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Evaluation of Selected Species of Tree Fodders Cultivated for Feeding Ruminants in the Hills of Nepal

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Abstract: Leaves and twigs from four species of tree fodders, *Artocarpus lakoocha* (AL), *Bauhinia purpurea* (BP), *Garuga pinnata* (GP) and *Ficus roxburghii* (FR), cultivated widely for feeding ruminants in the hills of Nepal and maintained at the Agriculture Research Station (Goat), Bandipur were investigated for their chemical composition and nutrient intake, digestibility and growth rate in growing female goats. Differences occurred between species of tree fodders on nutrient composition, which contained 286, 342, 312 and 263 g kg^{-1} DM; 174, 98, 116 and 178 g kg^{-1} total ash; 137, 163, 140 and 119 g kg^{-1} CP; 440, 458, 437 and 451 g kg^{-1} NDF; 383, 407, 382 and 406 g kg^{-1} ADF; 177, 135, 181 and 143 g kg^{-1} ADL; 19.5, 21.6, 20.9 and 29.3 g kg^{-1} Ca; and 2.2, 2.8, 2.4 and 2.5 g kg^{-1} P on DM basis for AL, BP, GP and FR, respectively. The DM intake was higher for goats fed AL (432 g/d) and GP (428 g/d) than BP (342 g/d) or FR (306 g/d). Nutrient digestibility was higher for goats fed AL and GP, except Ca, which was higher for goats fed FR. Similarly, highest daily weight gain was observed for goats fed AL (71 g/d) and GP (64 g/d) than either of BP (54 g/d) or FR (30 g/d). Overall, leaves and twigs from these tree fodders supported moderate growth, but may not be advisable for maximum ruminant production.

Key words: Tree fodders, nutritive value, digestibility, performance, goat

Introduction

Fodder trees are grown in the hills of Nepal from time immemorial. Their importance in supplying fodder, fuel wood, protection of soil erosion and environment and some other household needs has been well documented (Pandey, 1982). Inadequate feed supply and poor nutrition during the dry winter and early summer season (mid-January through mid-May) are the major constraints to increasing ruminant production in the hills of Nepal (Kiff *et al*., 1999). Of the 75 administrative districts in the country, 50 were found to be <80% sufficient in supplies of livestock feed (Schreier *et al*., 1991). Leaves and twigs collected from several species of fodder trees cultivated in a great variety of soil and climatic condition are a main source of green forage for ruminants during dry winter and early summer months and help maintain the body condition and production of ruminants.

Khanal and Subba (2001) described the nutritional characteristics of leaves and twigs from 31 species of fodder trees cultivated in the hills of Nepal. Khanal *et al*. (1999) have determined the proximate composition, detergent fibers and Ca and P contents of both cultivated and uncultivated tree fodders and browse plants available mostly in the western hills of Nepal. Similarly, Subba (1998) has determined the detail chemical composition of leaves from those available in the eastern hills of Nepal. Subba (1999) also ranked them according to various nutritional characteristics. On the other hand, farmers have their own preference based on their age-old practices in the cultivation and feeding of leaves and twigs from various species of tree fodders. Realizing this, Thorne *et al*. (1999) and Walker *et al*. (1999) attempted to derive a biological interpretation of indigenous knowledge system with regards to the quality of tree fodders and consistency and discriminatory power of indigenous and laboratory assessment of the nutritive values of tree fodders available in Nepal. Thorne *et al*. (1999) also attempted to find the potential complementarities between indigenous and laboratory-based indicators of tree fodder quality. However, part of their interpretation was based not on actual animal performance, but on in vitro studies. As a result, several of these authors pointed out the need to investigate on the quality of various fodder trees and shrubs based on the actual performance of ruminants. This would ultimately help reduce the severity of scarcity of feed and fodder and maintain ruminant production. Therefore, objective of this study was to investigate the performance of goats fed leaves and twigs from four species of selected fodder trees commonly cultivated in the hills of Nepal.

