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Nutritional evaluation of grasses and top foliages through *in vitro* system of sheep and goat for silvipasture system

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Abstract

Five species each of grass, shrubs and tree leaves were evaluated for nutritive value by *in vitro* gas production (IVGP) techniques using sheep and/or goat rumen inoculums. Average CP of shrubs and tree leaves was ($P<0.05$) higher than grasses. NDF, ADF and cellulose contents were lower ($P<0.05$) in shrubs and tree leaves than grasses. Mean cumulative gas production (ml/g) at 72h was ($P<0.05$) higher on shrubs than grasses in sheep and goat inoculums. IVGP from grasses, shrubs and tree leaves was more on goat than sheep inoculum. IVGP was more on *Dichanthium annulatum* (DA), *Securengia virosa* (SV) and *Anogeissus pendulla* (AP) on either sheep or goat inoculum. Average CP degradability of shrubs and tree leaves was higher ($P<0.05$) than grasses in goat inoculum. Mean *in vitro* degradability of NDF and ADF in rumen inoculums of sheep and goat was higher ($P<0.05$) for grasses than shrubs and tree leaves. Mean *IVDMD* of shrubs and tree leaves was higher ($P<0.05$) than grasses in goat rumen inoculum. The *IVDMD* of grasses; *Cenchrus ciliaris (*CC*)* and DA, shrubs; SV and *Helictris isora* (HI) and tree leaves; *Leucaena leucocephala* (LL) and *Grewia optiva* (GO) was higher ($P<0.05$) in rumen inoculums of sheep and goat. *In vitro* TVFA production in sheep and goat inoculums was higher ($P<0.05$) from grasses than shrubs and tree leaves. Total-N and NH_3-N concentration was lower ($P<0.05$) for grasses than tree leaves and shrubs. DA, CC among grasses, SV, HI among shrubs and LL, GO among tree leaves found nutritionally superior and may be used for silvi-pastures.

Keywords: Fermentation pattern, Gas production, Grasses, Nutrients digestibility, Top foliage

Abbreviations: ADF: Acid detergent fiber; **CP:** Crude protein; **IVDMD**: *In vitro* dry matter digestibility; **NDF**: Neutral detergent fiber; **OM**: Organic matter; **TVFA**: Total volatile fatty acids

Introduction

The availability and access to quality fodder resources is a major limitation in livestock production (Ajith *et al.,* 2012). Bundelkhand region of India frequently faces deficit of feed resources due to recurring drought which has resulted in overgrazing of common and grazing lands in the region coupled with local tradition/practice to leave the animals for grazing called *Anna Pratha* during lean period and rainy season (Tyagi, 1997). Ruminants particularly the small ruminants heavily depend on traditional feeding methods including common grazing on waste and community lands. Silvipasure studies have indicated that trees, shrubs, grasses and legumes combinations can play an important role not only in improving fodder production but also assured supply of fodder for the whole year. So to establish an efficient silvipasture system for small ruminants and to increase their productivity there was a need to evaluate the available feed resources (grasses, trees and shrubs) of the region for their nutritive value for subsequent introduction in silvipasture system. With this objective in present study five prominent species each of grasses, trees and shrubs were evaluated for their nutritive value *in vitro* using sheep and goat inoculums.

Materials and Methods

Collection of grasses, tree leaves and shrubs samples: Five species each of grass (*Cenchrus ciliaris*-CC*, Sehima nervosum*-SN*, Heteropogan contortus*-HC*, Chryosopogon fulvus*-CF *and Dichanthium annulatum*-DA*),* tree leaves (*Hardwickia binata*-HB*, Albizia lebbek*-AL*, Grewia optiva*-GO*, Anogeissus pendula*-AP and *Leucaena leucocephala*-LL*)* and shrubs (*Dichrostachys cinerea*-DC*, Securengia virosa*-SV*, Zizyphus xylopyrus*-ZX*, Helictris isora*-HI and *Acacia catechu*-AC*)* were selected based on yield, availability and preference of small ruminants. The samples were collected from the grazing lands and experiential farm, Indian Grassland and Fodder Research Institute, Jhansi. Collected samples were air dried under shade followed by oven drying at 65^{0}C. Dried samples were ground through Willey mill using 1 mm sieve and then stored in Tarson make plastic containers until further use.

