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Nutritional evaluation of forest tree leaves as livestock feed in sub mountainous region of India

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ABSTRACT

Samples of 7 species of forest tree leaves, fed to livestock in the semi-hilly arid zone of Punjab state in India, were collected at 30-day intervals for 12 months for evaluating their nutritional worth for livestock. The ground samples were pooled for dry hot, hot humid, fall and winter seasons. Irrespective of the season, the chemical composition revealed that the leaves of *Acacia modesta* (*phulahi*) and *Butea monosperma* (*dhak*) had higher crude protein then other leaves. The ether extract was the highest in *Phoenix acaulis* (*khajur*) and a lowest in (*kango*) leaves. The leaves of *khajur* and *bans* were highly fibrous. The leaves of *Anogeissus latifolia* (*chall*) had the highest concentration of cell solubles while that of *Bambusa arundinace* a (*bans*) had the lowest. Irrespective of the species of tree leaves, the season did not show any significant impact on the CP, OM and total ash content of tree leaves. The NDF, cellulose, hemicellulose and ADL contents were the lowest in summer and the highest concentration of NDF, ADF and ADL content was observed in winter. The relative proportion of globulins and prolamins predominated in most of the leaves. The leaves of *kango* had the highest Ca content followed by *dhak* and the lowest in *khajur* leaves. The leaves of *dhak* had the highest concentration of Mg, Co and Mn. The leaves of *chall* had the highest concentration of total tannins, but 98% of these were hydrolysable, while the leaves of *Bauhinia variegata* (*kachnar*) had the highest concentration of condensed tannins (77% of total tannins). The digestion kinetic parameters for DM, CP and NDF revealed that irrespective of season, the effective and true degradability were the highest in leaves of *chall* followed by that of *kango* leaves, but lowest in *khajur*, *dhak* and *bans* leaves. The leaves of *chall* had the lowest rumen fill value predicting highest voluntary intake, while reverse trend was observed in *khajur*, *dhak* and *bans* leaves. Irrespective of the species of tree leaves, the degradability of leaves as indicated by most of digestion kinetic parameters was highest in summer followed by that in fall and the lowest in winter. The rumen fill value was the lowest in summer predicting highest voluntary intake followed by fall and highest rumen fill was observed in winter predicting lowest intake. It was concluded that the leaves of *chall* and *kango* had great potential as livestock feed, while feeding of *khajur*, *dhak* and *bans* leaves should be avoided.

Key words: Forest tree leaves, *In- sacco* degradability, Mineral profile, Protein fractions, Tannins

In India only 2% of the cultivated area is under fodder production which could meet 8% requirements of the livestock. A survey conducted in the sub mountainou zone of Punjab state revealed that 65% of the farmers belonged to small and marginal category (land-holding ≥1.63 ha), 19% belong to medium (land-holding 5.3 ha) and only 2.2% farmers belonged to land-lord (≥ 16 ha) category (Hundal *et al.* 2009). The diet of the animals specifically in semi hilly arid zone of Hoshiarpur district was deficient in nutrients and animal were underfed. There is acute shortage of conventional green forages as the soil water-table is very low. Therefore, majority of the livestock in this region are dependent on the forest grasses and tree leaves. A comprehensive study revealed that out of 13 species of forest tree leaves and 10 species of wild grasses, leaves of *Morus alba*, *Ehretia leavis*, *Grewea* and *Leucaena* (Bakshi and Wadhwa 2004) and grasses like *Tarexacum* and *Sacharum* (Bakshi *et al.* 2005) were highly nutritious and showed great potential as alternate feed resources. However, animals refuse to eat certain tree leaves in a particular season, mainly because of high concentration of condensed tannins (Rana *et al.* 2006). *In-vivo* studies revealed that the leaves of *Melia azedarach*, *Morus alba* and *Leucaena leucocephala* supplemented with mineral mixture and common salt could be fed as complete feed to goat bucks (Bakshi and Wadhwa 2007). The objective of this study was to assess the potential of another set of 7 species of commonly fed forest tree leaves as livestock feed in different seasons.