Materials and Methods

Sixteen female growing Khari goats with an average initial weight of 8.89±0.6 kg and age of 140±20 days were selected for the study. Animals were blocked according to their initial body weight. Within block animals were allotted at random to one of four treatments, i.e., species of tree fodders selected for the

study. Tree fodder species were Badahar (*Artocarpus lakoocha*; AL), Tanki (*Bauhinia purpurea*; BP), Dabdabe (*Garuga pinnata*; GP) and Nemaro (*Ficus roxburghii*; FR), selection of which was based on their widespread availability across the low and mid hills of Nepal. While AL is regarded as one of the most nutritious fodder tree species by the farmers, BP is a leguminous fodder and expected to have higher protein contents. The GP is a relatively large tree with small thin leaves, whereas FR has big, rounded and thick leaves with a relatively large mid-rib. Leaves and twigs from the fodder trees were collected from the same north facing fodder block maintained in Agriculture Research Station (ARS, Goat), Bandipur at an altitude of 875 m from the sea level. Soil had a pH of 5.64 with 3.2% organic carbon, 174.3 ppm of available phosphorus and 0.27% total nitrogen. The Station received an annual rainfall of 2000 mm with an average of 85% relative humidity and minimum and maximum temperatures of 8 and 32°C, respectively.

Experimental goats were housed in individual cages in the same shed with facilities for collection of feed, orts and feces, but not urine. Goats were allowed to have an *ad libitum* access to leaves and twigs from one of the four fodder trees mentioned above. Water was offered twice daily at 1000 h and 1700 h while tree fodder leaves together with twigs and petioles were offered twice daily at 0900 h and 1600 h. Orts were collected 2 h after feeding. All animals were dewormed before allotting them to the experiment and further medication, if any, was administered as per the suggestion of a veterinarian.

Total experimental period was 74 days including a 14-day adaptation period. Growth was monitored every fortnight. Feeds offered and orts were collected daily for determining the daily feed and nutrient intakes. Total fecal output was measured during the final 8 days of the experiment and their samples collected during the total collection period. Dry Matter (DM) content of the feeds offered and orts collected as well as fecal samples was determined daily during the last 8 days of digestibility study.

Laboratory analyses of the tree fodder leaves and twigs offered and fecal samples collected was done for DM, Crude Protein (CP) and Total Ash (TA) contents as per AOAC (1980). Neutral detergent and acid detergent fibres (NDF and ADF) as well as acid detergent lignin (ADL) were determined as per (Van Soest and Robertson, 1985). Calcium was determined by titration (Turekin and Bolter, 1961) and phosphorus by spectrophotometric methods. Samples of leaves and twigs were analyzed for their chemical composition every fortnight during the experiment. These samples were air dried at ARS (Goat), brought to Animal Nutrition Division laboratory and ground to pass through a 1-mm sieve for further laboratory analyses. Wherever appropriate, all values are expressed on DM basis.

Data were statistically analyzed in SAS using PROC GLM (SAS, 1999/00). Model included treatment and block as the independent variables. In case of final body weight, initial body weight was used as the covariate. Means were separated using REGWQ.

Results and Discussion

Nutrient composition of the leaves and twigs from selected species of fodder trees is given in Table 1. The DM content was higher for BP ($p<0.05$) than AL and FR, but there was no difference ($p>0.05$) between the other species of tree fodders. The values were comparable to the earlier reports for the same species of tree fodders harvested at similar times of the year (Khanal and Subba, 2001; Thorne *et al.*, 1999; Wood *et al.*, 1994). The DM content would increase with the increasing maturity, which was probably another reason why it was higher for BP that was approaching fruit bearing stage. Crude protein content varied significantly ($p<0.05$) among species, highest being for BP, which is a leguminous tree fodder. Crude protein content in all of them was slightly lower than reported previously (Khanal and Subba, 2001; Khanal *et al.*, 1999; Subba, 1998). It was probably because of the differences in sampling procedures employed between the studies. While leaves and twigs were included in the current study to represent the actual feeding practice of the farmers, it was only the leaves that were used to determine CP content previously (Khanal and Subba, 2001). Time of harvest also affects the CP content with the same species of tree fodder varying in CP content by about 30 to 40% when harvested at different times of the year (Topps, 1992; Wood *et al.*, 1994). Nonetheless, all of them could be regarded to have medium CP content, which could make a valuable source of protein for ruminants. Moreover, Subba (1999) has shown that a higher proportion of CP present in these tree fodders is actually present in the form available to ruminants. The ash content was also different ($p<0.05$) among the four species of tree fodders with smaller values for BP and GP than either of the AL or FR. While Wood *et al.* (1994) reported higher ash contents for AL and FR, Khanal and Subba (2001) reported slightly lower ash contents for BP and GP. Such variations may exist owing to the differences in harvesting season, fodder maturity, leaf:twig ratio and even soil condition and topography.

