ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Comparison of Feeding Value of Some Popular Tree Fodders for Goats in the Mid-hill Region of Nepal

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Abstract

Large numbers of species of tree fodder are being used as green roughage source for goats in several farming systems. A study was carried out at Goat Research Station, Bandipur, Nepal in order to compare the feeding value of commonly used tree fodder leaves in mid-hills of Nepal. Altogether five treatments; tree fodder leaves of *Ficus semicordata*, *Shorea robusta*, *Ficus glaberrima* and *Ficus lacor* and mixed fodder as the conventional practices of the farmers were evaluated in Randomized Complete Block Design (RCBD) with three replications. Total of 30 male goats were used for the experiment in five groups, 6 for each treatment. The subsequent experiment was carried out to determine the nutrient digestibility of the tree fodder leaves by using fecal collection method. Nutrient composition, voluntary intake and nutrient digestibility of the fodder leaves and growth performance of goats were monitored. Crude protein (CP), total ash (TA), organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), hemicelluloses and cellulose proportion were better for *F. glaberrima* and *F. lacor* leaves, whereas the digestibility of those nutrients were better for *F. semicordata* leaves and moderate for *F. glaberrima* and *S. robusta*. Voluntary fodder dry matter intake was highest for *F. glaberrima* and least for mixed fodders. Growth performance of goats was higher for *F. lacor* and *F. glaberrima* than other tree fodder leaves and mixed fodders. The leaves of *F. lacor* and *F. glaberrima* had shown better feeding value than the conventional practices of farmers, mixed fodders. The leaves of *S. robusta* and *F. semicordata* were observed similar with the mixed fodders for their feeding value.

Keywords: Tree fodders; nutrient composition; digestibility; voluntary intake; average daily gain

Introduction

Feeding of ruminant livestock in developing countries is predominated by tree-fodders. Tree fodder furnish reliable alternative to roughages like Alfalfa for the livestock production systems in many cases (Cheema *et al.*, 2011). Accordingly, leaves and twigs collected from several species of fodder trees cultivated in a great variety of soil and climatic condition offer green fodder for ruminants during dry winter and early summer months in Nepal. Such supply of fodders in lean season helps to maintain the body condition and a modest level of production of ruminants in many cases (Kamalak *et al.*, 2004; Khanal and Upreti,

Article may be cited as:

T.P. Paudel et al. (2017) Int. J. Appl. Sci. Biotechnol. Vol 5(4): 442-448. DOI: 10.3126/ijasbt.v5i4.18401

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Peer reviewed under authority of IJASBT
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2008). The potential of such tree fodders in addressing the feed shortage and thereby supplying essential nutrients to animals has been less intensively studied for some species despite their wide use by the farmers (Mandal, 1997; Subba, 1998; Kamalak *et. al.,* 2004; Upreti and Shrestha, 2006). This has led to a serious challenge for nutritionists in improving animal productivity in developing countries with scarce and qualitatively variable fodder resources (Younas and Yahoob, 2005; Upreti and Shrestha, 2006; Pariyar *et al.*, 2013).

A number of tree fodders are in use by farmers in the mid hills of Nepal. The range of use of these fodders in goats is even wider. Among them some species e.g. *Ficus semicordata*, *Shorea robusta*, *Ficus glaberrima* and *Ficus lacor* are popularly used than others in the mid-hill region of Nepal (Walker et. al., 1999; Khanal and Subba, 2001). Since the feed and fodder availability is not sufficient to meet the nutrient requirement of growing ruminants' population, there is need to explore new feed resources which do not compete with human food chain. Investigating the qualities of various fodder trees and shrubs based on the actual performance of ruminants would ultimately help to reduce the severity of scarcity of feed and fodder and maintain ruminant production (Khanal and Upreti, 2008). Therefore, the study was carried out to evaluate the feeding value of different tree fodder leaves to the goats.