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MATERIALS AND METHODS

Procurement of forest tree leaves: Seven species of forest tree leaves, viz. *phulahi, kachnar, khajur, dhak, kango, bans* and *chall* commonly fed to livestock in the semi-hilly arid zone (commonly called Kandi area) of Punjab state, were collected at 30 day interval for 12 months and dried in a forced air oven at 60°C for 48 h. The ground samples were pooled according to season, viz. dry hot (April to June), hot humid (July to September), fall (October to December) and winter (January to March).

Chemical analysis: The samples of forest tree leaves were analysed for proximate components like total ash, CP and EE (AOAC 1995), cellulose (Crampton and Maynard 1938) and other cell wall constituents (Robertson and Van Soest 1981). Organic matter (OM) was calculated by subtracting total ash from 100 and hemicellulose by subtracting acid detergent fibre (ADF) from neutral detergent fibre (NDF). The fat and pigments were removed by extracting the ground tree leaves with petroleum ether containing 1% acetic acid using soxhlet apparatus (AOAC 1995). The defatted samples were fractionated into 4 protein fractions based on solubility in different solvents (Monteiro *et al.* 1982). The protein content of these fractions was estimated by Lowry's (1951) method. Tannins were extracted, from fat free samples, using 70% aqueous acetone. The contents were centrifuged at 3 000 g at 4°C for 10 min and the supernatant was taken for determination of tannins by Folin-Ciocalteu reagent using tannic acid as a standard (Makkar *et al.* 1993). Condensed tannins were determined by using Butanol-HCl (Porter *et al*. 1986). The hydrolysable tannins were calculated by subtracting the condensed tannins from total tannins. Water soluble oxalates were estimated as per Abaza *et al.* (1968). The extractable aliquots were used for the estimation of Zn, Fe, Cu, Mn and Co by atomic absorption spectrophotometer, while calcium by AOAC (1995) and phosphorus was determined by colorimetric method (Jackson 1987).

In-sacco *studies*: Adult male rumen fistulated buffaloes (3; live weight 387±25 kg) were maintained on 1.5 kg concentrate mixture (maize 15, wheat 15, mustard cake 20, groundnut cake 10, rice bran 10, deoiled rice polish 27, mineral mixture 2, salt 1 part each), 5 kg wheat straw and 2 kg green fodder, to meet their nutrient requirements (NRC 2001), 30 days before starting the *in-sacco* evaluation. The parachute nylon bag (8×15 cm; 50±10 µm pore size), containing 3 g ground test sample in triplicate, were incubated in the rumen of 3 rumen fistulated male buffaloes, for 0, 3, 6, 9, 12, 24, 36, 48, 60 and 72 h (Mehrez and Orskov 1977). On removal, the bags were washed under running tap water till the rinsing water became colourless. The bags after squeezing gently were dried at 55°C for 48 h. The disappearance of DM was calculated from the amount incubated and left in the bag at each incubation period. The residue was analysed for CP and NDF for determining the rate and extent of digestion in the rumen. The different parameters, characterizing extent and rate of ruminal degradation i.e. 'a' rapidly soluble fraction, 'b' insoluble but degradable fraction and 'c' degradation rate were calculated according to Orskov et al. (1988). The effective degradability (ED) was estimated according to McDonald (1981). The rumen fill (RF) values were calculated by using the equation of VanEys (1982).

Statistical analysis: The data were analysed in 7×4 factorial design (Snedecor and Cochran1994) by using SPSS (1996) version 12.0. The means were compared for statistical significance by using Tukey's b.

