Leucaena Seeds as Protein Supplement in the Rations of Growing Sheep

Sultan Singh*, S. S. Kundu, A. S. Negi, S. K. Gupta, N. P. Singh and V. C. Pachouri
Indian Grassland and Fodder Research Institute. Jhansi-284003 (UP). India

ABSTRACT : The study was carried out to evaluate *leucaena* seeds as a protein replacement of mustard seed cake (MSC) in the concentrate mixture of growing lambs. Fifteen growing male lambs (Local×Corridale) with an average body weight of 16.3 kg were allocated into three dietary treatments (T1, T2, and T3) with five animals in each group. Animals were offered dry mixed grass, berseem hay and concentrate mixture to meet their nutrient requirements. In concentrate mixture of T1, (Control) MSC was used as protein source, while in T2 and T3 groups, 25 and 50% of MSC was replaced by *leucaena leucocephala* seeds. On completion of three months (90 days) of feeding, a digestion cum-metabolism trial was conducted to determine DMI, nutrient utilization, and nitrogen balance. Changes in body weight were recorded at 15 day internals and eating patterns were recorded for 3 consecutive days at the end of the feeding trial. MSC had higher CP contents than *leucaena* seeds (27.0%). Mimosine contents in leucaena seeds were 1.1 compared to 0.2 and 0.4% in concentrate mixture of T2 and T3 group, respectively. Dry matter intake varied non-significantly (79.3±1.2 to 83.4±1.3 g/kg $w^{0.75}$) across the dietary treatments. Digestibility of DM and cell wall polysaccharides (NDF, ADF, Cellulose and hemicellulose) were comparable, however CP digestibility was relatively lower in *leucaena luecocephala* seeds based groups (T2 45.5±1.7 and T3 46.7±3.5) compared to MSC supplemented group (T1 47.7±0.9%). The growth rate of lambs was non-significantly higher in T1 (79.2±5.4) compared to T2 (73.8±8.8) and T3 (73.9±7.0), respectively. The animals were in positive nitrogen balance and N-balance varied from 1.8 to 2.9 g/d across treatment groups. The eating rate (% of total offered) of concentrate up-to 15 min was relatively higher in T1 (82.4) than T2 (74.2) and T3 (77.8%). However no effect of *leucaena* seeds was recorded on total DMI of animals. The results of the study revealed that the inclusion of up to 50% *leucaena* seeds, as protein source in concentrate mixture of lambs had no adverse effect on DMI, nutrient utilization, eating patterns, nitrogen balance and growth performance of lambs. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 10 : 1433-1438)***

Key Words : *Leucaena* Seeds, Growth, Eating Pattern, Nitrogen Balance

INTRODUCTION

The Availability of good quality grazing pastures and sufficient fodder/feeds is one of the most limiting factors for lower level of animal production in the tropics. In the demand and availability scenario of nutrients, digestible crude protein (DCP) and total digestible nutrients (TDN) are deficit in India to the tune of 21 and 51%, respectively. The traditionally used protein sources i.e. oil cakes (groundnut cake, mustard seed cake, soyabean cake, linseed cake, cotton seed cake etc) are not only scarce but also high in cost and when available are fed mainly to dairy animals. In this situation, feeding commonly available protein sources to small ruminants becomes a matter of concern. *Leucaena leucocephala* seeds and other unconventional protein sources seem to be alternative protein source to traditionally used oil cakes in the ration of ruminants, particularly sheep and goat.

Subabul (*L. leucocephala*) is a promising legume with its leaves, pods, and seeds as rich source of protein, minerals and essential fatty acids (NAS, 1977; Jones, 1979; Yadava, 1988; Chakraborty and Chhabra, 1988; Gupta et al., 1988; Gupta and Raheja, 1986; Ram et al., 1994; Dharamsare et al., 1991; Gupta and Atreja, 1998). Garcia et al. (1996) reported that the LLM contained 42% RDP and 48% UDP having amino acid values comparable to that of soyabean and fishmeal with the exception to that of sulfur amino acids. This indicates that *Leucaena leucocephala* seeds may be exploited as a protein and mineral source in the rations of ruminants despite the presence of Mimosine and its degradative product 3-hydroxy-4(1H)-pyridone (Ross and Springhall, 1963; Ram et al., 1994). Minosine contents vary in different plant parts of *leucaena*. The mimosine content in seeds in the range of 3.61 to 5.04% of DM has been reported (Jones, 1979; Gupta and Raheja, 1986; Chakraborty and Chhabra, 1988; Gawpawar et al., 1988). D' Mello (1992) reported as high as 14.5% minosine in *leuceana* seeds. With this background, the present study was planned to evaluate the *leucaena leucocephala* seeds as replacer of MSC in rations of lambs for DMI, nutrients utilization, eating pattern, nitrogen balance and growth performance of lambs.

