

Effect of Partial Replacement of Dietary Protein by a Leaf Meal Mixture Containing *Leucaena leucocephala*, *Morus alba* and *Azadirachta indica* on Performance of Goats

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ABSTRACT : This study was conducted to examine the effect of *Leucaena leucocephala*-*Morus alba*-*Azadirachta indica* (2:1:1) based leaf meal mixture as nitrogen source to partially replace (50%) soybean meal in conventional supplements on the performance of goats. Twelve non-descript female goats were divided into two equal groups in a completely randomized design to receive either the leaf meal mixture based supplement (LMAM) or soybean meal incorporated concentrate (SBM) and wheat straw for *ad libitum* intake for a two month period. The goats given LMAM and SBM concentrate had similar dry matter intake (50.2 ± 1.67 g/kg $W^{0.75}$) and nutrient digestibility. Nitrogen intake and its faecal and urinary excretion were similar irrespective of diets. The balance of nitrogen was positive and comparable (1.63 ± 0.08 g/d) in both dietary treatments. The plane of nutrition on both diets was comparable and the digestible crude protein and total digestible nutrients values of the composite diets offered did not differ significantly between the dietary supplements. The serum concentration of enzymes alanine aminotransferase and aspartate aminotransferase were statistically similar in both the groups, while haemoglobin and serum urea levels were significantly ($p < 0.05$) higher in LMAM and SBM treatments, respectively. It was concluded that the leaf meal mixture of *Leucaena leucocephala*-*Morus alba*-*Azadirachta indica* could be used as a vegetable protein supplement to wheat straw based diet of goats. (*Asian-Aust. J. Anim. Sci.* 2002, Vol 15, No. 12 : 1732-1737)

Key Words : Goats, Nutrient Utilization, Leaf Meal Mixture, Supplementation, Wheat Straw

INTRODUCTION

Goats have been recognized as the most effective livestock for promoting health and economy of marginal and landless farmers in many developing countries of the world. However, the development of proper feeding strategies for goats are of paramount importance to help them grow and produce well even in intensively cultivated areas. Cereal straws are increasingly being used as basal feeds for goats in the arable areas of the tropics. Evidence suggests that straw utilization could be improved by supplying deficient nutrients like nitrogen and other micro-nutrients to animals (Prasad et al., 2001). In this context, the role of fodder trees and shrubs in the diet of animals is considered particularly important in countries like India where small land holdings and large ruminant densities result in an especially severe problem of feed availability from more conventional sources like cakes and brans. A wide variety of multi-purpose tropical trees grown at the farmers' field can be used as nitrogen sources in supplementary feeds (Devendra, 1990; Topps, 1992; Ondiek et al., 2000). The leaves of *Leucaena leucocephala*, *Morus alba* and *Azadirachta indica* are potential nitrogen supplements (Nageswara Rao et al., 1996; Mahanta et al., 1999; Anbarasu et al., 2001; Liu et al., 2001). These tree forages not only provide a cheap source of nitrogen, energy

and micro-nutrients but have also many other advantages like their wide spread on-farm availability and easy accessibility to farmers, their laxative influence on the alimentary system, low degradability of nitrogen in the rumen and provision of variety in the diet. The tree leaves can be harvested, sun-dried and used in compounded protein supplements. The replacement of conventional ingredients by tree leaves will make such supplements cheaper than the commercial concentrates (Ondiek et al., 2000). However, the presence of anti-nutritional factors like mimosine in *Leucaena leucocephala*, triterpenoid derivatives (azadirachtin, nimbodin) in *Azadirachta indica* and phenolics in most of the leaves limit their use as animal fodder. Farmers usually minimize and overcome these problems by feeding different leaves in mixtures which not only dilutes and reduces the problem of palatability and toxic effects (Lowry, 1990) but also extends feed base for animals. In earlier experiments (Yusran and Teleni, 2000; Anbarasu et al., 2001), a mix of fresh leaves (*Gliricidia sepium*-*Leucaena leucocephala*-*Calliandra calothyrsus*) or a leaf meal mixture (*Leucaena leucocephala*-*Morus alba*-*Tectona grandis*) were successfully used as strategic supplements in the diet of cows and goats, respectively. However, an adherence to a fixed composition of leaf mixtures is not practicable because of area specific distribution and seasonal availability and accessibility of various plant species to the farmers. Hence, there is a need to test different potential sources and/or combinations of tree leaves to broaden the base of alternative quality feed resources for the feeding of livestock. Keeping this

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background in view, the experiment was undertaken to assess the suitability of *Leucaena leucocephala*-*Morus alba*-*Azadirachta indica* leaf meal mixture as a substitute of common vegetable protein supplement like soybean meal, used widely in concentrates.

