Chemical composition and *in sacco* degradability of forest based fodders of Nagaland state of India in Mithun (*Bos frontalis*)

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Abstract

The rumen degradation characteristics and effective degradability (ED) of dry matter (DM) and crude protein (CP) of 18 different forest-based foliages were studied in three rumen fistulated Mithuns (*Bos frontalis*) using the nylon bag technique. The animals were fed with Paddy straw plus Napier fodder (50:50 on DM) *ad libitum* and 1.5 kg concentrate mixture daily.

The mean values of the ED of DM and CP calculated for rumen outflow rates ($5\% \cdot h^{-1}$, as average), showed a high variation (27.1 to 41% and 26.4 to 44.1%) for DM and CP respectively. Degradation of DM was negatively correlated with NDF and ADF content. The best prediction of the ED of DM was derived from the contents of neutral detergent fiber and "a" water-soluble DM (R^2 =0.32 and 0.30 respectively). In the same manner, the best prediction of the ED of CP was derived from neutral detergent fiber and "a" water-soluble CP (R^2 = 0.32 and 0.56 respectively).

The study revealed that *Thysanolaena agrostis, Emblica officinalis* and *Ficus hirta* could be good sources of energy and that *Curculigo recusvata, Dacynia indica* and *Ficus infectoria* could be a medium source of bypass protein. NDF and water-soluble DM fractions of foliages are useful indicators of the effective degradability of DM and crude protein

Keywords: Chemical composition, *in sacco* study, Mithun (*Bos frontalis*), tree leaves

Introduction

Mithun *(Bos frontalis)* is a bovine of Indian origin, found mainly in subtropical rainforest of Northeastern Hill Region (NEHR) of India. This unique livestock species is also found in Bhutan, Myanmar, Bangladesh, China and Malaysia and considered to be a descendent of wild gaur (Simoons 1984). This hypothesis is supported by the resemblance, distribution and absence of a sterility barrier between mithun and gaur (Mondal and Pal 1999). This animal functions as a medium of fulfillment of social, cultural and economical obligations among the tribal communities of four states of NEHR of India. Mithun is considered as a symbol of prosperity and superiority of an individual in his society on the basis of number of heads he/she possess (Arora 1998). The steep slopes of the hills are the natural habitat of this rare and unique semi-wild bovine, mainly reared for meat purpose. This animal thrives well in hot humid and hilly terrain at an altitude varying from 300 to 3000 m above MSL. At higher altitudes, the territories of mithun are shared by Yaks (*Bos grunniens*) while at lower altitudes domestic cattle and mithun cohabit (Gupta et al 1996). Degradation of natural fodder resources due to shifting cultivation and other biotic pressure is a threat to the natural habitat of this rare ruminant.

NEHR of India is one of the mega biodiversity centers of the world (Annual Report, MoEF 2001), harbors a large variety of mithun-eating tree leaves, herbs, shrubs and grasses. The nutrient requirements of this semi-wild prized animal is mostly fulfilled by browsing on these fodder resources of forest origin. An attempt has been made to popularize these fodders with suitable agronomic packages of practices used among the tribal community to preserve and safeguard the fodder resources of the forest. Meager (or no) information is

available regarding the propagation techniques, chemical composition and degradability of these fodders available in hot spots of biodiversity of NEHR. Hence, the *in sacco* degradability study was conducted for rapid screening of some of the promising fodders and to develop a prediction equation for estimation of ED of DM and CP from chemical composition of different fodders in Mithun.

Materials and methods

Location and climate of the study area

The study was conducted at the National Research Centre on Mithun belonging to the Indian Council of Agricultural Research (ICAR). The center is located between 25.45º N latitude 93.53º E longitude with a mean altitude of 300 m above sea level. Temperature and humidity during the experiment ranged from 10.5 to 35 ºC and 82.5 to 91.6%, respectively.