Analytical techniques: Samples were analyzed for proximate constituents (AOAC, 2000) and cell wall fractions (NDF, ADF, cellulose and lignin) as per the method of Van Soest *et al*. (1991). *In vitro* DM digestibility of grasses, tree leaves and shrubs was estimated by two stages *in vitro* technique (Tilley and Terry, 1963) with rumen inoculums of sheep and goat maintained on grass hay-barley grain diet. Total in vitro gas production (IVGP) and DM degradability of samples were estimated using pressure transducer technique (Theodorou *et al.,* 1994). IVGP on different samples were recorded at 3, 6, 12, 24, 30, 48 and 72h. After 72 hours of incubation the residual DM was recovered by filtering using double layer muslin cloth and dried in oven. DM digestibility was expressed as DM difference before and after incubation. Digestibility of other chemical parameters was analyzed as a difference in its proportion in the DM before and after *in vitro* incubation

For fermentation pattern, 0.5g sample of grasses, tree leaves and shrubs were incubated in sheep and goat inoculum for 48 hours using *in vitro* technique (Tilley and Terry, 1963). After 48 hours of incubation, the samples were filtered through sintered crucible and filtrate thus obtained was analyzed for TVFA (Barnett and Reid, 1956), total-N (Kjeldhal method) and NH_3-N (Convey diffusion method) production. Data were statistically analyzed as per methods of Snedecor and Cochran (1968) for variance within and between grasses, shrubs and tree leaves using statistical software (M/s SPSS, IBM India Pvt. Ltd., V. 10) at probability (P) less than 0.05.

Results and Discussion

Chemical composition: Mean CP contents of shrubs and tree leaves were (P<0.05) higher by 7 to 10% than grasses but NDF, ADF and cellulose contents were lower (P<0.05) in shrubs and tree leaves than grasses (Table 1). Shrubs did not differ (P>0.05) in their CP contents and in tree leaves LL, AL and GO had (P<0.05) higher CP contents than AP (8.2) and HB (7.8%). CP contents of some of the tree leaves were higher than 15% e.g., LL, AL and GO but, it was less than 10% in AP and HB (P<0.05). Selective tree leaves such as SV and ZX as well as shrubs such as LL and GO had lesser cell walls than other tree leaves and shrubs. CP, ash and cell wall constituents of grasses studied were comparable to Singh *et al.* (1997). In the contrary, CP contents of 9 range grasses reported by Ismail *et al*. (2014) were higher, while NDF and ADF contents were lower than the present values. CP and fiber contents of evaluated tree leaves and shrubs were within the range of values reported by Smith (1992). Chemical composition of tree leaves and shrubs recorded were identical to the earlier findings (Bhadoria *et al*., 2002; Ramana *et al*., 2000). CP, ash and cell wall constituents of grasses studied were comparable to Singh *et al.* (1997). Such variation in composition is possible owing to the factors like weather, soil and plant. Chemical composition of tree leaves and shrubs recorded were comparable to earlier studies (Bhadoria *et al.*, 2002; Ramana *et al.*, 2000; Sahoo *et al.,* 2016). Kaitho *et al.* (1997) reported that CP, NDF and ADF values of leaves in 40 tropical browses were ranged between 7.9-30.7, 22.0-69.4 and 14.6-52.3%, respectively. From several studies, Holechek *et al.* (2004) summarized that fiber contents of grasses were higher than browse leaves or herbs. Like the present study, Hummel *et al.* (2006) recoded higher cellulose and hemicelluloses and low lignin contents in grasses than browse leaves, legumes and herbs. Omoniyi *et al.* (2013) recorded significant differences in OM, CP, NDF, ADF, cellulose and lignin contents of browse plants and our values of tree leaves and shrubs were within their reported values. Mean CP content of forest foliages (tree leaves) in temperate sub-Himalayas reported by Sahoo *et al*. (2016) were similar to CP values of tree leaves obtained in the present study, but NDF and ADF contents were lower.