Materials and Methods

Experiment 1: Voluntary Feed Intake

The experiment was carried out at Goat Research Station, Bandipur, Tanahun situated in the mid-hill area of Nepal at an altitude of 1250 masl and 27.94°N and 84.38°E. A total of 30 males of native hill goats were used for the experiment conducted from June to September, 2012 for 14-weeks experimental period including the adaptation period of initial 2 weeks. The goats were drenched with Albendazole @ 10mg kg^{-1} body weight before 15 days of the beginning of the experiment. The male goats of average five months aged with an average of 12.86 kg body weight were divided into five groups having six animals in each group. Altogether five treatments, four species of tree fodders and one of mixed ground fodders, were evaluated in Completely Randomized Design (CRD) with three replications. The tree fodders; *Ficus semicordata*, *Shorea robusta*, *Ficus glaberrima* and *Ficus lacor* were compared with the mixed fodders. The treatment of mixed fodders was used as the control group, which was considered as conventional feeding practices to the goat in mid hills of Nepal during spring season. The mixed fodder treatment comprised of the mixing of the fodders; *Pennisetum purpureum* Schumach., *Themeda triandra* Forsk, *Artemesia vulgaris* L., *Vetiveria zizanioides*, *Setaria pallidesesca*, *Hypoxis aurea* Lour, *Cynodon dactylon* (L.) Pers., *Pittosporum napaulense*, *Brachiaria documbens* Stapf. and *Desmodium intortum* (Mill.) Urb. Every experimental animal was confined in a single cage and provided fodder treatments and water was given in *ad-libitum* with concentrate ration at the rate of 1% of their body weight for 24 hours. Drinking water, tree fodder leaves together with twigs and petioles were offered twice daily at 0900h and 1600h and every experimental goat was offered 15% additional fodder leaves than the previous day's intake. The experimental diets for different treatments are presented in Table 1.

Table 1: Experimental diets for different treatments used in the experiment.

Treatments	Experimental diet
T_1	Mixed fodders + concentrate mixture
T_2	*Ficus semicordata* + concentrate mixture
T_3	*Shorea robusta* + concentrate mixture
T_4	*Ficus glaberrima* + concentrate mixture
T_5	*Ficus lacor* + concentrate mixture

Feed and fodder offered and refused were recorded everyday and the growth of goats was monitored every two weeks. The fodder and feed samples were analyzed using the techniques described by Goering and Van Soest, (1970) in the laboratory of Animal Nutrition Division, Khumaltar, Lalitpur, Nepal. The nutrient compositions of the feedstuffs are presented in Table 2.

Table 2: Nutrient contents of the different fodders used in the experiment (%).

Tree fodders	DM	CP	TA	OM	NDF	ADF	ADL
Mixed fodder	26.30	9.86	8.47	91.53	61.58	48.49	26.25
Ficus semicordata	34.50	10.02	13.90	86.10	61.22	54.33	36.53
Shorea robusta	31.22	10.27	3.05	96.95	65.92	55.91	32.83
Ficus glaberrima	32.03	10.85	12.09	87.91	40.59	30.38	18.32
Ficus lacor	32.79	12.50	13.96	86.04	55.14	44.51	26.19
Concentrate Mixture	88.91	16.32	12.16	-	-	-	-

DM= Dry matter, CP=Crude protein, TA= Total ash, OM= Organic matter, NDF= Neutral detergent fiber, ADF= Acid detergent fiber, ADL= Acid detergent lignin

Experiment 2: Digestibility of Nutrients

The subsequent experiment was carried out to determine the nutrient digestibility of the fodders by collection of feces from the same 30 male goats. The animals were housed in the same metabolic cages allowing collection of feces separately in a well-ventilated building. The duration of the experimental period was two weeks; one week for adaptation and one week for collection of feces and refusals. Animals were provided weighed amount of tree fodder leaves two times a day with *ad-libitum* water. Observations on fodder offered, refused and feces voided were recorded daily. The fodder refusals, fodder and fecal samples were collected two times (morning and evening) during the experimental period.