* Corresponding Author : Sultan Singh. Tel: +91-0517-444771, E-mail: sultan@igfri.up nic.in
Received February 15, 2002; Accepted May 14, 2002

MATERIALS AND METHODS

Animals and housing

Sixteen growing male (Local×Corridale) lambs with a body weight between 13 to 21 kg (mean weight 16.3 kg) were randomly distributed into three dietary treatment groups (T1, T2 and T3) with 5 animals in each group. Animals were tied with iron chains and housed in a small

animal shed with a mud floor at the animal experiment farm of Indian Grassland and Fodder Research Institute (IGFRI) Jhansi.

Feeds and Feeding:

Leucaena seeds used as protein source were collected manually by harvesting pods from the trees planted in Central Research farm area of the Institute. Harvested pods were dried on a cement floor and the seeds were separated. Lambs were offered dry mixed grass (consisting of *Cenchrus. cilliaris, Sehima. nervosum, Chryosopogon. fulvus, Dichanthium. annulatum*), berseem and concentrate mixtures to meet their nutritional requirements (ICAR, 1985). Feed ingredients and their relative proportions in different concentrate mixtures are given in Table 1. Initially, concentrate mixtures containing different protein sources were offered to lambs individually in feeding troughs between 09:00 to 10:00 h to meet 60% of the total protein requirement, while the remaining 40% of protein was met through berseem hay offered at 11:00 h. Concentrate mixture was supplemented with mineral mixture (containing 72% Ca, 9.0% p<0.06% Cu, 0.01% Co, 0.09% Mn, 0.02% I, 0.15% Zn and 40% Fe) and common salt. This was followed by giving the lambs of clean water and feeding them dry mixed grass. The Animals were again provided clean water at 15:00 h. Concentrate mixture offered to animals in control (T1) group consisted of mustard cake (MSC) as the sole source of protein. In concentrate mixture of groups T2 and T3, 25 and 50% of MSC was replaced by *Leucaena leucocephala* ground seeds as protein source on nitrogen basis.

Growth and metabolism trial:

Lambs were maintained on a dry grass, berseem, and concentrate mixture dietary regimen for a period of 120 days. The feeding trial was started from 30-1-2000 to 16-5-200. The meteorological data on temperature, humidity and rainfall for experimental period (February to 16 May, 2000) recorded from Institute Meteorological Observatory. The minimum and maximum temperature ranged from 7.2-26.0, and 25.0-40.7°C while the rainfall varied from 1.5-50.3 mm in different months. The weight gain of the animals was calculated for 105 days as the initial 15 days customization period was removed from growth trial. Lambs were weighed at two weeks intervals prior to watering and feeding. After 90 days of feeding a digestion-cum metabolism trial of 6 days duration was conducted. Lambs were kept in iron metabolic cages and samples of feed, feces and urine voided were collected individually during the metabolism trial. The samples were then pooled for each lamb for chemical analysis.

Table 1. Concentrate composition of different groups of lambs

Ingredients	T1	T2	T3
Barley	40	40	40
Wheat bran	23	20	18
Mustard cake	35	27	17
Leucaena seeds	-	11	23
Mineral mixture	1	1	1
Common salt	1	1	1
CP%	16.9	17.1	17.0

Analytical techniques

Dry matter content of feeds, fodder and feces were estimated by hot air oven drying at 100°C for 24 h. For chemical analysis, pooled samples of feeds offered, refusals and feces were dried at 60°C and then ground to pass through 1mm sieve using an electrically operated Willey mill. Fresh feces and urine samples were preserved in dilute and concentrated sulfuric acid, respectively, were analyzed for nitrogen by the micro-kjeldhal method. Feed and feces samples were analyzed for CP and ash contents (AOAC, 1992) and fiber fractions viz. NDF, ADF, cellulose and lignin contents (Goering and Van Soest, 1970). Mimosine contents *in leucaena leucocephala* seeds and concentrate mixtures of T2 and T3 groups were estimated as per the standard method described by Gupta et al. (1992).