Gas production kinetics: IVGP on sheep and goat inoculums was (P<0.05) comparable between grass and shrub species upto 24 h of incubation but lesser than tree leaves. At subsequent incubation intervals, IVGP in grasses was accelerated at higher rate than shrubs or tree leaves (Table 2). IVGP on grasses, shrubs and tree leaves was 8, 13 and 10% higher in goat than sheep inoculum due to relatively higher DM degradability, thus ascertained higher fermentation of substrate in goat compared to sheep. Earlier studies also indicated that the goats were more efficient than sheep in feed utilization (El Hag and Al Shargi, 1998). IVGP between species of grasses, shrubs and tree leaves were significant (P<0.05). Higher and lower IVGP on either sheep or goat inoculums was observed for DA and HC in grasses, SV and DC in shrubs and AP and AL among tree leaves. Higher IVGP observed on grasses than tree leaves and shrubs could be attributed to differences in their chemical composition (Blummel and Becker, 1997). According to stochiometry of IVGP, gases produced are

Table 1. Chemical composition (% DM basis) of grasses, shrubs and tree leaves

Attributes	OM	CP	EE	NDF	ADF	Hemi cellulose	Cellulose	Lignin	NFC
Grasses									
CC	89.40	5.35	1.91	69.90	42.00	27.90	29.05	6.50	12.24
SN	87.30	4.10	1.53	70.95	44.78	26.17	33.50	6.20	10.72
HC	89.50	3.80	1.59	72.05	41.82	30.23	35.50	7.80	12.06
CF	90.50	3.60	2.03	72.40	42.68	29.72	32.50	7.60	12.47
DA	90.70	4.20	2.58	71.90	38.40	33.50	30.00	6.40	12.02
Mean	89.48	4.21^{x}	1.93^{x}	71.44^{y}	41.94^{y}	29.50^{y}	32.11^{y}	6.90	11.90^{x}
SEM	0.60	0.30	0.19	0.45	1.03	1.23	1.17	0.33	0.31
Shrubs									
SV	90.30	11.30	2.79	27.50	17.20	10.30	13.40	4.10	48.71
HI	86.90	10.60	2.93	39.80	24.40	17.40	19.10	4.82	33.57
DC	86.70	12.50	2.03	42.05	29.01	23.04	12.05	14.50	30.12
AC	87.40	12.80	3.35	38.00	24.55	13.50	13.60	9.90	33.25
ZX	91.30	11.50	2.19	32.30	19.20	13.10	8.50	8.70	45.31
Mean	88.52	11.74^{y}	2.56^{xy}	35.93^{x}	22.87^{x}	15.47^{x}	13.33^{x}	8.38	38.19^{y}
SEM	0.95	0.40	0.24	2.65	2.10	2.21	1.71	1.88	3.69
Tree eaves									
LL	87.50	22.50	4.03^{y}	28.50	17.50	12.30	10.00	7.20	32.47
AL	91.00	19.70	3.21	47.60	31.80	15.80	19.00	12.50	20.49
HB	90.75	7.80	2.71	38.60	28.00	10.60	16.20	9.75	41.64
GO	86.83	16.00	3.69	35.30	18.60	16.70	13.70	4.40	31.84
AP	90.80	8.20	2.37	34.90	23.60	11.30	15.00	8.20	45.33
Mean	89.37	14.84^{z}	3.20	36.98^{x}	23.90^{x}	13.34^{x}	14.78^{x}	8.41	34.35^{y}
SEM	0.91	2.98	0.30	3.12	2.72	1.23	1.48	1.34	4.33

