Range Mgmt. & Agroforestry 36 (1) : 52-59, 2015
ISSN 0971-2070

Nutrients digestion, fermentation, gas production and partition factor of *Sehima nervosum* -tree foliage diets in sheep and goat inoculums

Sultan Singh*, A. Gupta and B. B. Singh
ICAR-Indian Grassland and Fodder Research Institute, Jhansi-284003, India
*Corresponding author e-mail: singh.sultan@rediffmail.com
Received: 9th September, 2014 Accepted: 29th April, 2015

Abstract
Dietary combinations of *Sehima-nervosum-SN* grass with tree leaves and shrubs 5 each in 50:50 and 75:25 proportions were evaluated for *in vitro* fermentation, nutrients degradation, metabolites production, gas production and partition factor in sheep and goat inoculums. SN at 50: 50 ratio with tree leaves and shrubs had higher (P<0.05) CP and lower NDF, ADF and cellulose than at 75:25 ratio. Mean nutrients degradability of diets differ (P<0.05) in both sheep and goat inoculums, while mean CP digestibility of diets was higher at 50:50 ratio of SN-tree foliage in both species. SN-SV (*Securengia virosa*) diets had highest nutrients digestibility against the lowest from SN-HB (*Hardwickia binata*) and SN-DC (*Dichrostachys cineria*) diets in both species inoculums. SN-DC diet had higher nutrients digestibility in goat inoculum while nutrients digestibility from other diets was at par with sheep inoculums. Mean concentration of TVFA (meq/l), total-N and NH_3-N (mg/100ml) from SN-SV and SN-LL (*Leucaena leucocephala*) diets was more both in sheep (79.50, 50.40 and12.60; and 73.50, 43.40 and 10.50) and goat inoculums (73.50, 57.40 and 13.65; and 77.50, 44.80 and 10.15), while SN-AC (*Acacia catechu*), SN-DC and SN-HB diets had lower production of these metabolites in rumen liquor of both species. Diets with SN: leaves of trees/shrubs in 50:50 ratio had higher total-N contents in goat inoculum. Mean gas production (ml/g/24 h), *IVDMD* and partition factor (PF) varied (P<0.05) amongst the SN-tree foliage based diets. Sheep had higher gas production at 75:25 ratio (143.11) than 50:50 ratio of grass-tree foliage diets (130.24 ml/g). Mean gas was higher at 75:25 ratio of grass-tree foliage diets in both species. Results revealed that dietary combinations of SN grass with SV, LL and GO had higher nutrients digestibility and more metabolites (TVFA, total-N and ammonia-N) production on fermentation in rumen inoculums of both sheep and goats.

Keywords: Fermentation, Goat and Sheep inoculums; Gas production; Nutrients degradation, Partition factor

Abbreviations: AC: *Acacia catechu*, **ADF**: Acid detergent fibre, **AL**: *Albizia lebbek*, **AP**: *Anagoesus pendula*, **DC**: *Dichrostachys cinerea*, **CP**: Crude protein, **GO**: *Grewia optiva*, **HB**: *Hardwickia binata*, **HI**: *Helictris siora*, **IVDMD**: *in vitro* dry matter digestibility **LL**: *Leucaena leucocephala*, **NDF**: Neutral detergent fibre, **PF**: Partition factor, **SEM**: Standards error of means **SN**: *Sehima nervosum*, **SV**: *Securenegia virosa*, **TVFA**: Total volatile fatty acids, **ZX**: *Zizyphus xylopyrus*

Introduction

Native grasses and foliage from tree leaves and shrubs are the important feed resources for the grazing livestock mainly the sheep and goats and altogether constitute major bulk of their diets (Ismail *et al*., 2014). Grass based feeding system with tree foliage supplementation is the prevailing and acceptable small ruminant production around the world. As the mature grasses and other crop residues (straws and stovers) had low nutritive value and often results in animal weight loss when offered alone (Hindrichsen *et al*., 2004) and are unable even to constitute the maintenance diet. Contrary foliage from tree and shrubs are rich in protein, mineral, soluble carbohydrate and vitamins (Bakshi and Wadhwa, 2007; Olafadehan, 2013), thus provide supplementary nutrients to the low quality fibrous feeds and pastures to improve their utilization (Tolera, 2007) to increase ruminant production (Rubanza *et al*., 2007; Barakat *et al*., 2013). In addition to their nutritional quality most tree foliage fed to livestock contain one or other type of anti-nutritional compound (Makkar, 2003; Ben Salem *et al*., 2005; Assefa, 2007) which restricts their wide use in ruminant feeding. Sheep and goats had different feeding behaviour, level of intake, eating rate, digestion and fermentation efficiency due to differences in their anatomy, physiology and microbial adaptations (Ngwa *et al*., 2000; Lu *et al*., 2005).

It is proved that supplementation of low quality grass hays, stovers and straws with concentrate improve their intake and digestibility (Nurfeta, 2010). Use of such supplement for landless people who rear a large proportion of sheep and goats is limited due to non-availability and high cost of concentrate supplements. The use of tree foliage as protein feed is an economic preposition with poor quality feeds and/or pasture based small ruminant production system in achieving a desired level of productivity. Therefore it is important to evaluate the region specific tree leaves and shrubs for their nutritive value to qualify them as strategic supplement or sole feed to ruminants. The present study evaluated the different *Sehima nervosum*-tree leaves/shrubs based diets *in vitro* in sheep and goat inoculums for nutrients digestibility, fermentation and partition factors to optimize the grass: shrubs/tree leaves proportion in silvi-pasture system for small ruminants.