Eating patterns

For eating patterns, lambs were first individually offered the required amount of concentrate in feeding troughs and intake was recorded at 15 and 30 min of feeding. This was followed by an offering of berseem hay and a half serving (250 g) of grass hay. Similarly the intake was recorded at 1, 2 and 4 h of their feeding. Animals were given 250 g of grass at 16:00 h. To calculate total intake, the residue left was recorded on the following day. This was continued for three consecutive days. To estimate meal size for 1 and 2 h, the amount of concentrate and roughage was pooled together.

Statistical analysis

The data generated during the study was analyzed statistically as per the methods described by Snedecor and Cochran (1968).

RESULTS AND DISCUSSION

Chemical composition

Chemical constituents of feed ingredients, fodder and concentrate mixtures fed to lambs are given in Table 2. The CP content of MSC (34.0) was higher than *leucaena* seeds (27.0%). Berseem hay was of medium quality as it had 15.2% CP, while the dry mixed grass contained only 3.1% CP, which indicates its maturity. Cell wall polysaccharides of concentrate mixtures were comparable to mustard cake. Mimosine contents in *Luecaena* seeds and concentrate

Table 2. Chemical compositions of feeds and fodder

Feed ingredients	OM	CP	NDF	ADF	Cellulose	H-cell	Lignin	Tannin
Dry mixed grass	92	3.1	79.4	52.1	38.9	27.3	8.0	-
Berseem hay	86.5	15.2	41.1	32.6	25.9	8.5	5.8	-
Leucaena seeds	95.7	27.1	44.2	20.6	16.5	23.6	4.2	1.1
Mustard seed cake	88.9	34.0	31.8	23.1	14.2	8.7	4.1	-
Wheat bran	89.7	14.1	35.1	10.9	7.6	24.2	1.9	-
Barley	88.30	8.14	23.70	8.50	7.12	15.20	0.5	-
Concentrate mixture-I	90.4	19.1	34.0	17.2	11.4	16.8	3.81	
Concentrate mixture-II	90.7	19.0	35.1	16.8	11.6	18.2	3.5	0.2
Concentrate mixture-III	91.4	19.3	29.7	16.0	11.3	13.6	3.3	0.4

mixture of T2 and T3 group were 1.0, and 0.2 and 0.4%, respectively. This shows that mimosine contents of *Leucaena* seeds were relatively lower in present study compared to reported values (Jones, 1979; Akbar, 1983; Gupta and Raheja, 1986; Chakraborty and Chhabra, 1988; Gampawar et al., 1988). These workers reported mimosine contents in the range of 3.6-5.0% in *Leucaena* seeds. D'Mello (1992), however reported that up to 14.5% minosine may be present in the *leucaena* seeds. The CP contents in *Leucaena* seeds (27.6%) reported by Akbar (1983) corroborate to the present results. However, Gupta and Raheja (1986) observed higher CP contents (36.5%) in *leucaena* seeds. Wide variation in CP (21.2-30.4), CF (6.1-11.0), EE (4.9-8.9), total ash (4.3-10.8), Ca (0.29-1.8) and P (0.3-0.38%) contents on DM basis had been reported by several workers (Shukla et al., 1987; Bhaskar et al., 1987; Gupta et al., 1886; Dharamsare et al., 1991 and Garcia et al., 1996). Cell wall fraction concentration in *Leucaena* seeds of different cultivars (Yadava and Yadava, 1988) are comparable to the present findings. Gupta and Raheja (1986) observed that *Leucaena* seed had 25.6, 17.6, 15.0, 7.9 and 2.6% NDF, ADF, cellulose, hemi-cellulose and lignin, which are consonance with the findings of the present study.