No significant difference ($p>0.05$) in detergent fibres or Ca and P content was observed among species. The NDF content was lower than previous reports for AL and BP, but it was similar in case of GP and FR (Khanal and Subba, 2001). Thorne *et al.* (1999) reported higher NDF and ADF values for FR than was observed in the current study. As expected, ADL content was high for all species. Relatively higher ADL and lower hemicellulose content (NDF minus ADF) is probably one of the characteristics of tree fodders and shrubs fed to ruminants. Similar

Table 1: Nutrient composition (g kg^{-1}) of leaves and twigs from selected species of fodder trees[1] used for feeding ruminants in the hills of Nepal

Nutrients	AL	BP	GP	FR	SEM[2]
DM	286[b]	342[a]	312[ab]	263[b]	17.4
Total ash	174[a]	98.2[b]	116[b]	178[a]	13.5
CP	137[bc]	163[a]	140[ab]	119[c]	9.3
NDF	440	458	437	451	27.1
ADF	383	407	382	406	35.0
ADL	177	135	181	143	32.1
Ca	19.5	21.6	20.9	28.3	3.2
P	2.2	2.8	2.4	2.5	0.5

Figures in the same row with different superscripts differ ($p<0.05$)
[1]Fodder tree species used were AL = *Artocarpus lakoocha*, BP = *Bauhinia purpurea*, GP = *Garuga pinnata*, FR = *Ficus roxburghii*.
[2]Standard error of mean

Table 2: Nutrient intake (g/day) by female goats fed leaves and twigs from selected species of fodder trees[1] cultivated in the hills of Nepal

Nutrients	AL	BP	GP	FR	SEM[2]
DM	431.8[a]	341.7[b]	427.9[a]	305.8[c]	9.98
DM, % BW	003.95[a]	03.27[b]	03.98[b]	03.14[a]	0.09
DM, /kg $w^{0.75}$	072.0[a]	59.0[b]	72.2[a]	55.5[b]	1.69
OM	356.8[b]	306.3[c]	378.2[a]	251.3[d]	7.38
Total ash	075.0[a]	35.3[d]	48.7[c]	54.5[b]	1.71
CP	050.5[b]	52.4[ab]	55.8[a]	30.3[c]	1.54
Ca	008.42[b]	05.82[c]	08.94[a]	08.96[a]	0.17
P	000.95[a]	00.96[a]	01.03[a]	00.76[b]	0.03

Figures in the same row with different superscripts differ ($P < 0.05$).
[1]Fodder tree species used were AL = *Artocarpus lakoocha*, BP = *Bauhinia purpurea*, GP = *Garuga pinnata*, FR = *Ficus roxburghii*.
[2]Standard error of mean

Table 3: Nutrient digestibility (%) by female goats fed leaves and twigs from selected species of fodder trees[1] cultivated in the hills of Nepal

Nutrients	AL	BP	GP	FR	SEM[2]
DM	53.4[a]	46.5[ab]	58.8[a]	44.8[b]	3.02
OM	58.9[a]	46.1[b]	65.5[a]	46.0[b]	3.73
Total ash	58.4[a]	49.3[b]	47.0[b]	34.5[c]	3.89
CP	53.2[a]	45.0[b]	57.0[a]	44.1[b]	2.26
NDF	50.3[b]	40.8[a]	50.3[a]	42.5[b]	2.32
ADF	45.2[a]	40.2[ab]	49.4[a]	38.7[b]	3.50
Hemicellulose	49.3[b]	38.2[c]	60.4[a]	41.0[c]	2.06
Ca	60.7[ab]	47.7[c]	55.5[b]	65.7[a]	1.88
P	47.9[ab]	38.1[c]	50.7[a]	41.6[bc]	2.62

Figures in the same row with different superscripts differ ($p<0.05$).
[1]Fodder tree species were AL = *Artocarpus lakoocha*, BP = *Bauhinia purpurea*, GP = *Garuga pinnata*, FR = *Ficus roxburghii*.
[2]Standard error of mean

results of high ADL and low hemicellulose content have been reported previously for these tree fodders cultivated under similar conditions (Khanal *et al.*, 1999; Subba, 1998). Calcium content was close to or more than 2% on DM basis. High Ca and medium to high CP content is worth considering, because hill farmers of Nepal give a priority to feed tree fodder leaves and twigs to lactating ruminants, primarily buffaloes that have greater demand for CP and Ca contents during early lactation. This may also be useful while making feeding package and supplementation strategies for ruminant production in the hills of Nepal, particularly during drier months. The P content was within the normal range of requirement in the forages (McDowell, 1997).