Collected samples of fodders and fecal were dried at constant heat in hot air oven at 72°C for 24 hours and dry matter was estimated. Nitrogen content was determined by Micro Kjheldal method and crude protein content was then calculated (AOAC, 1990). Ash content was determined by ashing at 550°C in a muffle furnace for 16 hours. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by the method developed by Goering and Van Soest (1970).

Statistical Analysis: One way analysis of variance (ANOVA) was carried out to compare the voluntary fodder intake, body weight gain and digestibility of the nutrients by using GenStat Discovery Edition 4 (2011) computer software.

Results

Voluntary Fodder Intake

Voluntary fodder dry matter intake of a goat was significantly different ($p<0.05$) for the treatments. The intake of *F. glaberrima* (T4) was higher than others, 687.37 g day^{-1} animal^{-1}. It was discretely inferior for *F. lacor* (T5), *S. robusta* (T3), *F. semicordata* (T2) and mixed fodders (T1). The concentrate mixture dry matter intake (Feed DMI) of goats was recorded across treatments were similar ($p>0.05$), however, the fodder dry matter intake (Fodder DMI) of goats were significantly different across different treatment groups ($p<0.05$). Accordingly, *F. glaberrima* had shown highest fodder DMI than any other fodder treatments. The goat fed with mixed fodders which was used as a control group had shown less fodder DMI than the goats fed with other individual tree fodder leaves (Table 3).

Digestibility of Nutrients

Nutrient digestibilities of the different tree fodder leaves to the goats is presented in Table 4. The DM digestibility was higher ($p<0.05$) for *F. semicordata* and *F. glaberrima* (80.94 and 76.31 percent, respectively) than in the case of *F. lacor* (65.64 percent). Other fodders *S. robusta* and mixed fodders (control group) had shown similar ($p>0.05$) DM digestibility with *F. glaberrima*. Likewise, CP digestibility was considerably inferior ($p<0.05$) at 54.77 and 64.59 percent for mixed fodders and *F. lacor*, respectively. It was higher ($p<0.05$) for *S. robusta*, *F. semicordata* and *F. glaberrima* which were similar ($p>0.05$) among them.

Total ash digestibility was remarkably low ($p<0.05$) for *S. robusta* (29.69 percent) where as *F. lacor* and mixed fodders had shown moderate total ash digestibilities. *F. semicordata*, *S. robusta* and *F. glaberrima* had shown better OM digestibilities than *F. lacor*. The NDF and ADF digestibilities were found better ($p<0.05$) for *F. semicordata* (80.71 and 83.88 percent, respectively) and other fodder leaves had shown moderate NDF and ADF digestibilities. Similarly, ADL of the *F. semicordata* was also more ($p<0.05$) digestible than the ADL of other fodders (Table 4).

Table 3: Voluntary fodder intake and total dry matter intake of the male goats

Parameters	Mixed fodder	*F. semicordata*	*S. robusta*	*F. glaberrima*	*F. lacor*	SEd
Voluntary fodder intake, g day^{-1} per animal	304.00^{e}	394.40^{d}	403.10^{c}	687.37^{a}	424.20^{b}	8.07
Total dry matter intake						
Feed DMI, g day^{-1} per kg metabolic weight	15.67	15.56	15.51	16.71	14.01	1.09
Fodder DMI, g day^{-1} per kg metabolic weight	39.33^{c}	51.66^{b}	53.99^{b}	82.17^{a}	50.20^{b}	1.32

Row means with different superscripts differ significantly *(P<0.05)*.

Table 4: Nutrient digestibility of different tree fodder leaves by male goats.