DMI and nutrients digestibility:

Dry matter intake and nutrients utilization in lambs of different dietary groups is presented in Table 3. Dry matter intake of the lambs did not differ significantly across the dietary regimens. Lambs had 79.3±1.2, 80.6±2.2 and 83.4±1.3 g intake per kg $W^{0.75}$ in T1, T2, and T3 groups, respectively. Intake values on % body weight basis were 3.8±0.0, 3.8±0.0 and 3.9±0.0 in animals of T1, T2 and T3 group, respectively. The roughage to concentrate ratio was 60.8:39.2, 60.7:39.3 and 61.9:38.1 in T1, T2 and T3 groups, respectively. Gampawar et al. (1988) observed that replacement of CP up to 30% by *Leucaena* seed had no affect on feed intake. Complete the replacement of GNC by *leucaena* seeds in concentrate mixture of goats exhibited non-significant difference on mean daily DMI (Gupta et al., 1987). Goats consumed 52-67 g/kg $W^{0.75}$ dry matter on *leucaena* seed based ration feeding (Chakarborty and Chhabra, 1988) which is relatively lower to the present findings. Higher DMI in present study may be attributed to supplementary effect of berseem hay on intake. Goats had 3.1% DMI on feeding of subabul pods (Radha et al., 1995). DMI in buffalo calves was 3.2 and 2.8% in de-oiled GNC and water treated subabul based concentrate mixture containing crushed subabul seed at 0.5 and 10% levels, respectively.

Table 3. Dry matter intake and nutrients digestibility in lambs of different dietary groups

Parameter	T1	T2	T3
DMI			
g/day	727.7±29.4	745.5±66.7	804.2±56.1
% body weight	3.8±0.0	3.8±0.0	3.9±0.0
g/kg $W^{0.75}$	79.3±1.2	80.6±2.2	83.4±1.3
Roughage: concentrate	60.8:39.2	60.7:39.3	61.9:38.1
Nutrients digestibility			
DM	59.7±0	58.2±1.3	58.7±0.9
OM	62.3±0.5	60.2±1.4	59.5±0.9
CP	47.7±0.9	45.5±1.7	46.7±3.5
NDF	46.9±0.2	47.9±1.6	45.2±1.4
ADF	40.0±0.7	41.1±2.2	39.60±1.3
Cellulose	52.7±0.8	53.7±1.3	51.5±1.3
Hemi-cellulose	58.2±0.6	61.6±1.4	56.5±1.6

Treatment means± SEM were non-significant at $p<0.05$ levels.

The digestibility of nutrients was comparable in all the dietary treatment groups. Lambs revealed 59.7±0.2, 58.2±1.3 and 58.7±0.9% DM digestibility in T1, T2 and T3 groups, respectively. Crude protein digestibility was non-significantly lower in *leucaena leucocephala* seeds based groups (T2, 45.5±1.7 and T3, 46.7±3.5) compared to MSC supplemented group (T1, 47.7±0.9), respectively. Utilization of fiber fraction viz. NDF, ADF, cellulose and hemi-cellulose was comparable amongst the dietary groups. Animals had 46.9±0.2, 47.9±1.6 and 45.2±1.4% NDF digestibility in T1, T2 and T3 dietary groups, respectively. Across the dietary regimens ADF digestibility varied from 39.60±1.3 to 41.1±2.2%. On the other hand cellulose and hemicellulose digestibility in lambs was 52.7±0.8 and 58.2±0.6; 53.7±1.3 and 61.6±1.4 and 51.5±1.3 and 56.5%±1.6% due to T1, T2 and T3 dietary treatments. Inclusion of

leucaena seed in different ratios in concentrate mixture of ruminants had no adverse effect on nutrient utilization (Gupta et al., 1987; Gupta et al., 1991 and Tiwari and Chawala, 1995). However significantly ($p<0.05$) lowered digestibility of CP and EE were observed by (Gupta et al., 1987) due to 100% replacement of GNC by *leucaena* seeds in goats. Later observation may probably be due to over protection of protein by tannins resulting in lower digestibility of CP.