There was a significant difference ($p<0.05$) in the nutrient intake of animals (Table 2), lowest nutrient intakes being for FR group. The DMI, DMI/100 kg bw and DMI/kg $w^{0.75}$ was lower for BP and FR groups than AL and GP groups. Large thick leaves and twig like mid rib in case of FR and thinly distributed leaves that would increase the overall proportion of twigs in case of BP might have contributed to the lower DM intakes. It was observed during the experiment that goats did not relish FR and had palatability problems. Aryal *et al.* (1994) have observed higher intakes of DM with 620 g/d when male goats weighing 7.6 kg initially were given various tree fodders (depending on the availability round the year) supplemented with concentrate (16% CP) at 1% of their body weight. They have observed an intake of 3.8 kg DM/100 kg BW and 76.2 g kg^{-1} $w^{0.75}$, which was similar to that of AL and GP groups but higher than BP and FR groups. However, higher CP content (Table 1) led to similar CP intake in BP group compared with AL and GP groups. Other studies related to nutrient intakes of female goats fed such tree fodder leaves and twigs exclusively are limited. A dramatic increase in feed intake (and feed conversion ratio) in both sheep and goats have been observed when the basal diet was supplemented with rumen undegradable protein and starch (Throckmorton and Leng, 1984). Since rumen undegradable protein and starch was not supplemented in the current study, their positive effects on intake and digestibility of nutrients could not be ascertained.

Digestibility of nutrients was affected by the species of tree fodders and could be considered relatively low (Table 3). Inclusion of twigs with leaves may have contributed to the lower digestibility of nutrients. Higher ADL contents (Table 1) may also have rendered relatively poor digestibility of nutrients from these tree fodders since it forms complexes with hemicellulose, which would otherwise be digestible. Previous studies on tree fodder leaves have shown higher neutral cellulase, DM and OM digestibility (Khanal and Subba, 2001). Presence of antinutrient factors such as tannins may also have contributed to poor digestibility, because all but BP are shown to contain >2% tannin in their leaves (Khanal and Subba, 2001; Subba, 1998; Wood *et al.*, 1994). Though not measured, tannin content in the current study might have been higher because of the inclusion of twigs. Digestibility of nutrients for AL and GP was similar and significantly higher ($p<0.05$) than that of BP and FR, which were not different ($p>0.05$) from each other in most of the cases, except digestibility of total ash and Ca. However, Ca digestibility was highest ($p<0.01$) for FR than for the rest, reasons for which were not clear.

Table 4: Final body weight, average daily gain and feed:gain ratio of female goats fed leaves and twigs from selected species of fodder trees[1] cultivated in the hills of Nepal

Nutrients	AL	BP	GP	FR	SEM[2]
Final BW (kg)	13.0[a]	12.1[b]	12.7[ab]	10.6[c]	0.31
Daily gain (g/d)	71.1[a]	53.9[b]	64.4[a]	29.7[c]	3.24
Feed:gain ratio	6.07[a]	6.34[a]	6.64[a]	10.3[b]	0.87

Figures in the same row with different superscripts differ ($p<0.05$)
[1]Fodder tree species used were AL = *Artocarpus lakoocha*, BP = *Bauhinia purpurea*, GP = *Garuga pinnata*, FR = *Ficus roxburghii*.
[2]Standard error of mean

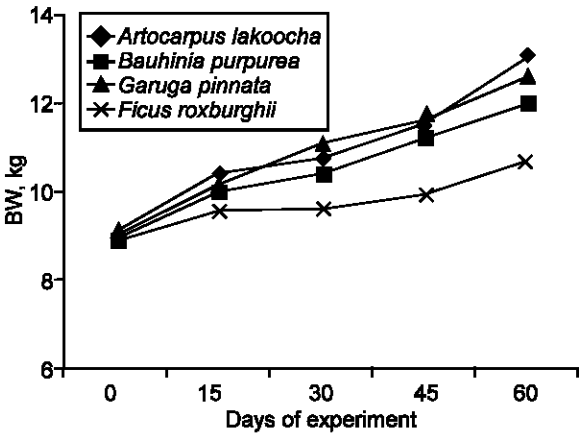

Fig. 1: Growth pattern of female goats (kg) fed leaves and twigs from selected species of fodder trees cultivated in the hills of Nepal