MATERIALS AND METHODS

The experiment was conducted at Animal Nutrition Research Sheds of Indian Veterinary Research Institute (IVRI), Izatnagar in Uttar Pradesh province of India. It is located at 170 m above sea level (28° 22' latitude north and 79° 24' longitude east) in the northern upper Gangetic plain, having an annual rainfall of 900-1,200 mm. It is the region of the deepest soil in India with hardly any variation in relief and suitable for growing various types of subtropical crops and trees. Cereal straws such as wheat and rice form the basal diet of ruminants in the area.

Animal management and rations

Twelve local non-descript maiden does of approximately 2 years age with an average initial body weight of 14.6±0.69 kg were randomly allotted to two dietary treatments, each consisting of 6 does, in a completely randomized design. The goats were penned individually in a well-ventilated shed with free access to fresh water. They were offered a basal diet of wheat straw for *ad libitum* intake and either of the two concentrate mixtures computed as indicated in Table 1. The control diet (SBM) was formulated to be representative of a commercial concentrate and contained deoiled soybean meal as the principal protein source while leaf meal mixture formed part of other concentrate mixture (designated as LMAM) by replacing 50% protein of SBM supplement.

The leaf meal mixture component of LMAM concentrate contained sun-dried ground leaves of *Leucaena leucocephala*, *Morus alba* and *Azadirachta indica*. The leaves were individually sun-dried and ground in an electric grinder with 4 mm screen (C-Type, capacity-1t/h, Kiran India) before mixing them in the ratio of 2:1:1 on DM basis. The goats were given supplement to meet their protein requirement for maintenance and growth (25 g/day) as per Kears (1982) recommendations.

Experimental procedure

The daily allowance of the concentrates were offered in single meal at 9:00 h and wheat straw was then offered for *ad libitum* intake, after ensuring that the goats had consumed the concentrates. Orts of wheat straw were weighed 24 h post feeding to ascertain daily feed consumption. Daily DM intake and fortnightly body weight of all the animals were recorded throughout the study. Blood samples were collected by jugular vein-puncture

Table 1. Ingredients and chemical composition of supplements and wheat straw

Items	Supplements ^a		Wheat straw
	SBM	LMAM	
Ingredients (%)			
Maize	20	20	
Wheat bran	52	15	
Soybean meal	26	13	
Leaf meal mixture	-	50	
Mineral mixture ^b	1	1	
Salt	1	1	
Chemical composition (% DM)			
Organic matter	91.95	90.33	91.78
Crude protein	23.95	23.13	3.32
Ether extract	2.57	3.66	1.03
Total ash	8.05	9.67	8.22
NDF	33.14	26.82	83.53
ADF	10.07	10.71	54.28
Hemi-cellulose	23.07	16.11	36.28
Cellulose	7.46	7.02	30.40
ADL	2.61	3.69	6.80
Calcium	0.78	1.77	0.45
Phosphorus	0.79	0.56	0.08
Total tannins	-	3.15	-
Mimosine	-	1.15	-
Bulk density (kg/m ³)	443.14	374.66	83.65

^a SBM: Soybean meal, LMAM: Leaf meal based supplements, # NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin.

^b Mineral mixture contained (g/kg), calcium 220, phosphorus 95, sodium chloride 300, potassium iodide 2.5, iron 05, copper 0.8, cobalt 1, manganese 1 and sulphur 1.5.

before feeding in the morning on day 45 for analysis of haemoglobin (Hb), serum urea, serum alanine aminotransferase (ALT) and serum aspartate aminotransferase (AST).