Growth rate

The average daily gain (g/d) of lambs on MSC supplemented diets (T1) was non-significantly ($p>0.05$) higher than T2 and T3 dietary groups (Table 4). Daily gain of animals ranged between 73.8±8.8 to 79.2±5.4 g across the dietary treatments. Change in weight of animals at 15 days interval (fortnightly) up to 105 days has been presented in Figure 1. In the 1st fortnight of the growth trial, the lambs body weight gain varied between 57.8 to 67.0 g/d amongst the dietary groups. In the 2nd fortnight, animals in all the groups showed lower body weight gain by 20 g compared to 1st fortnight. Lambs attained maximum growth during 4th and 6th fortnight in MSC (103, 105) and *leucaena* seeds supplemented groups (T2 100, 93.5 and T3 96.5, 101.0), respectively. Replacement of CP up to 30% by *leucaena* seeds in Sahiwal×Jersy calves and 100% of GNC by *Leucaena leucococephala* seeds in concentrate mixture of Beetal×Bengal kids had no adverse effect on their body growth (Gampawar et al., 1988; Gupta et al., 1987). Similarly replacement of CP in concentrate mixture up to 89% by *Leucaena* seeds exhibited normal growth rate in goats (Chakarborty and Chhabra, 1988). Gupta et al. (1991) observed growth rate of 0.653 and 0.577 kg/d in male buffalo calves fed concentrate mixtures having de-oiled GNC and water treated sababul seeds, respectively. Average daily gain of 0.500, 0.490 and 0.454 kg/d in buffalo calves fed concentrate mixture containing crushed subabul seed at 0, 5 and 10% levels, respectively (Tiwari and Chawla, 1995) followed similar patterns of growth as observed in the present study.

Table 4. Growth rate of animals on different dietary treatments

Parameter*	T1	T2	T3
Initial weight	14.7±0.6	152±1.16	17.2±2.1
Final weight	23.6±1.0	23.6±2.0	25.0±1.7
Total gain	8.5±0.5	7.7±0.9	7.75±0.7
Growth rate (g/d)	79.2±5.4	73.82±8.8	73.9±7.0

Treatment means± SEM were non-significant at $p<0.05$ level.

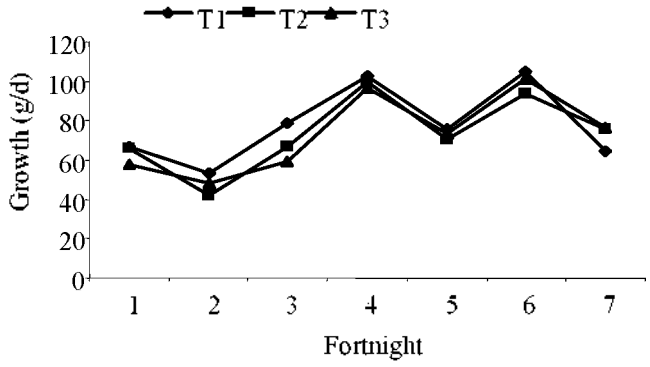

Figure 1. Body weight change at fortnight interval

Nitrogen balance

Nitrogen intake of lambs (g/d) varied from 13.7±0.2 to 15.9±1.0 amongst dietary groups (Table 5). All the animals were in positive nitrogen balance, which did not vary ($p>0.05$) among the treatment groups. Nitrogen balance (g/d) was relatively higher in T3 (2.97±0.8) than T1 (1.9 ±0.5) and T2 (1.82±0.5). Faecal and urinary nitrogen excretion was comparable among the dietary regimens. The nitrogen retention (% of intake) was comparable among different groups, while N-retention (% of digested) was 10 units more in T3 compared to other dietary groups. This higher balance in T3 may be due to relatively higher N intake and lower urinary loss compared to other groups. Similar findings on nitrogen utilization of *leucaena leucocephala* seeds based concentrate mixtures have been reported in different ruminant species by various workers (Gupta et al., 1991; Tiwari and Chawla, 1995)

Eating patterns

The eating rate of concentrate and total diets at different period in lambs has been given in Table 6. Concentrate intake (g) is first 15 min was 248.2, 228.7 and 250.0 in group T1, T2, and T3, respectively. This shows that animals consumed 82.38, 74.26 and 77.8% of total offered concentrate during 15 minutes of feeding in different dietary groups exhibiting reduced intake of concentrate in the *leucaena leucephala* seeds supplemented groups. However intake (%) of concentrate was almost identical in control (98.4) and *leucaena leucocephala* supplemented group (T2 97.8 and T3 96.9) at 30 min of feeding. Animals consumed 93.3, 97.5, and 120.0 g roughage during first h in

Table 5. Nitrogen balance in lambs on various dietary treatments

Parameter	T1	T2	T3
Nitrogen balance g/d			
Nitrogen intake	14.7±0.4	13.7±0.2	15.9±1.0
Faecal-N	7.6±0.1	7.5±0.4	8.4±0.6
N-digested	7.0±0.3	6.2±0.1	7.5±0.9
Urinary-N g/day	5.1±0.5	4.4±0.4	4.5±0.8
Balance	1.9±0.5	1.8±0.5	2.9±0.8
Retention			
N-retention (% intake)	13.6	13.4	18.6
N-retention (% digested)	28.1	29.4	38.6

Treatment means±SEM were non-significant at $p<0.05$ level.