In sacco degradability study

Three adult male Mithuns of 3 - 4 years (280±3.0 kg) fitted with rumen fistula were used for this work. These animals were daily fed with 1.5 kg concentrate mixture (14% mustard oil cake, 28% wheat bran, 29% rice polish, 27% broken maize, 1% mineral mixture and 1% salt) and roughage component comprising of equal part of Paddy straw plus Napier fodder (DM basis) *ad libitum*. The *in sacco* study was conducted according to the method of Ørskov and McDonald (1979) to study the rumen degradability of dry matter and protein fraction of different foliages. After a preliminary feeding period of 14 days, 5 g of the previously dried and ground samples were weighed into nylon bags (16×7 cm size with pore size 50 microns) which were attached to plastic tubes. The bags were manually pushed deep into the liquid phase of the ventral sac of the rumen and incubated for 6, 12, 24, 36, 48, 60 and 72 hours in a " Sequential removal" method (Osuji et al 1993). Three bags were incubated for each sample in each mithun bull for each incubation time. After incubation, the bags were washed for about three minutes in slow-running cold tap water, by rubbing between the fingers and the thumb for five minutes and oven-dried at 70°C for 48 hours and weighed after cooling at room temperature in a desiccator. DM and CP disappearance was expressed as a proportion of amount incubated, and the data were fitted to the exponential model. The effective degradability (ED) of CP and DM was calculated for a speed of rumen outflow of $0.05h^{-1}$, according to the equation: ED = a + (b x c)/c + k.

Collection and preparation of samples

The survey was conducted in ten different randomly selected pockets (Varying altitude ranged from 350 to 2500 m above MSL) of Nagaland state of India to evaluate the availability and distribution of tree leaves, herbs and grasses eaten by mithun. Considering the above points of view, eighteen different fodder species were found to be promising. Samples of trees, shrubs, herbs and grasses were collected. The samples were dried for a minimum of 36 hours at 70º C and their dry matter content was estimated. All samples were then ground in a laboratory mill through a 1mm screen. The finely ground samples were analyzed for proximate components (AOAC 2000) and cell wall fractions (Van Soest et al 1991).

Propagation study

The propagation study was carried out in a green house by means of seeds, root cuttings and stem cuttings. The stem and root cuttings were obtained during the summer before onset of the monsoon and seeds were procured from forest/local farmers according to availability. Each of the propagation materials (seeds, roots and stem cuttings) were kept in six replicates in different polythene bags. Organic manure plus sand was used to fill the

polythene bags for the propagation study. Agronomic practices (watering and weeding) were followed in regular intervals for 90 days. The percentage of germination from stem, root cuttings and seeds was determined.

Statistical analysis

One-way analysis of variance (ANOVA) was carried out to compare the data for chemical composition and degradability. The significance between the individual means was identified using the Duncan multiple range test (Duncan 1955). Regression analysis was used to establish the relationship between chemical composition and *in sacco* effective degradability of DM and CP

Results and discussion

Taxonomical classification and mode of propagation of the different foliages are shown in Table 1.

Table 1. Taxonomical classification and mode of propagation of different fodders of forest origin

SL.No	Taxonomy			Description	Propagation
	Family	**Genus**	**Species**		
1	Thysanolaenopoaceae	Thysanolaena	*T. agrostis*	G	RC
2	Urticaceae	Debrogesia	*D. longifolia*	TL	SC
3	Leiaceae	Smilax	*S. zeylanica*	CR	-
4	Euphorbiaceae	Emblica	*E. officinalis*	TL	S
5	Caesalpinaeceae	Albizzia	*Albizzia sp.*	TL	S and SC
6	Polygonaeceae	Polygonum	*P. chinensis*	H	SC
7	Laminaeceae	Borrena	*B. hirticulata*	G	S and RC
8	Poaceae	Thysanolaena	*T. maxima*	G	S and RC
9	Hypoxydoceae	Curculigo	*C. recusvata*	G	RC
10	-	Ficus	*F. hirta*	TL	S and SC
11	Moraceae	Ficus	*F. hookeri*	TL	S and SC
12	Rosaceae	Dacynia	*D. indica*	TL	SC
13	Rosaceae	Pranus	*P. cerasoides*	TL	S and RC
14	-	Ficus	*F. infectoria*	TL	S and SC
15	Bignoniaceae	Stereospermum	*S. chelonoedes*	S	SC
16	Sabiaceae	Sabia	*Sabia sp.*	TL	SC
17	Temstrmeaceae	Surarya	*S. curniculata*	TL	S
18	Oleaceae	Jasminum	*Jasminum .sp*	H	S and SC