AC: *Acacia catechu,* AL: *Albizia lebbek,* AP: *Anogeissus pendula,* CC: *Cenchrus ciliaris,* CF: *Chryosopogon fulvus,* DC: *Dichrostachys cinerea,* DA: *Dichanthium annulatum,* GO: *Grewia optiva,* HB: *Hardwickia binata,* HI: *Helictris isora,* HC: *Heteropogan contortus*, LL: *Leucaena leucocephala,* SV: *Securengia virosa,* SN: *Sehima nervosum* ZX: *Zizyphus xylopyrus*

end products of substrate fermentation; mostly the result of fermentation of carbohydrates to acetate, propionate and butyrate (Menke and Steingass, 1988). Hence, substantial differences in carbohydrates fractions in feeds mainly influence total gas production (Deaville and Givens, 2001). Apori *et al.* (1998) reported significant differences in total gas production of tree leaves and shrubs at 24h and 48h of incubation and comparable to observations in the present study. Gas production kinetics (4-72h) indicated that grasses were more fermentable than browse leaves (Hummel *et al.,* 2006).

***Substrate degradability in vitro**:* Average DM and CP degradability of grasses, shrubs and tree leaves was comparable on sheep inoculum, while CP degradability in goat inoculums was higher (P<0.05) for shrubs and tree leaves than grasses. Mean *in vitro* degradability of NDF and ADF on sheep and goat rumen inoculums was higher (P<0.05) for grasses than shrubs and tree leaves, respectively (Table 3). In grasses, DA had highest CP, NDF and ADF degradability (%) in sheep (72.40, 64.3 and 58.2) and goat (73.51, 66.40 and 58.26%), while lowest in CF on either sheep (58.9, 48.2 and 45.6) or goat (60.3, 49.73 and 47.51) inoculums. Among shrubs, maximum degradability of DM, CP, NDF and ADF on sheep or goat were observed in SV and lowest in *DC*. Maximum or minimum *in vitro* degradability of nutrients in tree leaves was observed in LL and AP or HB, respectively on rumen inoculums of sheep and goat. Papachristou (1997) found that goat digested N more (P<0.05) efficiently (55.7 vs 41.7%) than sheep. Caceres (1998) observed that CP and OM digestibility (%) of *A. lebbeck* in sheep was 76.4 and 79.4, and 61.2 and 61.7 for wet and dry season, respectively. Prasad *et al.* (2000) reported that *IVDMD* of grass (*Panicum maximum*) was 18% lesser (50.6%) than subabul leaf. *In sacco* DM and N digestibility of *LL* was 65.6 and 51.2%, respectively in sheep. Ismail *et al.* (2014) reported digestible DM (DMD) of 55.29 to 67.42% in 9 range grasses grown in Sudan which was comparable to the present study. Merkel *et al.* (1999) fed three tropical tree legumes with two tropical grasses as sole feed to sheep and found that grass had higher DMD

Table 2. Gas production (ml/g) due to fermentation of grasses, tree leaves and shrubs in sheep and goats inoculums at different hours of incubation