A digestion and nitrogen balance trial was conducted after 45 days of feeding. During the metabolism trial, the goats were housed in individual metabolic cages with arrangements for quantitative collection of faeces and urine separately. The trial lasted for 10 days with 3 days adaptation period to accustom the goats to cages prior to a 7 days collection and measurement period. Samples of feed offered and refused were collected daily and kept in a hot air oven at 80±2°C for dry matter (DM) estimation. The dried material obtained during the trial period was pooled, ground in a Tecator cyclotec mill with 1 mm screen and stored at room temperature for chemical analysis. Similarly, total daily faecal output was recorded and a sub-sample collected and dried in a hot air oven to a constant weight for dry matter estimation. Representative samples of individual daily faecal and urine collection were pooled for 7 days and preserved in diluted (1:4) sulphuric acid for N estimation. The other sub-samples were retained for further chemical analysis in a freezer.

Chemical analysis and statistics

Proximate analysis and cell wall components were determined by the method of AOAC (1995) and Goering and Van Soest (1970), respectively. While the mimosine content of *Leucaena leucocephala* and LMAM concentrate was measured by the method of Megarrity (1978), the determination of tannins in the LMAM was done by oxidation with acid permanganate on volumetric basis (AOAC, 1995). Hemoglobin content was estimated immediately after collection of blood by acid haematin method (Benjamin, 1985). Activity of serum enzymes ALT and AST was ascertained using standard analytical methods described by Reitman and Frankel (1957). Serum urea was estimated by improved diacetyl monoxime method (Rahmatulla and Boyde, 1980).

The data were subjected to analysis of variance in a completely randomized design as per Snedecor and Cochran (1989) by programming and processing in a personal computer.

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of wheat straw and the two concentrate mixtures used in this experiment is shown in Table 1. The chemical composition of basal feed of wheat straw was comparable with the values reported earlier (Wales et al., 1990). The experimental concentrates offered were isonitrogenous and with similar levels of organic matter. The LMAM concentrate had higher ether extract and ash levels than SBM concentrate. This might be due to the presence of carotenoids, xanthophylls and minerals especially calcium in tree leaves which increases the ether extract and ash content, respectively (D'Mello and Acamovic, 1989). Among cell wall constituents, NDF and hemicellulose content of SBM concentrate were higher than LMAM, however the ADF content was comparable between both the supplements. The use of wheat bran in higher proportion might have increased the NDF and hemicellulose content of SBM diet as compared to LMAM. The concentrates having ingredients of by-product origin usually high in hemicellulose could contribute to the fibrous component of the diet (Van Soest, 1982). In many tree leaves as have been used in this study, ADF fraction is usually present in larger proportion in relation to the NDF, which indicates a high content of cellulose and lignin and low levels of hemicellulose (Topps, 1992). These factors may also explain the difference observed in bulk density values (kg feed/m^3) of LMAM and SBM concentrate (Mertens, 1982). The moderate total amount of tannins and mimosine in LMAM concentrate mixture was understandable because of the presence of phenolics in tree leaves and mimosine in *Leucaena leucocephala*.

Dry matter intake

Dry matter intake (DMI, $\text{g/kg W}^{0.75}$) of goats did not differ significantly between the treatments (Figure 1). Goats maintained their DMI in both the treatments ($50.2 \pm 0.46 \text{ g/kg W}^{0.75}$) during the entire experimental period. The intake of concentrate moiety ($21.99 \pm 0.46 \text{ g/kg W}^{0.75}$), which comprised proportionately about 0.42 parts of the total intake by goats, remained also unaffected by dietary treatments. Most of the straw-based basal feeds in the tropics are usually low in nitrogen, digestible nutrients and minerals (Goodchild and McMeniman, 1994; Khandaker et al., 1998). An ideal supplement to such feeds should not only compensate for the nutrient deficiency but should also maintain or even boost the intake of basal diets, a phenomenon that has been frequently observed in animals fed on legumes or tree leaves (McMeniman et al., 1988; Narayan Dutta et al., 1999; Ondiek et al., 2000; Anbarasu et al., 2001). Interestingly, in the present experiment, despite bulky nature of LMAM concentrate (Table 1), it maintained straw intake of goats at par with commercial type vegetable protein concentrate SBM, which are either not easily accessible or too expensive for small and marginal farmers.