Nutrients	Mixed fodder	*F. semicordata*	*S. robusta*	*F. glaberrima*	*F. lacor*	SED
Dry matter	70.87^{bc}	80.94^{a}	72.15^{b}	76.31^{ab}	65.64^{c}	2.64
Crude Protein	54.77^{c}	75.02^{a}	77.07^{a}	72.72^{a}	64.59^{b}	2.56
Total Ash	57.46^{c}	70.81^{a}	29.69^{d}	68.12^{ab}	58.89^{bc}	4.01
Organic Matter	72.12^{bc}	82.57^{a}	78.75^{a}	77.44^{ab}	66.74^{c}	2.52
Neutral Detergent Fiber	64.92^{bc}	80.30^{a}	68.29^{b}	59.22^{c}	57.58^{c}	3.43
Acid Detergent Fiber	63.16^{b}	80.71^{a}	68.13^{b}	55.46^{c}	55.48^{c}	3.61
Acid Detergent Lignin	49.53^{c}	83.88^{a}	65.30^{b}	55.85^{bc}	60.58^{b}	3.83

Row means with different superscripts differ significantly (P<0.05).

Table 5: Growth performances of the goats

Parameters	Mixed fodder	*F. semicordata*	*S. robusta*	*F. glaberrima*	*F. lacor*	SEd
Initial Body weight, kg	12.55	12.42	11.85	14.06	13.45	1.28
Final Body weight, kg	18.16^{a}	17.83^{a}	17.50^{a}	21.49^{b}	21.21^{b}	1.49
Total weight gain, kg	5.61^{a}	5.41^{a}	5.65^{a}	7.43^{b}	7.76^{b}	0.83
Average daily gain, g	62.22^{a}	60.11^{a}	62.78^{a}	82.56^{b}	86.22^{b}	9.22

Row means with different superscripts differ significantly (P<0.05)

Growth Performance

The growth performances of the goats for the treatments of different tree fodder leaves are presented in Table 5. Initial body weights of the goats were statistically similar across treatment groups (p>0.05). The goats fed with tree fodder leaves of *F. glaberrima* and *F. lacor* attained higher (p<0.05) body weight in the 12 weeks of experimental period in comparison to the goats fed with the mixed fodders and *F. semicordata* and *S. robusta* leaves. Accordingly, the goats fed with tree fodder leaves of *F. lacor and F. glaberrima* yielded heavier weight gain (7.76 and 7.43 kg, respectively) with greater average daily gain (ADG) of 86.22 and 82.56 g day^{-1}, respectively compared to the goats fed with other fodders.

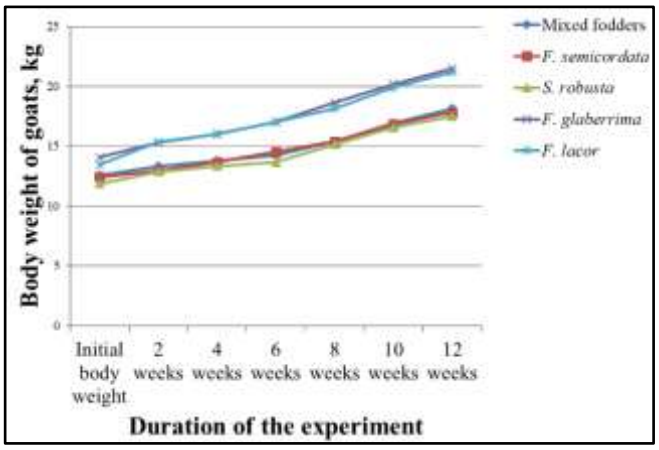

Fig. 1. Weekly body weight of the male goats fed with different fodder treatments.

The Fig. 1 shows the body weight attained by the experimental animals in different weeks. All the treatments had shown similar trends of growth of male goats in different weeks, however, the goats fed with tree fodder leaves of T4 and T5 had shown higher body weight than others.