RESULTS AND DISCUSSION

Chemical composition of tree leaves: Irrespective of the season, the leaves of *phulahi* and *dhak* had higher (P<0.05) CP content as compared to other leaves (Table 1). The EE content was highest (P< 0.05) in *khajur* leaves and lowest in *kango* leaves. The leaves of *khajur* (highest NDF) and *bans* (highest ADF and cellulose content) were highly (P<0.05) fibrous, while the leaves of *chall* had the lowest (P<0.05)

Table 1. Chemical composition of forest tree leaves in sub mountainous region of Punjab in different seasons

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7	PSE	S_1	S_2	S_3	S_4	PSE
Total ash	6.02^{b}	6.97^{cd}	4.98^{a}	9.97^{e}	6.53^{bc}	14.15^{f}	7.33^{d}	0.18	8.45	7.50	8.13	7.88	0.13
OM	93.98^{e}	93.03^{cd}	95.02^{f}	90.03^{b}	93.47^{de}	85.84^{a}	92.67^{c}	0.14	91.55	92.50	91.87	92.11	0.57
CP	13.11^{c}	11.05^{b}	7.61^{a}	13.09^{c}	10.29^{c}	12.45^{c}	9.07^{b}	0.18	11.15	11.13	11.00	10.54	0.36
EE	2.24^{ab}	2.59^{bc}	2.86^{c}	1.95^{a}	1.81^{a}	2.21^{ab}	2.20^{ab}	0.13	2.89^{c}	2.36^{b}	1.80^{a}	2.02^{ab}	0.14
NDF	65.78^{c}	62.38^{b}	77.46^{e}	66.84^{d}	66.98^{d}	79.56^{f}	49.01^{a}	0.33	64.49^{a}	66.58^{b}	67.54^{c}	68.83^{c}	1.71
ADF	46.48^{bc}	45.75^{b}	54.65^{f}	49.28^{d}	47.10^{c}	51.74^{e}	37.56^{a}	0.48	47.59^{b}	47.80^{b}	46.83^{a}	47.81^{b}	1.03
Hemicellulose	19.30^{d}	16.62^{b}	22.81^{e}	17.55^{c}	19.89^{d}	27.82^{f}	11.46^{a}	0.57	16.90^{a}	18.77^{b}	20.71^{c}	21.02^{c}	0.76
Cellulose	28.13^{d}	26.30^{c}	33.62^{f}	25.73^{bc}	25.20^{b}	31.16^{e}	24.32^{a}	0.35	27.35^{a}	28.00^{b}	28.04^{b}	27.71^{ab}	0.66
ADL	14.43^{d}	14.42^{d}	12.54^{c}	16.42^{e}	16.96^{e}	9.52^{a}	10.29^{b}	0.29	12.40^{a}	13.73^{b}	13.61^{b}	14.32^{c}	0.55

TL_1, *Phulahi* (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (Not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*); S_1, dry hot (April-June); S_2, hot humid (July-September); S_3, fall (October- December); S_4, winter (January- March);figures with different superscript in a row differ significantly;P<0.05; PSE, pooled standard error.

concentration of cell wall constituents. But the ADL was highest (P< 0.05) in leaves of *kango* and *dhak*, lowest in the leaves of *chall*. The leaves of *chall* had the highest (P<0.05) concentration of cell solubles while that of *bans* had the lowest (P<0.05), predicting higher voluntary DM intake of *chall* leaves and lowest in case of *bans* leaves. Irrespective of the species of tree leaves, the season did not show any significant impact on the CP, OM and total ash content of tree leaves. The NDF, cellulose, hemicellulose and ADL contents were lowest (P<0.05) in summer as compared to other seasons. The highest (P<0.05) concentration of NDF, ADF and ADL content was observed in winter.