SL. No: Sample number, G: Grass, TL: Tree leaves, CR: Creeper, H: Herbs, S: Shrubs, SC: Stem cutting,
 S: Seeds, RC: Root cuttings

The overall germination rates of stem and root cuttings and seeds were 59%, 29.4% and 58%, respectively. The vegetative propagation appeared to be possible for a majority of the foliage species (Napier 1988). However, there were species differences in responding to the time of propagation. Rooting potential increased when the cuttings were harvested towards the end of the dry season (April to June). Vegetative cuttings (stem/root) could be taken at most times of the year for propagation, but spring and summer were best, especially when new

growths have started to mature (Jennings 1997). The study revealed that the propagation techniques differed greatly from species to species but generalizations are possible (James et al 2004).

Table 2. Chemical composition of fodders (% DM basis)

Sl No	OM	DM	CP	EE	NDF	ADF	Ash
	Attributes						
1	92.8	26.3	15.1	1.8	32.4	17.1	7.20
2	92.1	30.2	17.8	2.1	33.2	22.1	7.90
3	92.7	28.7	10.9	3.7	38.6	27.9	7.30
4	99.5	21.9	16.3	3.1	34.7	21.0	10.5
5	90.7	25.3	18.7	2.1	37.2	22.5	9.30
6	91.2	20.1	14.2	2.8	35.9	23.7	8.80
7	87.2	15.2	16.1	1.9	29.1	17.2	12.8
8	92.1	26.0	10.2	2.1	30.2	20.1	7.90
9	89.2	25.8	12.3	2.8	37.5	25.6	10.8
10	90.2	24.1	17.5	1.4	30.1	17.5	9.80
11	92.4	26.3	14.2	2.1	31.8	20.5	9.60
12	89.1	22.5	13.8	2.8	36.5	19.7	10.9
13	91.2	31.5	22.4	3.1	25.0	14.4	8.80
14	89.0	35.2	18.5	2.9	35.8	20.5	11.0
15	87.9	22.1	14.8	3.7	34.1	26.9	12.1
16	88.6	26.3	25.4	3.4	29.5	18.4	11.4
17	86.9	31.7	12.3	1.7	34.0	21.2	13.1
18	90.5	34.9	10.3	2.0	30.1	18.4	9.50

SL. No: Sample number, OM: Organic matter, DM: Dry matter, CP: Crude protein, EE: Ether extract, NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Analysis for chemical composition (Table 2) revealed that the range of values for CP (10.2 to 25.4 %), EE (1.4 to 3.7%), NDF (25 to 38.6 %) and ADF (14.4 to 27.9%) indicated a wide margin in nutrients distribution among the different samples. The CP content of *Sabia sp* was significantly higher than the other species. All the selected foliages showed high CP content making them suitable in relation to N supply to the rumen microorganism (Norton 2003). The NDF and ADF content of foliages were comparable to those reported by Romero et al (2000). However, the geographical area and/or the season in which samples were collected influences the chemical composition (Alvira et al 1983).

The instantly soluble DM fraction 'a' of the samples was 17.5% and 28.7% in *Ficus infectoria* and *Stereospermum chelonoedes*, respectively. The insoluble but degradable dry matter fraction with time 'b' was lowest in *Sabia sp* 26.5% and highest in *Emblica officinalis* 64.1%. The effective degradability ranged from 27.1% to 41.0% among the fodder samples (Table. 3).