Discussion

The results of the study revealed that the body weight gain of the male goats fed with the leaves of *F. lacor* and *F. glaberrima* were higher (p<0.05) compared to the goats fed with mixed fodders. The leaves of other fodder trees, *F. semicordata* and *S. robusta*, had yielded similar body weight gain with the mixed fodders (p>0.05). The higher proportion of CP and TA (12.50% and 13.96%, respectively) and lower NDF, ADF, hemicelloluse and cellulose content of the *F. lacor* than other fodder leaves might have made substantial contribution to the higher body weight gain of the goats, however the CP and TA digestibility of the *F. lacor* was moderate. The lower ADF and cellulose digestibility of *F. lacor* could be due to the relatively higher ADL content (26.19%) which co-binds those nutrients and reduces the digestibility (Upreti and Shrestha, 2006). Lignin is the primary factor causing decline in digestibility of plant cells. It reduces the digestibility of the cell wall carbohydrate, primarily hemicelluloses and cellulose, with which it is co-bonded (Upreti and Shrestha, 2006). Remarkably higher voluntary intake of tree leaves of *F. glaberrima* and moderate CP and

TA content on it (10.5% and 12.09%) could have contributed for higher body weight gain which is in agreement with the result of another experiment (Ghimire, 2013). In addition, lower NDF and ADF fractions in the leaves of *F. glaberrima* (Table 2) might have resulted into increased digestibility of the nutrients than in the case of mixed fodders (Table 4). Furthermore, the leaves of *F. glaberrima* could have lower retention time of food materials in the digestive tract of the goats which increased voluntary intake of fodders in comparision to other fodders due to lesser fractions of cell wall contents and ADL. The passage rate of the fiber fraction of the feedstuffs in the digestive tract depends upon the size of indigestible fraction, rate of degradation and extent of digestion. The leaves of *S. robusta* and *F. semicordata* had shown similar performance on body weight gain ($p<0.05$) with conventional practices of mixed fodders (Table 3). The NDF, ADF and ADL content of the leaves of *F. semicordata* and *S. robusta* and mixed fodders were observed in higher than that can be incorporated in the goat ration. Similar results of high ADL content have been reported previously for these tree fodders cultivated under similar conditions (Khanal *et al.*, 1999; Subba, 1998). Although, the CP and NDF content of leaves of *F. semicordata* were similar with mixed fodders, TA and ADL contents were higher. Likely, the leaves of *S. robusta* were richer in CP, NDF and ADL content in comparison to mixed fodders, whereas remarkably poorer in TA fraction (3.05%). The leaves of *S. robusta* had higher CP and lower TA digestibility with similar digestibility of NDF, hemicelluloses and cellulose compared to mixed fodders in the experiment.

Voluntary fodder dry matter intake was obtained significantly different for the tree fodder leaves ($p<0.05$), in which *F. glaberrima* had shown outstandingly higher voluntary intake (82.17 g day^{-1} per kg metabolic weight). The leaves of *F. lacor*, *S. robusta* and *F. semicordata* had also shown higher voluntary fodder intake than mixed fodders ($p<0.05$). One of the primary reasons might be the browsing behavior of the goats that is preference of picking broader leaves. Further, the lower proportion of NDF and ADL in the leaves of *F. glaberrima* and *F. lacor* (Table 2) could have resulted lower retention time of foods in the digestive tract of the goats which might have helped in elevating the voluntary intake of *F. glaberrima* and *F. lacor* than that of mixed fodders. The concentrations of dietary fiber and non-sugar carbohydrate level, and the rate of digestion of the potentially digestible fiber fraction affect passage rate (Tamminga, 1993). Level of NDF concentration in a diet is negatively correlated to dry matter intake since fiber ferments slowly and stays in the rumen relatively longer than other less-fibered feed components. Increase in fiber digestibility increases the dry matter intake by stimulating the intake through creating the space for another meal sooner (Robinson and McQueen, 1997). The leaves of *F. lacor* had lower proportion of NDF, ADF, and ADL content than the mixed fodders. The indigestible fraction of NDF is a major factor affecting the utilization of carbohydrate sources as it varies greatly and may exceeded more than one half of the total NDF in the rumen. Glenn and Canale (1990) demonstrated that particulate matter leaving the rumen has a high ratio of ruminal indigestible fiber to digestible fiber. They proposed that the rate that grass and legume cell wall reach this ratio might serve as a regulator of particulate turnover from the rumen.