Table 6. Eating patterns of animals on different dietary regimens

Parameter	T1	T2	T3
Concentrate intake (g) in 15 m	248.2±18.5	228.7±13.9	250.0±9.7
% Consumption in 15 m	82.4±5.82	74.3±2.3	77.8±2.2
Concentrate intake (g) in 30 m	296.7±6.2	302.5±23.1	312.5±18.8
% Consumption in 30 m	98.4±0.7	97.8±0.8	96.9±1.4
Grass consumption (g) in 1st h	93.3±12.4	97.5±9.5	120.0±30.8
% Intake of total grass	19.5±2.9	20.1±1.8	24.5±6.6
Meal size (g in 2 h)	395.0±20.7	406.2±25.9	442.5±27.3
Meal size (g/kg $W^{0.75}$/h	43.0±1.3	44.1±1.2	46.3±3.4
Total intake g/d	778.4±44.5	756.2±42.7	802.5±39.5

Treatment means± SEM were non-significant at $p<0.05$ levels.

T1, T2 and T3, respectively. Intake of total roughage offered was relatively higher in T3 (24.5) compared to T2 (20.1) and T1 (19.5%), respectively. Meal size in first two hrs of feeding was 395.0, 406.25 and 442.5 g in lambs of T1, T2 and T3 groups, respectively. Feed consumption g/kg $W^{0.75}$/h up to 2 h of feeding was relatively higher in T3 (46.3) than in T2 (44.1) and T1 (43.0) groups. This shows that, initially, the intake of concentrate reduced due to *leucaena* seeds. The lower rate of intake in *leucaena leucocephala* seeds supplemented groups may be attributed to more grinding of crushed leuccaena seeds during eating compared to the easily ground mustard seed cake. However, there was no adverse effect of *leucaena leucocephala* seeds on total DMI of animals and it ranged from 756.2±42.7 to 602.5±39.5 g/d amongst the dietary groups. Studies on eating patterns with *leucaena* seeds are scare, however a number of workers had reported inconsistent effects of *leucaena* seeds on total dietary intake in ruminant animals.

CONCLUSION

The results of the study revealed that *leucaena* seeds can be used as potential protein replacer of conventionally used mustard seed cake (MSC) in the concentrate mixture of growing lambs since it did not alter the dietary intake, nutrients utilization, eating pattern, N balance and growth performance of animals.

ACKNOELEDGEMENTS

The authors sincerely acknowledge the Director, IGFRI for financial support. The authors are thankful to Sh. Ram Kishan and Rashid Ahmed for technical support in the chemical analysis of the samples.

REFERENCES

Akbar, M. A. 1983. Studies on Subabul (*Leucaena leucocephala*) as a source of protein supplement for buffalo calves. M. V. Sc. Thesis, Haryana Agricultural University, Hisar, Haryana, India.

AOAC. 1992. Official Methods of Analysis.14th Ed. Association of Analytical Chemists. Washington, DC.

Chakaraborty, R. P. and A. Chhabra .1988. Chemical composition of *Leucaena leucocephala* seeds and effects of its feeding on growth and feed conversion efficiency in goats. Indian J. Anim. Nutr. 5(3):244-247.

D' Mello, J. P. F. 1992. Chemical composition to the use of tropical legumes in animal nutrition. Anim. Feed Sci. Technol. 38:237-61.

Dharamsare, K. S., A. S. Gampawar and M. V. Gorentiwar. 1991. Effect of supplementation of Subabul (*Leucaena leucocephala*) seed on growth rate in heifers. Indian J. Anim. Nutr. 8:61-64.

