucocephala* and *Prosopis cineraria* leaves as nitrogen supplements (16 g/kg $W^{0.75}$/d) to improve the utilization of a basal diet of rice straw by goats was assessed in a feeding trial. Rice straw supplementation with forage oats (*Avena sativa*) was fed as a control diet. DMI, g/kg$W^{0.75}$ of rice straw by goats receiving *Leucaena* was significantly ($p<0.05$) higher followed by *Prosopis* and oat fodder. The supplementation of *Leucaena* improved the digestibility coefficient of DM, OM, CP, NDF and ADF and nutrient density. Goats on *Prosopis* or oat fodder supplemented straw responded similarly in terms of nutrient utilization. The intake (g/kg$W^{0.75}$) of DCP, TDN and nitrogen balance of goats were significantly higher ($p<0.05$) when *Leucaena* was fed. It is suggested that the *Leucaena* may be a useful N-supplement in areas where livestock are fed poor quality crop residues. (*Asian-Aus. J. Anim. Sci. 1999. Vol. 12, No. 5 : 742-746*)

Key Words : Goats, Tree Forage, Rice Straw, Supplementary Value

INTRODUCTION

Crop residues such as straws are used as basal feeds for ruminants in India and many tropical countries. The feeding value of crop residues is, however, limited by major deficiencies of crude protein, metabolizable energy and minerals (Owen, 1985). There is evidence that the utilization of cereal straws may be improved by supplementation with fodder tree foliages and legumes to improve the supply of fermentable nitrogen, carbohydrates and micronutrients (Devendra, 1990). Under tropical conditions a wide variety of legume trees are grown and their foliage offers an economical alternative to costly protein supplements. This has encouraged widespread introduction of *Leucaena leucocephala* and *Prosopis cineraria* for eco-regeneration and as protein rich fodder in most of the tropical waste lands. Both browses are good sources of supplemental nitrogen and minerals but *Prosopis cineraria* and *Leucaena leucocephala* contain higher levels of tannins and mimosine as toxic constituents, respectively. These anti-nutritional factors restrict their utility as a sole ruminant feed. This study was conducted to evaluate the effect of supplementation of these browses (*Leucaena* and *Prosopis*) and a conventional oat (*Avena sativa*) forage on the intake and digestibility of rice straw by goats.

MATERIALS AND METHODS

Animal management and experimental diets

Eighteen male Barbari goats, weighing 18.5±0.9 kg were used in the experiment. The goats were drenched with anti-helminthics and dipped against external parasites before the commencement of the experiment. They were divided into 3 treatment groups of 6 animals each. The goats were confined in individual feeding stalls and adapted to the test diets for 10 days followed by a feeding period of 60 days. Feeds used for the experiment were chaffed rice straw (variety Saket) as the basal diet, and three forages of oats (T-1), *Prosopis cineraria* (T-2) and *Leucaena leucocephala* (T-3), used as nitrogen (N) supplements at about 16 g DM/kg$W^{0.75}$ to meet the dietary CP requirement for maintenance of goats (NRC, 1981). The foliage of tree legumes (leaves and petioles) was sun-dried and stored for feeding of animals. Similarly, green oat forage was harvested in one lot at the pre-flowering stage, chaffed and dried under the sun for 3-4 days (<80-85% DM) to maintain a uniform composition during the trial. The supplements were offered once as the first feed in the morning at 09.00 hrs. Chopped rice straw was offered *ad lib* at the level of 125% of the previous day's intake. Clean water was provided free choice to all the goats. Amounts of all feeds offered and refused were monitored for calculating intake levels. Animals were weighed fortnightly before the morning feeding. The amount of supplementation was adjusted fortnightly on the basis of body weight of the animal.

Digestibility and nitrogen balance trials

On completion of the feeding trial, the goats were transferred to metabolism crates for nutrient digestibility and nitrogen balance studies. The goats were accustomed to the cages for 5 days followed by a collection period of 7 days. Samples of feeds offered and refused were collected daily. Pooled samples were ground and stored for chemical analysis. Total daily (24 h) faecal output was recorded and a

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20% sub-sample collected and dried in a forced draught oven overnight at 100±5℃ to a constant weight for dry-matter estimation. Representative samples of each daily faecal and urine collection were drawn, pooled for seven days and preserved in diluted (1:4) sulphuric acid for N-estimation. The other sub-samples were retained for further chemical analysis.

Chemical analysis and statistics

Proximate analysis, total tannins and cell-wall composition were determined by the standard methods of AOAC (1981) and Goering and Van Soest (1970), respectively. The mimosine content of forage supplements was measured by the method of Megarrity (1978).

Analysis of variance was carried out using a complete randomized design to test the effect of supplements on the utilization of rice straw based diets by goats. The least significance difference (LSD) was used to test the statistical significance of the difference between supplement means (Snedecor and Cochran, 1970).

RESULTS AND DISCUSSION

The chemical composition of rice straw and different supplements used in this experiment are shown in table 1.