Table 3. Degradation kinetics and effective degradability (ED) of dry matter and crude protein of different fodder samples

Sl. No	Dry matter					Crude protein				
	a	b	a+b	RSD	ED	a	b	a+b	RSD	ED
1	23.7^f	42.7^h	66.4^k	1.14	41.0^k	20.9^{cd}	36.8^{fg}	57.7^e	0.64	37.3^{ef}
2	28.6^g	46.1^i	74.7^l	1.10	38.1^{hi}	20.0^{bc}	40.0^i	60.0^f	1.83	37.1^{ef}
3	18.3^{ab}	33.4^e	51.7^c	0.92	27.5^a	20.4^{bc}	29.9^c	50.3^c	1.00	30.8^b
4	28.6^g	64.1^j	92.7^m	1.71	39.3^i	26.1^{ij}	39.9^i	66.0^i	1.26	40.1^{hi}
5	23.5^f	26.9^a	50.4^b	0.89	31.8^c	22.2^{def}	23.8^b	46.0^b	0.81	31.7^{be}
6				0.76					2.20	

	19.5[bcd]	36.9[f]	56.4[fg]		37.6[gh]	27.6[j]	37.7[gh]	65.3[i]		44.1[j]
7	24.0[f]	32.3[de]	56.3[fg]	2.10	34.2[c]	23.8[fg]	37.9[g]	61.7[gh]	0.52	40.7[hi]
8	23.2[f]	31.6[cd]	54.8[e]	1.05	38.1[hi]	22.0[ef]	41.2[ij]	63.2[h]	0.69	38.7[fg]
9	18.8[abc]	26.5[a]	45.3[a]	0.83	29.6[b]	18.7[a]	21.3[a]	40.0[a]	0.37	26.8[a]
10	26.9[g]	47.8[i]	74.7[l]	0.84	36.8[efg]	25.4[li]	36.9[fgh]	62.3[h]	1.10	39.8[ghi]
11	20.8[de]	38.4[g]	59.2[i]	1.16	34.9[d]	26.7[ij]	34.1[ie]	60.8[fg]	0.47	36.4[e]
12	20.4[cd]	29.4[b]	49.8[b]	0.93	27.1[a]	19.5[ab]	30.1[c]	49.6[c]	0.40	26.4[a]
13	22.5[ef]	35.5[f]	58.0[hg]	0.4	36.7[fg]	29.3[k]	35.6[f]	64.9[i]	1.80	40.2[hi]
14	17.5[a]	26.9[a]	44.4[a]	1.07	32.0[c]	20.4[bc]	34.2[e]	54.6[d]	0.70	26.6[a]
15	28.7[g]	27.6[a]	56.3[f]	1.32	35.4[def]	21.4[cde]	32.0[d]	53.4[d]	0.46	33.6[d]
16	27.3[g]	26.5[a]	53.8[d]	0.79	35.1[def]	24.9[gh]	50.4[l]	75.3[l]	1.20	32.7[cd]
17	27.9[g]	29.9[bc]	57.8[g]	0.94	35.5[ef]	26.4[ij]	42.3[j]	68.7[j]	1.00	39.7[gh]
18	27.2[g]	37.1[g]	64.3[j]	1.67	38.3[ij]	25.7[hi]	47.2[k]	72.9[k]	3.78	41.0[i]
Sig.	**	**	**	-	**	**	**	**	-	**

SL. No; Sample number; a and b are constants of the exponential equation [P= a+b (1-e^{-ct})] where 'a' is the rapidly degradable fraction, b the slowly degradable fraction and 'c' the rate of degradation of fraction 'b', ED: Effective degradability (outflow rate: 0.05 h^{-1}); RSD: Residual standard deviation, * P<0.05, ** P<0.01

The 'a' and 'b' fractions of fodders ranged from 18.7 to 27.6 and 21.3 to 50.4%, respectively, with rate constant 'c' 0.009 to 0.04. The total potential degradability 'a + b' of protein ranged from 40 to 72.9% and the effective protein degradability was 26.4 to 44.1%. The undegradable protein (UDP) contents of different fodders varied from 55.9 to 73.6 g per 100 g of protein.