Nutrient utilization

The digestibility of various nutrients was comparable ($p > 0.05$) among goats on different supplements (Table 2). The results obtained across a wide range of tree leaves indicate that while it may not be possible to exactly predict the effect of phenolics on nutritive value of tree leaves incorporated diets, the reduction in digestibility has been attributed to the negative effect of secondary plant chemicals such as phenolics through formation of indigestible complexes with proteins (Reed et al., 1990; Rittner and Reed, 1992; Singh and Bhat, 2001). However, there was no decrease in nutrient digestibility of ration supplemented with LMAM concentrate probably due to presence of only moderate amount of tannins in the ration. It has been reported that diets containing upto 5% tannins are utilized efficiently by the animals without any deleterious effect on intake or nutrient digestibility (Barry

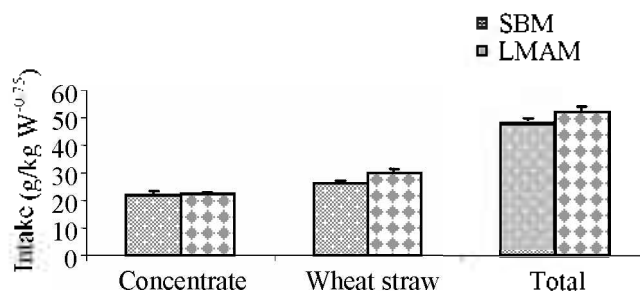


Figure 1. Mean daily feed intake by goats fed soybean (SBM) or leaf meal (LMAM) based concentrate supplement.

Table 2. Utilization of nutrients and N-balance in goats fed different supplements

Items	Supplements ^a		SEM
	SBM	LMAM	
Nutrient digestibility (%)			
Dry matter	55.11	52.25	1.17
Organic matter	57.43	54.62	1.13
Crude protein	51.97	51.89	0.77
Ether extract	64.38	59.88	2.72
Neutral detergent fibre	50.54	48.69	1.42
Acid detergent fibre	45.39	44.32	1.68
Hemi-cellulose	58.01	56.72	0.70
Cellulose	42.56	45.72	0.06
Nitrogen balance (g/d)			
Intake	7.33	7.72	0.40
Faecal loss	3.38	3.77	0.21
Urinary loss	2.36	2.29	0.14
Balance	1.59	1.66	0.08
Retention			
As % of intake	21.84	21.69	0.55
As % of absorbed	40.67	42.37	0.89

^aSBM: Soybean meal, LMAM: Leaf meal based supplements.

Means in a row did not differ significantly ($p > 0.05$).

and McNabb, 1999). The comparable digestibility of CP observed in LMAM and SBM supplemented diet could be attributed to probable analogous protein quality of soybean meal and leaf meal mixture, which is further substantiated by the similar pattern of nitrogen retention. The digestibility values of other nutrients such as ether extracts and fibre fractions did not differ significantly between dietary treatments and are in conformity with the findings of several workers on diets based on leaf meals and oil cakes (Warly et al., 1994; Haque et al., 1997; Mahanta et al., 1999; Ondiek et al., 2000).

Daily intake of nitrogen was comparable among goats irrespective of dietary treatments (Table 2). All the animals had positive nitrogen balance, indicating adequate nutritional level of the two supplements. The N-utilization pattern observed in LMAM group may be consistent with the alternative hypothesis of escape protein as a mechanism to explain the positive effects of tannins on protein utilization in ruminants (Reed, 1995; Singh and Bhat, 2001). Contrary to reports indicating higher faecal nitrogen losses in animals given tanniferous forages (Ndemanisho et al., 1998; Srivastava and Sharma, 1998), the faecal nitrogen excretion of goats on LMAM concentrate was not more than the goats given SBM concentrate though it contained moderate amount of tannins (3.2%). Another feature of nitrogen utilization as evidenced by similar nitrogen retention as percentage of absorbed nitrogen (an indicator of availability of amino acid-N at tissue level) in these animals was apparently due to the analogous amino acid composition and apparent biological value of proteins in soybean meal or leaf meal mixture (Mc Donald et al., 1987; D' Mello and Acamovic, 1989).