Protein fractions and antiquality factors: The water soluble protein content was highest in *kachnar* and lowest in that of *kango* (Table 2), while water soluble sugars were highest in *kango* and lowest in *phulahi*. In almost all the tree leaves, the salt soluble protein fraction i.e. globulin and alcohol soluble fraction, prolamin predominated. The water-soluble fraction albumin ranged between 7.63 and 22.97%. The glutelin fraction ranged between 10.48 and 27.19% of total proteins. The leaves of *chall* had the highest concentration of total tannins, but 98% of these were hydrolysable, while the leaves of *bans* had the lowest concentration of total tannins. The leaves of *kachnar* had the highest concentration of condensed tannins i.e. 77% of the total tannins. The water soluble oxalates were highest in *bans* and lowest in *phulahi*. The high concentration of oxalates reduces the availability of calcium by forming precipitates of calcium oxalates. The level of soluble oxalates in tree leaves was much below the toxic level of 4% (Lal *et al.* 1966).

Mineral profile of tree leaves: The mineral composition of tree leaves revealed that *kango* had the highest Ca content followed by *dhak* and lowest on *khajur* leaves. The level was higher than the recommended level in the diet (NRC 2001) and could be useful for high yielding animals during early stages of lactation. Calcium is closely associated with phosphorus metabolism.The phosphorus (P) content varied between 0.05 and 0.10% (Table 3). The minimum requirement of P in the diet of ruminants varies from 0.12 to 0.24%. The leaves of *dhak* had the highest concentration of Mg, Co and Mn, while leaves of *bans* had the lowest Mg and Co and that of *khajur* had lowest Mn content. The other trace elements like Fe, Cu and

Table 2. Water soluble nutrients, protein fractions and tannins (% DM basis) in tree leaves in sub mountainous region of Punjab

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7
Sugars	0.97	3.86	2.84	2.09	4.91	2.25	4.63
Proteins	0.62	3.83	2.55	2.57	1.03	1.89	1.96
Protein fractions (relative %)							
Albumin	11.03	7.63	14.70	10.11	19.49	8.87	22.96
Globulin	40.79	35.09	24.22	45.55	34.83	32.10	34.19
Prolamin	32.04	38.79	45.19	28.18	35.19	31.85	31.64
Glutelin	16.13	18.49	15.90	16.16	10.49	27.19	11.21
Tannins,%							
Condensed	0.71	3.95	2.30	0.49	1.11	0.07	0.25
Hydrolysable	1.75	1.17	1.99	1.67	5.03	1.59	14.75
Total tannins	2.46	5.12	4.29	2.16	6.14	1.66	15.0
Oxalates	0.39	0.73	0.51	0.84	0.79	0.96	0.68

TL_1, Phulahi (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*).

Table 3. Mineral composition of tree leaves in sub mountainous region of Punjab

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7
Calcium (%)	2.80	3.00	1.10	3.58	4.00	1.42	1.36
Phosphorus (%)	0.06	0.10	0.05	0.05	0.07	0.09	0.05
Magnesium (ppm)	47.44	39.05	30.28	54.09	42.88	25.56	32.29
Cobalt (ppm)	0.062	0.074	0.05	0.129	0.082	0.039	0.086
Iron (ppm)	0.052	0.051	0.049	0.059	0.053	0.053	0.064
Manganese (ppm)	0.135	0.169	0.105	0.244	0.133	0.161	0.135
Copper (ppm)	0.073	0.078	0.081	0.072	0.076	0.074	0.073
Zinc (ppm)	0.187	0.177	0.16	0.171	0.206	0.164	0.169

TL_1, Phulahi (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*).

Zn were almost comparable amongst different species of tree leaves tested in this study.

In-sacco *studies*: The digestion kinetic parameters for DM degradation revealed that irrespective of seasons, the insoluble but potentially degradable fraction, 48 h degradability, effective and true degradability, apparent and potential extent of digestion were highest (P<0.05) in leaves of *chall* followed by that of *kango* leaves, but all these parameters were lowest (P<0.05) in *khajur*, *dhak* and *bans* leaves (Table 4). The leaves of *chall* had the lowest (P<0.05) rumen fill value followed by that of *kango* predicting highest voluntary DM intake, while that of *khajur*, *dhak* and *bans* leaves had highest (P<0.05) rumen fill values, predicting low voluntary DM intake. Irrespective of the species of tree leaves, the DM degradability of leaves as indicated by most of digestion kinetic parameters was highest (P<0.05) in summer followed by that in fall (October to December) and lowest (P<0.05) in winter. The rumen fill value was lowest (P<0.05) in summer predicting highest voluntary intake followed by fall and highest (P<0.05) rumen fill was observed in winter predicting lowest DM intake.