Attributes	Fermentation hours													
	3		6		12		24		30		48		72	
	Sheep	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**	**Sheep**	**Goat**
Grasses														
CC	6.5	11.2	12.2	19.2	24.5	35.6	64.8	75.9	92.8	103.4	127.6	135.4	152.5	161.2
SN	5.5	8.3	10.3	14.6	21.7	30.3	59.3	68.62	84.5	93.4	111.32	121.1	134.6	140.
HC	6.3	8.2	12.1	15.5	13.5	30.0	46.6	66.5	70.1	91.5	96.3	117.5	125.0	137.5
CF	7.3	13.2	13.8	21.0	23.0	31.5	39.3	50.1	48.3	60.9	58.0	75.4	67.0	93.1
DA	13.0	19.3	21.8	30.8	45.3	55.6	76.0	102.3	103.8	126.9	133.7	158.5	173.0	183.3
Mean	7.72^{x}	12.04	14.04^{x}	20.22^{x}	25.60^{x}	36.60^{x}	57.20^{x}	72.68^{x}	79.90^{x}	95.22^{xy}	105.38^{xy}	121.58^{y}	130.42^{y}	143.02^{y}
SEM	1.35	2.04	2.02	2.89	5.28	4.85	6.51	8.52	9.63	10.64	13.53	13.61	17.85	14.97
Shrubs														
SV	6.0	10.8	10.5	16.5	20.2	28.6	43.5	53.6	57.3	67.3	73.8	88.5	90.0	108.4
HI	9.0	13.6	16.0	22.8	27.2	38.1	63.0	81.3	88.0	104.8	114.5	127.8	130.6	141.1
DC	11.0	12.5	18.8	23.5	36.0	48.7	86.3	97.0	114.5	119.5	138.66	139.5	154.0	153.2
AC	3.5	8.0	7.5	13.0	15.3	22.5	38.6	48.0	47.9	59.5	59.1	79.5	66.0	95.7
ZX	10.2	17.0	18.5	23.7	31.3	36.7	60.8	71.2	80.0	87.0	98.5	105.2	114.3	133.2
Mean	7.94^{x}	12.38	14.26^{x}	19.90^{x}	26.00^{x}	34.92^{x}	58.44^{x}	70.22^{x}	77.54^{x}	87.62^{x}	96.91^{x}	108.10^{x}	110.98^{x}	126.32^{x}
SEM	1.40	1.49	2.25	2.18	3.73	4.46	8.42	8.97	11.77	11.22	14.18	11.37	15.35	10.60
Tree leaves														
LL	13.0	23.3	24.3	39.8	43.7	62.8	70.3	97.0	90.6	115.3	112.3	132.1	128.0	144.5
AL	9.2	15.0	16.8	25.7	31.8	44.0	55.2	70.5	67.5	83.2	82.4	94.7	92.8	103.0
HB	3.3	5.7	7.6	12.7	21.3	30.7	50.9	63.5	63.5	77.2	74.1	98.2	88.6	110.0
GO	25.2	23.3	47.3	39.6	72.5	63.3	101.8	97.6	118.3	116.8	137.9	138.8	154.8	158.0
AP	8.3	11.3	13.8	19.3	25.0	35.0	62.0	76.3	87.0	102.3	119.6	135.3	151.6	166.0
Mean	11.80^{y}	15.72	21.96^{y}	27.42^{y}	38.86^{y}	47.16^{y}	68.04^{y}	80.98^{y}	85.38^{y}	98.96^{y}	105.26^{y}	119.82^{y}	123.16^{xy}	136.30^{xy}
SEM	3.69	3.43	6.88	5.42	9.23	6.83	9.06	6.96	9.78	8.12	11.86	9.62	14.05	12.69

(65-72%) than tree legumes (55-63%). The lower degradability of NDF and ADF in tree leaves and shrubs than grasses indicated complexity of cell walls, which might be due to bounding of cell wall carbohydrate with proanthocynidin present in top foliages. Shehata *et al.* (1988) observed higher digestibility of DM, CP and CF of *Atriplex nummualria* i.e., 55.7, 50.6, 58.7 ad 30% in Barki sheep than 40.7, 45.6, 55.8 and 23.0% in Barki goats, respectively. Ventura *et al.* (1999) reported that rumen degradability of OM and CP of the native forage shrubs in goats ranged from 33.5-57.5 and 30.4-72.2%, respectively. Papachristou (2000) reported that *IVOMD* of shrubs varied from 52.0-58.1%. These workers reported N-digestibility up to 64% on sole feeding of *Robinia pseudoacacia*. Goats digested N efficiently than sheep (55.7 vs 41.7; P<0.05) when fed *Carpinus oreintalis* and *Fraxinus ornus* shrubs. Apori *et al.* (1998) evaluated leaves of 4 fodder trees and 3 shrubs for in sacco degradation using sheep. DM and CP degradability of tree leaves and shrubs ranged between 45.7-87.5 and 52.5-93.4%, respectively and our values of DM and CP were within these values. Kaitho *et al.* (1997) reported a significant difference in DM degradation of 40 browse leaves. In a *in vivo* study Gurung *et al.* (1993) reported a wide variability in the rumen degradability of DM (32.3-76.9%) and CP (26.7-90%) of 13 important tree leaves found in Eastern hills of Nepal.