Table 1. Chemical composition of rice straw and supplements (% DM basis)

Attributes	Feeds			
	Rice straw	Oat fodder	*Prosopis* leaves	*Leucaena* leaves
OM	88.9	89.7	86.1	88.2
CP	6.0	12.0	15.5	29.6
Total ash	11.0	10.3	13.8	11.8
NDF	66.5	57.3	44.6	32.1
ADF	49.2	37.7	35.2	15.8
Total tannins	-	-	7.0	3.4
Mimosine	-	-	-	2.2

The straw crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and ash contents were comparable to other published values (Yadav and Yadav, 1989; Sharif, 1984). The CP content of paddy straw was below the critical level required at normal forage consumption (4 g CP/kg $W^{0.75}$) by goats for maintenance (NRC, 1981; Kearl, 1982) and supplementation with tree forages and oat improved the straw diets to meet this level. *Leucaena* leaves had higher CP and OM whereas, NDF, ADF and total tannins were lower than their corresponding values in *Prosopis* leaves. Oat forage had a lower nitrogen concentration and no tannins or mimosine but contained higher levels of NDF and ADF than both browses. Intake was significantly affected by the composition of the dietary supplement (table 2).

Table 2. Body weights, feed intake, nutrient digestibility and plane of nutrition of goats

Variables	Treatments			
	T1	T2	T3	SEM
Body weight, kg				
Initial	18.70	18.66	18.33	0.97
Final	18.20	18.00	18.83	1.08
Gain	-0.50	-0.66	0.50	0.17
Intake, g/kg$W^{0.75}$				
Supplement	16.36	15.82	16.27	0.16
Rice straw**	19.80^{a}	27.81^{b}	34.54^{c}	1.20
Total**	36.16^{a}	46.63^{b}	50.81^{c}	1.23
DMI, kg/100 kg LW**	1.77^{a}	2.12^{b}	2.42^{c}	0.10
Digestibility (%)				
DM*	50.38^{a}	49.09^{a}	55.87^{b}	0.86
OM*	55.74^{b}	52.54^{a}	60.38^{c}	0.88
CP*	48.82^{b}	40.56^{a}	60.49	2.02
NDF*	53.91^{a}	43.47^{a}	59.73^{b}	0.96
ADF*	50.99^{ab}	50.15^{a}	53.99^{b}	0.72
Nutrient density (%)				
DCP**	4.20^{a}	3.70^{a}	7.51^{b}	0.36
TDN**	52.18^{a}	48.68^{a}	56.10^{b}	0.88
Nutrient intake, g/kg$W^{0.75}$				
CP**	3.00^{a}	3.60^{a}	6.80^{b}	0.60
DCP**	1.53^{a}	1.62^{a}	3.84^{b}	0.23
DOM*	17.96^{a}	20.19^{b}	27.19^{c}	0.79
TDN*	18.87^{a}	21.20^{b}	28.56^{c}	0.83

a,b,c Means bearing different superscripts are significantly different; ** $p<0.01$, * $p<0.05$.