The digestion kinetic parameters for CP revealed that irrespective of seasons, the potential degradable fraction, 48 h degradability, effective and true degradability, apparent and potential extent of digestion were highest (P<0.05) in *chall* followed by that of *kango*, but lowest in *khajur*, *dhak* and *bans* leaves (Table 5). The rumen degradable protein (RDP) was highest (P<0.01) in the leaves of *chall* followed by *kango* and *phulahi*, but lowest in the leaves of *khajur* and *dhak*. Reverse but significant (P<0.01) trend was observed in rumen undegradable protein (UDP). Irrespective of the species of tree leaves, the effect of season revealed that these parameters

Table 4. Digestion kinetic parameters (%) for DM in forest tree leaves in sub mountainous region of Punjab in different seasons

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7	PSE	S_1	S_2	S_3	S_4	PSE
a	28.28^{f}	27.07^{e}	21.12^{b}	25.25^{d}	23.44^{c}	17.56^{a}	23.13^{c}	0.18	18.84^{a}	26.52^{a}	24.43^{b}	24.98^{c}	0.14
b	29.32^{c}	32.32^{e}	23.68^{b}	21.25^{a}	42.33^{f}	31.53^{d}	54.54^{g}	0.17	37.76^{d}	31.61^{b}	34.66^{c}	30.23^{a}	0.14
c, per hr	0.057^{b}	0.056^{b}	0.037^{a}	0.043^{a}	0.066^{c}	0.045^{a}	0.077^{d}	0.002	0.063^{c}	0.049^{a}	0.056^{b}	0.050^{a}	0.002
DMD	54.36^{d}	56.47^{e}	39.44^{a}	43.80^{b}	63.44^{f}	46.83^{c}	75.75^{g}	0.19	53.29^{b}	55.98^{c}	55.65^{c}	52.16^{a}	0.14
ED	48.74^{d}	49.48^{e}	35.08^{a}	39.52^{c}	54.13^{f}	38.59^{b}	64.34^{g}	0.17	46.08^{b}	48.51^{c}	48.56^{c}	45.35^{a}	0.13
TD	68.92^{d}	68.92^{d}	59.43^{a}	62.99^{b}	72.21^{e}	64.22^{c}	75.22^{f}	0.17	70.11^{c}	65.63^{a}	67.61^{b}	66.02^{a}	0.13
PED	67.21^{d}	67.14^{d}	57.98^{a}	61.54^{b}	70.33^{e}	62.65^{c}	73.35^{f}	0.20	68.28^{c}	63.95^{a}	66.33^{d}	64.40^{a}	0.15
AED	40.93^{d}	42.04^{e}	27.26^{a}	30.75^{b}	48.74^{f}	33.12^{c}	59.84^{g}	0.19	41.52^{c}	40.58^{b}	41.66^{c}	37.77^{a}	0.15
RF	24.24^{c}	23.79^{c}	29.55^{f}	28.17^{e}	21.17^{b}	27.26^{d}	16.85^{a}	0.16	23.97^{a}	24.38^{a}	23.94^{a}	25.45^{b}	0.12

TL_1, Phulahi (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*); S_1, Dry hot (April,June); S_2, Hot humid (July September); S_3, fall (October, December); S_4, winter (January, March);'a', rapidly soluble fraction; 'b', insoluble but degradable fraction; 'c', degradation rate; ED, effective degradability; TD, true degradability; PED, potential extent of digestion; AED, apparent extent of digestion; RF, rumen fill; figures with different superscript in a row differ significantly; P<0.05; PSE, pooled standard error.