The process of fiber digestion consists of hydrolysis of polysaccharides and the conversion of monosaccharides to volatile fatty acids (VFAs), gasses, and heat (Tamminga, 1993). The rate of hydrolysis is generally the limiting factor in fiber digestion in the rumen (Varga and Kolver, 1997) indicating towards the variation in the digestibility of Dry Matter (DM). The DM digestibility was obtained better ($p<0.05$) for *F. semicordata* and *F. glaberrima*, whereas *F. lacor* had shown the least DM digestibility. The digestibility of CP, TA, OM, NDF, ADF, ADL, hemicelluloses and cellulose were found better for *F. semicordata*. The tree leaves of *F. glaberrima* and *F. robusta* had shown moderate nutrient digestibility, but better than the leaves of *F. lacor* and mixed fodders. Crude protein digestibility was found better ($p<0.05$) for all individual tree fodder leaves than for mixed fodders. The CP digestibility of the mixed fodder was obtained lower and it could be due to more of the N bound to fiber fractions.

Digestibility of nutrients was affected by the species of tree fodders used in the experiment. Higher ADL contents may also have rendered relatively poor digestibility of nutrients from these tree fodders since it forms complexes with hemicellulose, which would otherwise be digestible (Khanal and Upreti, 2008). Previous studies on tree fodders leaves have also shown differences on NDF, DM and OM digestibility (Khanal and Subba, 2001). The fodder species used in the present experiment had higher levels of tannin with considerable variations (Subba, 1998). Presence of higher levels of anti-nutrient factors such as tannins may also have contributed to poor digestibility of the tree fodder leaves (Khanal and Subba, 2001; Subba, 1998). At higher levels, tannin reduces digestibility of fiber in rumen (Reed *et al.*, 1985) by inhibiting the activity of bacteria (Chesson *et al.*, 1982) and anaerobic fungi (Akin and Rigsby, 1997).

Higher NDF content in the feedstuff is associated with lower digestibility (Upreti and Shrestha, 2006) and ultimately affecting the voluntary intake of feed and availability of net energy. ADF is also highly associated with digestibility of the fodders to the animals. Higher ADF content in the feed stuff invariably result into lower digestibility (Salton, 1999; Sun *et al.*, 2013; Riaz *et al.*, 2014). Factors ensuring high quality fodders are high concentrations of N and lower concentrations of polyphenolic secondary plant compounds (Ndlovu *et al.*,

1996) and the higher rate of NDF digestion (Woodford and Murphy, 1988; Firkins, 1997). Farmers can use ADF and NDF values to estimate digestibility, and feed intake for each fodder respectively; meaning for every increase in the percentage content of ADF and NDF, there lies the compromise in the quality of feedstuff.

Conclusion

Relatively recent but unsettled debate of putting small ruminants to either stall feeding or grazing system has triggered the execution of the study. From the perspective of nutrient composition, digestibility, voluntary intake and weight gain performance of the goats, commonly used tree fodders are the better sources of green roughages. The result further supported that the *F. lacor* and *F. glaberrima* are better sources of nutrient and thereby may contribute to superior performances on voluntary intake, nutrient digestibility and body weight gain of goats among the tested tree fodders. This has inferred that incorporating a modest proportion of these quality fodders in the diet improves the performances of goats and may be other ruminants. It may also have the added benefit of increased nutrients use by the animal and thereby strategically improve nutrient management in the livestock enterprises.

Acknowledgements

The authors are highly grateful to Nepal Agricultural Research Council, Kathmandu, Nepal for providing the opportunity and resources to conduct the experiment. The author team also expresses the sincere thanks to the staffs of Goat Research Station, Bandipur, Tanahun, Nepal for their cooperation and for their untiring help in executing the experiment.

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