Gampawar, A. S., V. M. Gorantiwar and S. S. Bhaiswar. 1988. Effect of feeding Sbabul (*Leucaena leucocephala*) seeds as a part of protein supplement on growth in Sahiwal×Jersey calves. Indian J. Anim. Nutr. 5(3):240-243.

Goering, H. K. and P. J. Van Soest. 1970. *Forage fiber analysis*. Agriculture Hand Book no. 379, AR, USDA, Washington, DC.

Gupta, B. K. and R. K. Raheja. 1986. Lipid, mineral and other nutritional components of subabul (*Leucaena leucephala*) seeds. Indian J. Anim. Nutr. 3(4):233-237.

Gupta, P. C., A. S. Virk, V. K. Khatta, N. Kumar and V. Sagar. 1987. Nutrient digestibility, growth and meat quality of goats fed Subabul (*Leucaena leucocephala*) seed containing diets. Indian J. Anim. Nutr. 4:238-242.

Gupta, P. C., M. A. Akbar and V. Sagar. 1986. Subabul (*Leucaena leucocephala*) A new feed resource, Department of Animal Nutrition, H.A.U. Hisar. India.

Gupta, B. K., R. P. Gupa and N. S. Malik. 1988. Effect of replacement of green lucerne with Subabul (leucaena leucocephala) leaf meal in the diet on nutrient utilization and growth in buffalo calves. Indian J. Anim. Sci. 5:202-206.

Gupta, B. K., A. K. Ahuja and N. S. Malik. 1991. Effect of replacement of de-oiled GNC with processed Subabul (*Leucaena leucocephala*) seeds in ration of buffalo calves. Indian J. Anim. Nutr. 8:131-134.

Gupta, P. C., V. K. Khatta and A. B. Mondal. 1992. Analytical Technique in Animal Nutrition. 2nd ed. Directorate of Publications, H.A.U., Hisar, India.

Gupta, H. K. and P. P. Atreja. 1998. Effect of feric chloride treated leucaena leucocephala on metabolism of mimosine and 3-hydroxy (1H)-pyridone in growing rabbits. Anim. Feed Sci. Technol. (In press)

Garcia, G. W., T. U. Ferguson, F. A. Neckles and K. A. E. Archibald. 1996. The nutritive value and forage productivity of

Leucaena leucocephala . Anim. Feed Sci. Technol. 60:29-41.

ICAR. 1985. Nutrient Requirements of Livestock and Poultry. ICAR, Krishi Anushndhan Bhavan, Pusa, New Delhi.

Jones, R. J. 1979.Value of *Leucaena leucocephala* as a feed for ruminants in the tropics. World Animal Review. 31:13-23.

NAS. 1977. Leucaena : promising Forage and Tree Crop for the Tropics. National Academy of Sciences, Washington, DC.

Radha, K., M. M. Naidu and K. J. Redy. 1995. Nutritive value of Sababul (Leucaena leucocephala) pods in goats. Indian J. Anim. Nutr. 13:73-76.

Ram J. J., P. P. Atreja, A. Chhabra and R. C. Chopra. 1994. Mimosine degradation in calves fed sole diet of Leucaena leucocephala in India. Tropical Health Production 26:199-206.

Ross, E. and J. A. Springhall. 1963. Evaluation of ferrous sulphate as a detoxifying agent for Mimosine in *Leucaena leucocephala* by mineral supplementation for feeding to ruminants. Anim. Feed Sci. Technol. 50:157-167.

Shukla, P. C. P. M., Talapada, H. B. Desai and M. I. Meisuriya. 1987. Chemical composition and nutritive value of Leucaena leucocephala seeds. Indian J. Anim. Nutr. 3:207-208.

Snedecor, G. W. and W. G. Cochran.1968. *Statistical Methods*. IBH Publishing Co., Kolkata.

Tiwari, S. P. and G. L. Chawla. 1995. Utilization of Subabul (*Leucaeana leucocephala*) seed in the ration of Surti buffalo calves. In Current Status and Future Strategies in meeting the challenges in Animal Nutrition. VII Animal Nutrition Research Workers Conference, 7-9 December, at Bombay Veterinary College, Bombay, p. 65(Abstr).

Yadava, P. S. and I. S. Yadava. 1988. Cell wall constituents and mineral contents in subabul (*Leucaena leucocephala*). Indian J. Anim. Nutr. 5(3):230-236.