Table 5. Digestion kinetic parameters (%) for CP in forest tree leaves of sub mountainous region of Punjab in different seasons

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7	PSE	S_1	S_2	S_3	S_4	PSE
A	36.98^{e}	36.60^{e}	18.62^{c}	13.92^{a}	18.41^{c}	30.90^{d}	15.25^{b}	0.17	23.59^{a}	24.14^{b}	25.80^{c}	24.00^{ab}	0.13
B	36.11^{c}	32.14^{b}	26.40^{a}	32.76^{b}	61.40^{e}	38.02^{d}	73.03^{f}	0.18	43.12^{c}	42.05^{b}	45.03^{d}	41.15^{a}	0.14
c, per hr	0.068^{c}	0.05^{b}	0.038^{a}	0.054^{b}	0.074^{cd}	0.049^{b}	0.079^{d}	0.002	0.059^{b}	0.048^{a}	0.071^{c}	0.058^{b}	0.002
CPD	70.27^{d}	64.16^{c}	40.70^{a}	41.24^{a}	76.17^{e}	61.64^{b}	84.48^{f}	0.20	63.16^{b}	60.12^{a}	67.19^{c}	60.18^{a}	0.15
RDP	63.35^{e}	57.50^{d}	34.59^{a}	35.94^{b}	64.11^{e}	56.10^{c}	70.79^{f}	0.26	54.06^{c}	52.21^{a}	59.27^{d}	52.97^{b}	0.20
UDP	36.65^{b}	42.50^{c}	65.41^{f}	64.06^{e}	35.89^{b}	43.90^{d}	29.21^{a}	0.26	45.94^{b}	47.79^{d}	40.73^{a}	47.03^{c}	0.20
ED	62.80^{e}	57.57^{d}	34.62^{a}	36.50^{b}	64.16^{f}	56.17^{c}	70.81^{g}	0.20	54.35^{c}	51.97^{a}	59.31^{d}	53.01^{b}	0.15
TD	71.83^{d}	63.80^{b}	59.64^{a}	66.80^{c}	74.62^{e}	66.15^{c}	75.51^{f}	0.19	68.28^{b}	63.13^{a}	72.72^{d}	69.21^{c}	0.14
PED	70.05^{d}	62.34^{b}	58.17^{a}	65.15^{c}	72.75^{e}	64.54^{c}	73.64^{f}	0.18	66.58^{b}	61.58^{a}	70.92^{d}	67.57^{c}	0.13
AED	53.84^{e}	45.65^{c}	27.66^{a}	32.69^{b}	61.27^{f}	46.55^{d}	68.34^{g}	0.22	48.13^{c}	44.19^{a}	52.93^{d}	46.74^{b}	0.16

TL_1, Phulahi (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*); S_1, dry hot (April,June); S_2, hot humid (July September); S_3, fall (October, December); S_4, winter (January, March);'a', rapidly soluble fraction; 'b', insoluble but degradable fraction; 'c', degradation rate; RDP, rumen degradable protein; UDP, rumen undegradable protein; ED, effective degradability; TD, true degradability; PED, potential extent of digestion; AED, apparent extent of digestion; figures with different superscript in a row differ significantly; P<0.05; PSE, pooled standard error.

Table 6. Digestion kinetic parameters (%) for NDF in forest tree leaves of sub mountainous region of Punjab in different seasons