DMI (g/kg$W^{0.75}$) off rice straw was highest with *Leucaena* supplement, followed by *Prosopis* and least with the oat forage. This is consistent with the findings of Mosi and Butterworth (1985) who showed that plant cell-wall content is the primary restrictive determinant of intake. Except for group T-3, the goats could not achieve recommended intake levels of DM (50-55 g/kg$W^{0.75}$; NRC, 1981; Kearl, 1982). However, the general effect of browses to stimulate total intake of poor quality paddy straw observed in this trial is important to nutritional management of livestock. The increase in DMI was approximately 40.51% and 20.65% in the *Leucaena* and *Prosopis* supplemented groups, respectively over the T-1 probably due to enhanced cellulolysis, digestion of cell-walls in the reticulorumen (Khandaker et al., 1998) and metabolism in body tissues (Weston, 1967). Higher DMI of diets with browses in general and *Leucaena* in particular was not only due to the effect of dietary CP, but also to their readily fermentable fibre content. Mosi and Butterworth (1985) reported that legume hay supplementation of cereal crop residues significantly increased total DMI, but Han et al. (1993) did not find any influence on DMI by supplementation with grass hay. An ideal forage supplement should maintain or increase intake of the basal diet rather than substitute for it, a phenomenon that has been frequently observed in animals fed on legumes (Moran et al., 1983; McMeniman et al., 1988). In this study, rice straw intakes were significantly improved by the forage supplements. The net effect of including tree leaves in the rice straw diets was to improve the protein and energy intake of the goats. This improvement was more pronounced in group T-3 due to the combined effect of increasing the DM digestibility (12% units) and to an increase in the total DMI of rice straw component (table 2). DM, NDF and ADF digestibility of diets T-1 and T-2 were comparable but significantly lower than diet T-3. This is in agreement with intake data and therefore, limited intake in T-1 and T-2 as compared to T-3 was probably caused by a reduction of potential digestibility due to nitrogen limitations. This may be confirmed by DCP/TDN ratio which is around 1:13, wider than the ratio of 1:10 recommended for optimal rumen fermentation (NRC, 1981). Goats exhibited a significant depression in CP and OM digestibility and N-utilization of rice straw diets supplemented with *Prosopis cineraria*. This is possibly a response to higher total tannin and fibre content of *Prosopis* leaves. The results obtained across a wide range of browse species indicate that while it may not be possible to predict the effect of phenolics on nutrient value of forages with certainty (Ahn et al., 1989; Rittner and Reed, 1992), they have the largest effects on microbial degradation of protein through the formation of indigestible complexes with protein (Robbins et al., 1987; Hanley et al., 1992). *Leucaena* leaves also contained moderate amount of tannins (3.4%) but their fibre content was significantly less than *Prosopis* or oat forage. The net effects of supplementing rice straw with *Leucaena* leaves therefore were improved palatability and nutrient digestibility of the diet. Although attention is usually focussed on secondary components as limiting the nutritional value of browse, fibre cannot be ignored. Fibre was as important as condensed tannins in reducing the tolerance for rumen fill besides increasing endogenous and microbial-N loss in faeces (Woodland and Reed, 1995). The significant improvement of CP digestibility by the addition of *Leucaena* may have been due to the increased CP content of the diet (13.56%) as discussed by Ha and Kenelly (1984). Positive associative increases in the digestion of rice straw could be possible if additional protein, soluble carbohydrates and minerals from *Leucaena* stimulated microbial activity (Burroughs et al., 1950; Hunt et al., 1954). Dietary supplementation of tree foliage had a significant effect on N-intake (g/d) by goats. Because of the high CP content in the *Leucaena* fodder (29.6%), the N-intake of goats was higher (p<0.01) in group T-3 followed by T-2 as compared to T-1 (table 3).

Table 3. Nitrogen balance of goats

Attributes	Treatments			
	T1	T2	T3	SEM
Nitrogen balance, g/d				
Intake	4.56[a]	5.49[a]	9.10[b]	0.70
Faecal-N	2.48[a]	3.68[b]	3.74[b]	0.20
Urinary-N	1.13[a]	1.20[a]	1.78[b]	0.13
Nitrogen retention, g/d	0.95[a]	0.92[a]	3.59[b]	0.51
Nitrogen retention				
as % of intake	20.83[b]	15.88[a]	39.45[c]	1.20
as % of digested	45.67	43.81	48.51	0.96

[a,b,c] Means bearing different superscripts are significantly different (p<0.01).

However, there was no significant differences in the total excretion of N in faeces between groups T-2 and T-3 which were significantly higher than treatment T-1. Though the nitrogen retentions as percentage of absorbed-N were comparable in goats fed different dietary supplements, the goats retained significantly more N (p<0.05) as a percentage of total-N intake in the *Leucaena* group followed by oat forage and *Prosopis* supplemented groups. The tendency for higher percentage of faecal N-losses on T-2 as compared to T-3 and T-1 in the present trial is related to the negative effects of polyphenolic compounds in *Prosopis* on microbial degradation of protein through the formation of indigestible complexes with protein (Waterman et al., 1980; Robbins et al., 1987). Consequently, the average daily retention of N was significantly more (p<0.05) in T-3 as compared to T-1 and T-2, but the goats maintained positive N-balance irrespective of dietary treatment.

The digestible crude protein (DCP) and total digestible nutrient (TDN) contents of experimental diets T-1 and T-2 were comparable (table 2), but they were significantly lower (p<0.01) than diet T-3. Similarly, intake (g/kg$W^{0.75}$) of CP, DCP, TDN and digestible organic matter (DOM) was significantly higher (p<0.01) in goats fed T-3 than in T-2 or T-1, owing to the higher DMI and digestibilities of the organic nutrients (table 2). Interestingly, though the intake of DCP (1.5-1.6 g) and TDN (19-21 g) by goats fed T-1 and T-2 was lower than the stipulated requirements (2.8 g DCP; 28 g TDN) of NRC (1981) for maintenance, the animals remained in positive nitrogen equilibrium. The nitrogen balance as an indicator of adequate protein intake is of questionable value in adult animals because they can adjust their nitrogen out put and reach equilibrium, particularly at lower levels of N-intake (Singh, 1976). Apparently, the goats offered *Leucaena* supplement gained weight, while those on the *Prosopis* and oat forage supplements lost weight, but the differences were not statistically significant (table 2).

Results of this experiment indicate that the provision of *Leucaena* (30% of total DMI) as a protein supplement will significantly increase total DM intake and the digestibility of rice straw diets. The judicious use of legumes and tree leaves should form part of feeding strategies to maintain animal production at critical times of the year. Further studies are warranted to look at microbial protein synthesis as affected by types and levels of soluble carbohydrate provided as tree forage supplements to low quality crop residues.

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