Plane of nutrition and body weight changes

The nutritive value of composite diets, wheat straw and respective concentrate mixture, in terms of per cent content of digestible crude protein (DCP) and total digestible nutrients (TDN) did not differ significantly (Table 3). Daily intake ($\text{g/kg W}^{0.75}$) of DCP and TDN by goats in both the groups was also comparable. Incidentally, all the goats had DCP intake well above the recommended allowance (NRC, 1981; Kearn, 1982). TDN intake ($\text{g/kg W}^{0.75}$) was similar between the treatments. However, it is significant to note that though TDN intake by goats in both the groups was 22-24% lower than the recommended value 32-34 $\text{g/kg W}^{0.75}$ for maintenance and growth (20 g/d) (NRC, 1981; Kearn, 1982), the goats remained in good health condition and could attain the desired body weight changes during the experiment. It gave an indication that indigenous goats might require significantly lower level of dietary energy than the recommended values in-vogue. Initial and final body weights of goats were similar irrespective of different protein supplements and thus accounted for the comparable net live weight changes (Table 3). These results were in agreement with the earlier reports indicating similar body condition in animals on various leaf meals or conventional cakes (Tewatia et al., 1997; Ndemanisho et al., 1998; Mahanta et al., 1999; Anbarasu et al., 2001).

Blood biochemical profile

The Hb level in goats was within normal range (8-12 g/d) as reported by Benjamin (1985) and Kaneko (1997). However, significantly ($p < 0.05$) higher level of Hb in goats fed LMAM than SBM fed goats (Table 3) could be attributed to the presence of considerable amount of trace

Table 3. Effect of supplementation on body weight changes, plane of nutrition and blood-biochemical profile

Attributes	Supplements ¹		SEM
	SBM	LMAM	
Body weight changes			
Initial body weight (kg)	14.80	14.34	0.69
Final body weight (kg)	15.59	15.25	0.70
Net gain (kg)	0.79	0.91	0.11
Average daily gain, g/day	17.48	20.08	2.58
Nutrient density (%DM)			
Digestible crude protein	6.70	6.21	0.21
Total digestible nutrients	55.83	54.18	1.23
Nutrient intake, ($\text{g/kg W}^{0.75}$)			
Digestible crude protein	3.15	3.19	0.09
Total digestible nutrients	26.91	27.33	0.85
Blood-biochemical profile			
Hemoglobin (g/dl)	10.50 ^a	11.67 ^b	0.31
Serum urea (mg/dl)	49.67 ^b	41.15 ^a	3.12
AST (IU/L)	82.92	87.33	5.85
ALT (IU/L)	33.33	34.58	1.23

^{a,b} Means with different superscripts in a row differ ($p < 0.05$).

¹ SBM and LMAM treatments containing soybean meal and leaf meal mixture protein, respectively.

element like iron, copper etc. in tree leaves (Vercose, 1987), which are essential for Hb synthesis. The serum AST and ALT level were similar in this study despite dietary variation. This confirmed that replacement of SBM by LMAM had no adverse effect on liver and muscles. The serum urea concentration (mg/dl) were close to the normal range reported for goats (Kaneko, 1997) irrespective of dietary treatments. However, the serum urea concentration in SBM group was significantly ($p < 0.05$) higher in comparison to the LMAM group. This could be due to lower dietary density of ME (kcal/g) relative to the rumen degradable protein (RDP) in the SBM supplement as compared to LMAM (Patra, 2001). The efficient utilization of RDP for microbial growth requires an optimal supply of available energy (Nocek and Russell, 1988). In the face of lower availability of energy per unit RDP, there appeared to be a reduction in entrapping of RDP for biosynthesis of microbial cell materials with the resultant un-utilized ammonia nitrogen being converted to urea in liver (Victor, 2000).

CONCLUSION

The tree leaves are usually lower in crude protein than conventional cakes, but they may be effectively used to substantially replace common protein ingredients of commercial concentrates without any apparent adverse impact on their nutritional performance and health. Considering the palatability, easy on-farm accessibility and wider use of tree fodder base, leaf meal mixtures like *Leucaena leucocephala*-*Morus alba*-*Azadirachta indica* may mitigate the shortage of protein source for marginal goat farmers. Further long term trials are necessary to evaluate the feasibility and the potential of various leaf meal mixtures in commercial formulations for sustainable goat production.

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