Parameters	TL_1	TL_2	TL_3	TL_4	TL_5	TL_6	TL_7	PSE	S_1	S_2	S_3	S_4	PSE
a	16.65^{e}	14.56^{d}	8.70^{c}	14.50^{d}	8.29^{c}	6.34^{a}	7.22^{b}	0.16	4.43^{a}	11.22^{b}	12.39^{c}	15.61^{d}	0.12
b	31.67^{c}	35.46^{d}	27.42^{b}	25.62^{a}	45.24^{f}	41.31^{e}	55.18^{g}	0.20	42.09^{c}	37.94^{b}	38.32^{b}	31.30^{a}	0.15
c, per hr	0.046^{b}	0.052^{bc}	0.036^{a}	0.047^{a}	0.061^{cd}	0.051^{bc}	0.067^{d}	0.003	0.056^{b}	0.052^{ab}	0.051^{ab}	0.047^{a}	0.002
NDFD	43.40^{c}	45.58^{d}	29.99^{a}	36.50^{b}	50.35^{e}	43.30^{c}	58.94^{f}	0.20	41.65^{a}	45.30^{c}	46.13^{d}	42.94^{b}	0.15
ED	37.56^{d}	38.48^{e}	24.93^{a}	31.26^{b}	40.32^{f}	34.06^{c}	47.46^{g}	0.18	33.89^{a}	37.18^{c}	38.22^{d}	35.89^{b}	0.14
TD	63.90^{b}	66.69^{d}	59.17^{a}	65.43^{c}	69.70^{e}	66.49^{d}	72.70^{f}	0.19	68.29^{d}	66.66^{c}	65.81^{b}	64.44^{a}	0.14
PED	62.56^{b}	65.05^{d}	57.71^{a}	63.68^{c}	68.26^{e}	64.85^{d}	70.87^{f}	0.18	66.60^{d}	65.13^{c}	64.25^{b}	62.86^{a}	0.14
AED	32.34^{c}	34.04^{d}	21.90^{a}	26.71^{b}	38.58^{e}	32.34^{c}	46.51^{f}	0.17	32.93^{b}	34.12^{c}	34.59^{d}	31.11^{a}	0.13
RF	27.62^{d}	26.89^{c}	31.60^{f}	29.72^{e}	25.10^{b}	27.55^{d}	22.03^{a}	0.17	27.30^{b}	26.86^{a}	26.68^{a}	28.03^{c}	0.13

TL_1, Phulahi (*Accacia modesta*); TL_2, *kachnar* (*Bauhina variegate*); TL_3, *khajur* (*Phoenix acaulis*); TL_4, *dhak* (*Butea monosperma*); TL_5, *kango* (not available); TL_6, *bans* (*Bambusa anindinacea*); TL_7, *chall* (*Anogeissus latifolia*); S_1, dry hot (April, June); S_2, hot humid (July,September); S_3, fall (October, December); S_4, winter (January, March); 'a', rapidly soluble fraction; 'b', insoluble but degradable fraction; 'c', degradation rate; ED, effective degradability; TD, true degradability; PED, potential extent of digestion; AED, apparent extent of digestion; RF, rumen fill; figures with different superscript in a row differ significantly; $P<0.05$; PSE, pooled standard error.

for CP degradability were highest during fall followed by that in hot summer but lowest in hot humid season. The RDP was highest ($P<0.01$) during fall followed by that during dry hot and lowest during hot humid season. While the UDP content was highest ($P<0.01$) hot humid followed by that during winter and lowest during fall.

The degradation kinetic parameters for NDF revealed that irrespective of seasons, the potentially degradable fraction, degradation rate, 48 h degradability, effective and true degradability, apparent and potential extent of digestion were highest ($P<0.05$) in *chall* followed by *kango* and lowest ($P<0.05$) in *khajur*, *phulahi*, *dhak* and *bans* leaves (Table 6), indicating that highly fibrous leaves were poorly digested. Irrespective of the species of tree leaves, the potential degradable fraction, degradation rate, true degradability and potential extent of digestion were highest ($P<0.05$) during dry hot summer, while 48 h NDF degradability and effective degradability were highest ($P<0.05$) during fall, but most of these parameters were lowest during winter season, when the leaves are highly fibrous and lignified. It was concluded that the leaves of *chall* and *kango* had great potential as livestock feed, while feeding of *khajur*, *dhak* and *bans* leaves should be avoided.

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