There were significant (P<0.01and P<0.05) negative correlations between ED of DM and cell wall content (NDF and ADF respectively) (Table 4).

Table 4. Correlation coefficients between chemical constituents and effective dry matter degradability

	DM	Ash	CP	NDF	ADF
Ash	-0.668[NS]				
CP	0.04[NS]	0.317[NS]			
NDF	-0.068[NS]	-0.20[NS]	0.39[NS]		
ADF	-0.136[NS]	-0.02[NS]	-0.43[NS]	5.33**	
EDD	0.031[NS]	-0.221[NS]	0.115[NS]	-0.566**	-0.493*

CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, EDD: Effective dry matter degradability, NS: Non-significant (P>0.05), ** P<0.01, * P<0.05

The regression equation showed that NDF and water soluble DM "a" were well correlated with *in saccco* ED of DM while for ED of CP the best correlation was with the water soluble protein "a" fraction (Table 5).

Table 5. Prediction of *in sacco* dry matter and protein digestibility from chemical constituents

Y	Equation and factors	R^2	P	MSE
ED of DM	Y=34.32 + 0.031* DM	-0.06	NS	4.07
	Y=39.8 - 0.221* Ash	-0.01	NS	3.97
	Y=33.18 + 0.115* CP	-0.05	NS	4.05
	Y=55.50 - 0.566* NDF	0.28	**	3.35

	Y=45.20 - 0.493* ADF	0.15	*	3.64
	Y=21.89 + 0.56* "a" Water soluble DM	0.30	**	3.40
ED of CP	Y=64.4 - 0.86* NDF	0.32	**	4.60
	Y=5.51 + 1.29* "a" Water soluble CP	0.56	**	3.70

*ED: Effective degradability, DM: Dry matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, NS: Non-significant (P>0.05), ** P<0.01, * P<0.05*

As pointed out by Chermiti et al (1996), the water soluble DM is mostly derived from the cell contents and in the NDF method is represented by the detergent soluble fraction. The water-soluble "a" fraction determined by the *in sacco* method was comparable with NDF as predictors of whole tract digestibility of DM in Mithun (R^2 of 0.30 and 0.32, respectively). The coefficient of determination (R^2) between potential DM digestibility (*in sacco 72 hour* degradability method) was 0.28 for water soluble DM compared with 0.06 for NDF (Enoh et al 2005; Pheng Buntha and Chhay Ty 2006).

The faster degradation of DM of *Stereospermum chelonoedes, Debrogesia longifolia, Emblica officinalis* and *Suraya curniculata* could be advantageous, which may probably release greater rumen metabolites, enhance rumen microbial functions and proliferations (Mackie and White 1990; Bonsi et al 1995). Feeding fast degrading foliage such as *Stereospermum chelonoedes, Debrogesia longifolia, Emblica officinalis* and *Suraya curniculata* could be advantageous in improving the rumen ecology (i.e., N, minerals and isoacids), and they may further enhance forage intake since they move out of the rumen faster and thus reduce rumen fill (Bonsi et al 1994; Bonsi et al 1995).

Conclusions

- *Thysanolaena agrostis, Emblica offencinalis, Ficus hirta* and *Jasminum sp.* could be a very good source of energy as the effective DM degradability was high.
- *Dacynia indica, Ficus infectoria,* and *Curculigo recusvata* could be a medium source of bypass protein as the ruminal degradation of CP was low.
- *Sabia sp., Pranus cerasoide* and *Albizzia spp* had relatively high protein content and thus have the potential to be good quality forages for ruminants animals during the critical period.
- The majority of the fodder species can be propagated in farmer's fields through vegetative propagation i.e. stem cuttings without much input.
- NDF and the water-soluble DM fraction are simple and reliable methods to predict the effective DM degradability of most mithun-relished foliages.

Acknowledgements

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