Daily weight gain, feed:gain ratio and final body weight of female goats are given in Table 4, while the growth pattern every fortnight is presented in Fig. 1. Higher nutrient intake accompanied by better digestibility of various nutrients might have had positive effects on growth rates ($p < 0.05$) female goats fed AL and GP than BP or FR. Goats in AL group tended to grow faster ($P = 0.08$) than goats in GP group even though the digestibility and intakes of nutrients in these two groups were similar. Farmers, however, consider AL as the most *posilo* (nutritious) tree fodder, regard it as the king of tree fodders and often feed it to lactating buffaloes only. Two of the four animals fed FR lost their body weight during the 2nd and 3rd fortnights of the experiment. This must be due to poor intake and digestibility of the fodder species concerned, which was probably not sufficient to meet the maintenance requirement of the animals. Growth rate of other groups of animals was also relatively poor, because high growth rates can not be supported on the products of fermentative digestion and that rumen undegradable protein supplements are essential to take advantage of the energy absorbed from volatile fatty acids (Preston, 1998). Another reason may be the sex of the animals since females grow at slower rates than males at similar age (Anous and Mourad, 1993).

An overall weight gain of 81 g/d was obtained under Indian conditions when Sirohi, Marwari and Kutchi goats were raised between 3 to 6 months of age (Nagpal *et al.*, 1995), all of which are heavier breeds than Khari used in the current study. A maximum growth rate of 66 g/d was observed between 6 to 12 months of age in Nepali hill bucks (Khari) in eastern Nepal when goats were allowed to have ad libitum access to tree fodders and supplemented with corn at 25 g/d per kg bw (Shrestha *et al.*, 1990). However, the growth declined to 48 g/d when supplemental corn was reduced to 10 g/d per kg bw. Growth rate was even less at 41.3 g/d per kg bw for male kids that weighed 7.6 kg initially and reared for one year on ad libitum access to tree fodders supplemented with concentrate at 1% of their body weight (Aryal *et al.*, 1994). Although daily weight gain obtained in the current study was better than or comparable to that observed previously in the same breed (Upreti *et al.*, 1999; Upreti and Khanal, 1998; Aryal *et al.*, 1994; Shrestha *et al.*, 1990), it was poorer than many other international findings (Penning *et al.*, 1996; Mahgoub and Lodge, 1996; Nagpal *et al.*, 1995). Supplementation of rumen undegradable protein would probably have increased their growth rate.

Weight gain was highest during the first fortnight of the experiment and significant difference ($p<0.01$) existed in the growth rates during all stages of growth, from the beginning to the end of the experiment. Consistent with the daily gain, final weight was also higher for goats fed AL and GP than BP or FR. Final weight at 6 mo of age in the current study was similar to that observed previously at the same age for the same breed maintained at Lumle Farm in the western hills of Nepal (Khanal *et al.*, 2005). Lower final weight and poor growth rate led to poorer feed:gain ratio for goats fed FR than goats fed the rest of fodders. Overall, the growth rate was poor for goats irrespective of the species of tree fodders and raising goats solely on such fodder tree leaves and twigs may not be advisable for optimum production.

Conclusions: Feeding of leaves and twigs from different species of fodder trees to growing female goats showed the differences existed not only in the nutrient composition among individual fodder tree species, but also in the intake, digestibility and performance of the animals. *Artocarpus lakoocha* and *Garuga pinnata* were better in terms of overall response by the animals. *Bauhinia purpurea*, though highest in crude protein content, was not as good as *Artocarpus lakoocha* and *Garuga pinnata* in terms of animal performance. *Ficus roxburghii* was merely able to maintain the animals. Based on the performance of female goats in the current study, feeding of these species of tree fodders is probably not sufficient to obtain higher production from ruminants. Further studies on the effects of supplementing this vital source of fodder with rumen

undegradable protein, starch or both on nutrient intake, digestibility and performance of the animal is important.

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