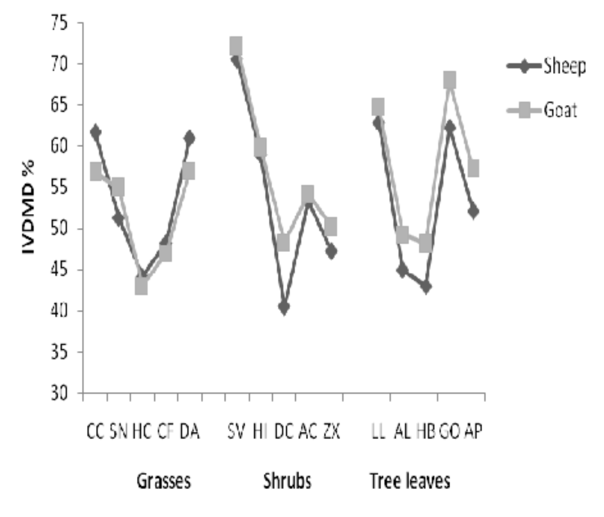

Fig 1. *IVDMD* of grasses, shrubs and tree laves in sheep and goat inoculums

Table 3. Crude protein and cell wall fractions digestibility (%) of grasses, shrubs and tree leaves

Attributes	Sheep				Goat			
	DM	CP	NDF	ADF	DM	CP	NDF	ADF
Grasses								
CC	66.15	64.3	56.5	50.8	61.50	61.2	52.60	48.02
SN	58.60	63.04	55.90	54.6	61.80	61.12	59.17	56.21
HC	53.70	58.90	48.20	45.6	61.30	60.3	49.73	47.51
CF	57.00	59.7	52.7	49.10	57.40	61.2	56.4	52.67
DA	72.00	72.40	64.3	58.2	73.80	73.51	66.4	58.26
Mean	61.5	63.67	55.52^{y}	51.66^{y}	63.2	63.48^{x}	56.26^{y}	52.34^{y}
SEM	3.33	2.40	2.64	2.18	2.78	2.52	2.88	2.14
Shrubs								
SV	80.50	76.70	54.4	47.3	81.60	82.7	59.7	53.4
HI	71.80	72.98	49.3	42.1	74.30	73.73	53.7	44.8
DC	50.50	49.05	43.2	40.1	52.50	52.46	45.2	40.8
AC	53.10	62.3	48.7	40.3	55.40	68.63	50.1	43.7
ZX	57.20	65.34	50.1	43.8	67.50	69.24	53.2	45.8
Mean	62.7	65.3	49.1^{x}	42.7^{x}	66.3	69.3^{y}	52.4^{x}	45.7^{x}
SEM	5.79	4.81	1.79	1.33	5.52	4.92	2.37	2.10
Tree leaves								
LL	66.70	74.95	58.0	49.7	72.10	88.8	63.1	54.8
AL	60.10	54.5	47.3	43.2	58.30	53.6	45.8	40.3
HB	53.50	51.7	42.8	38.7	60.80	54.2	46.2	43.0
GO	64.40	64.40	50.2	45.8	61.20	65.6	52.1	43.9
AP	76.70	76.3	54.10	48.0	75.60	78.2	53.03	44.8
Mean	62.3	64.1	50.5^{x}	45.1^{x}	63.6	68.08^{y}	52.0^{x}	45.3^{x}
SEM	3.83	5.06	2.63	1.93	3.45	6.86	3.13	2.48

***In vitro* dry matter digestibility:** Mean *IVDMD* (%) of shrubs (56.8) and tree leaves (57.4) was higher ($P<0.05$) than grasses (51.7) in goats when estimated following Tilley and Terry (1963) technique, but their *IVDMD* was similar on sheep inoculums (Fig 1). The *IVDMD* of CC and DA in grasses, SV and HI in shrubs and LL and GO in tree leaves was higher ($P<0.05$) in rumen inoculums of both sheep and goat. *IVDMD* (%) of SV was maximum on sheep (75.0) or goat (69.0) inoculum compared to lowest in DC on sheep (40.5) and goat (48.3) inoculums, respectively. Earlier studies suggested *IVDMD* range of 58.42 to 60.32% in range grasses (Singh and Srinivas, 1998), 38 to 78% in tree leaves (Skerpe and Bergstorm, 1986) and 53.5 to 69.7% in shrubs (Rahim *et al*., 2013) and the values observed in the present study were within the suggested ranges. Relatively lower *IVDMD* of AL, HB, DC and HC could be attributed to higher ADF content. Rao *et al.* (1993) reported that *Sesbania sesban* was degraded by 73% in 24 h compared to *L. leucocephala* and *Gliricidia* leaves which degraded to 64.5 and 72.7% even after incubating up to 48 h. Omoniyi *et al.* (2013) reported *IVDMD* of browse plants within the range of 33.33 to 68.87% which confirmed our recorded values.

Fermentation pattern: *In vitro* TVFA production in the inoculum of either sheep or goat at the end of the incubation was more ($P<0.05$) with range grasses than shrubs and tree leaves (Table 4). On the contrary total-N and NH_3-N was low in range grasses compared to tree leaves and shrubs. Higher total-N and NH_3-N production in either sheep or goat inoculum was observed in grass species like DA and CC, and TVFA was observed in SN. *In vitro* TVFA and N-fractions yield were more on SV shrub and tree leaves of LL and GO. *In vitro* TVFA and N-fractions was relatively higher on sheep inoculum with grass substrates while they were higher on goat inoculum with tree leaves or shrubs as substrates. Among tree leaves, maximum TVFA, total-N and NH_3-N production was observed with LL. The observations of Abdel Rehman and Eissa (1994) that higher concentration of TVFA with grass (*Stipagrostis scopario*) than shrub (*Hammada elegans*) samples incubated substantiated our findings. The differences in *in vitro* TVFA and N-fractions on different shrubs and tree leave could be due to type and level of tannins and related polyphenols in the leaves (Ebong, 1995).

Table 4. *In vitro* total-N (mg/100 ml), NH_3-N (mg/100 ml) and total volatile fatty acids (TVFA; meq/l) production on grasses, shrubs and tree leaves

Attributes	Sheep			Goat		
	Total-N	NH_3-N	TVFA	Total-N	NH_3-N	TVFA
Grasses						
CC	44.8	7.7	73.5	44.8	7.0	73.0
SN	39.2	7.0	80.5	44.8	5.6	83.0
HC	39.2	5.6	62.5	33.6	5.6	53.0
CF	44.8	5.6	65.0	39.2	5.6	60.0
DA	50.4	8.4	70.0	44.8	7.0	71.5
Mean	43.7^{x}	6.9^{x}	70.3^{y}	41.4^{x}	6.2^{x}	68.1^{y}
SEM	2.10	0.56	3.19	2.24	0.34	5.25
Shrubs						
SV	56.0	12.6	47.5	61.6	14.0	48.5
HI	44.8	11.2	86.0	43.4	10.5	43.0
DC	50.4	7.0	47.0	56.0	11.2	46.5
AC	44.8	8.4	65.0	50.4	8.4	49.0
ZX	50.4	9.8	73.0	50.4	11.2	82.5
Mean	46.3^{xy}	9.8^{y}	63.7^{x}	52.4^{y}	11.2^{y}	53.9^{x}
SEM	2.10	0.99	7.51	3.05	0.90	7.23
Tree leaves						
LL	56.0	13.3	73.5	61.6	15.4	73.5
AL	56.0	11.2	60.5	50.4	11.9	52.0
HB	44.8	8.4	55.0	39.2	9.1	52.2
GO	50.4	11.2	61.0	56.0	12.6	60.0
AP	39.2	9.8	46.5	44.8	8.4	68.0
Mean	49.3^{y}	10.8^{y}	59.3^{x}	50.4^{y}	11.5^{y}	61.1^{xy}
SEM	3.27	0.82	4.41	3.96	1.26	4.27

Conclusion

Utilization of shrubs and tree leaves was more efficient in goats and grasses in sheep. Grasses DA, CC; shrubs SV, HI and tree leaves; GO, LL, AP had higher CP, low fiber and higher nutrients digestibility in rumen inoculums of both sheep and goats. These grasses and top foliage may be utilized to develop efficient silvipasture systems for small ruminants.

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