Materials and Methods

Selection, sampling, processing and diets formulation: *Sehima nervosum-SN grass,* leaves from 5 trees (*Hardwickia binata-HB, Albizia lebbek-AL, Grewia optiva-GO, Anogeissus pendula-AP* and *Leucaena leucocephala-LL)* and 5 shrubs (*Dichrostachys cineria-DC, Securengia virosa-SV, Zizyphus xylophyrus-ZX, Helictris isora-HI and Acacia catechu-AC)* were selected based on their relative yield potential, availability and use in feeding systems in Bundelkhand region. Samples were collected from the grazing fields and nursery of Crop Improvement and Grassland and Silvipastoral Management Division of Institute. After collection, initially the samples of grass, tree leaves and shrubs were dried in shade on cemented floor and later in hot air oven at 60-65 ^{0}C till a constant weight. The dried samples were ground to pass through 1 mm sieve using Wiley mill and stored in plastic containers. Grinded samples were used for the formulation of 20 diets in 50:50 and 75:25 proportions using SN grass and leaves respectively.

Analytical techniques: Feed resources and diet combinations were analyzed for moisture, ash and CP (AOAC, 1995). NDF, ADF, cellulose and lignin were estimated following method of Goering and Van Soest (1970) modified by Van Soest *et al*. (1991).

In vitro methods: To estimate the *in vitro* dry matter digestibility (*IVDMD*) of diets two stage technique of Tilley and Terry (1963) was followed, while for rumen metabolite estimations first stage of *in vitro* technique was followed where 0.5g samples of *SN*-tree leaves and shrubs diets (50:50 and 75:25 ratios) in triplicate were incubated with sheep and goat inoculum. After 48 hours of incubation, the samples were filtered through sintered crucible and filtrate thus obtained was analyzed for total nitrogen and ammonia-nitrogen and TVFA as per method of McKenzie and Wallace (1954), Conway *et al*. (1951) and Briggs *et al.* (1957), respectively.

For gas production and DM degradability studies pressure transducer technique of Theodorou *et al*. (1994) was followed where SN grass: shrubs and tree leaves diets were incubated with sheep and goat rumen inoculums for 24 h. Residue left after incubation was analyzed for CP, NDF and ADF and the loss of nutrients was used to calculate degradability for respective animal species. Partitioning factor was calculated with some modification as the ratio of mg of DDM to ml of gas produced (Blümmel and Lebzien, 2001).

Statistical analysis: The statistical analysis of data was done using SPSS 13.0. Duncan's multiple range test was applied for caparison of means within of *SN* grass-shrubs/trees foliage diets.

Results and Discussion

Chemical composition: Mean contents of CP, NDF, ADF, cellulose and lignin differed significantly (P<0.05) amongst diets. Diets with 50:50 ratio of SN: tree leaves/ shrubs had (P<0.05) lower NDF, ADF and cellulose than diets of 75:25 ratio (Table 1). Mean CP contents of SN-LL and SN-AL were higher and lower for SN-HB and SN-AP diets. Both NDF and ADF contents were more in SN-AL (61.36 and39.26), SN-HI (60.49 and37.87) and SN-DC (60.56 and 37.95 %) and lower in SN-LL (55.20 and 35.05), SN-GO (56.79 and 35.69) and SN-ZX diets (56.28 and 34.46%). Mean lignin contents were more in SN-ZX (8.90) and SN-AL (8.47) and less in SN-SV (5.21) and SN-GO (5.72%) diets. The variability in CP and fiber contents of different diets may be attributed to differences in nutrient contents of tree leaves and shrubs. Differences in CP, fiber, OM contents of *Pennisetum purpureum* based diets supplemented with different tree leaves has been reported (Isah *et al.,* 2013; Osakwe *et al*., 2007) which substantiates the present findings. Similarly the chemical composition of haylage (different grasses) and pumpkin foliage diets has been reported by Aregheore (2007) which is on the pattern of present results.

Nutrients degradability: Mean degradability of DM, NDF and ADF was higher (P<0.05) for SN-HI, SN-SV, SN-LL and SN-GO diets in rumen inoculum of both sheep and

Table 1. Chemical composition of different dietary combinations of *Sehima nervosum* with shrubs and tree leaves

Diets		OM	CP	NDF	ADF	Cellulose	Hemi cellulose	Lignin
SN: AC 50: 50		89.71	7.52	54.95	34.35	23.78	20.60	7.55
SN: AC 75: 25		89.13	4.81	63.91	39.81	30.94	24.10	7.24
Mean		89.42	6.17	59.43	37.08	27.36	22.35	7.40
SN: ZX 50: 50		90.13	6.91	51.05	31.07	19.70	19.98	10.33
SN: ZX 75: 25		87.82	6.30	61.51	37.85	26.83	23.66	7.47
Mean		88.98	6.61	56.28	34.46	23.27	21.82	8.90
SN: HI 50: 50		88.87	6.74	55.22	35.01	26.36	20.21	6.55
SN: HI 75: 25		88.36	4.72	65.75	40.73	29.74	25.02	6.93
Mean		88.62	5.73	60.49	37.87	28.05	22.62	6.74
SN: SV 50: 50		88.95	6.91	49.92	29.19	22.55	20.73	4.82
SN: SV 75: 25		88.32	4.90	60.40	41.66	33.40	19.84	5.60
Mean		88.64	5.91	55.16	35.43	27.98	20.29	5.21
SN: DC 50: 50		90.16	7.79	56.23	35.97	22.80	20.26	10.90
SN: DC 75: 25		88.76	5.00	64.88	39.93	28.90	24.95	7.40
Mean		89.46	6.40	60.56	37.95	25.85	22.61	9.15
SN: LL 50: 50		87.89	12.16	50.18	32.13	23.97	18.05	6.61
SN: LL 75: 25		87.67	8.40	60.21	37.96	28.11	22.25	6.17
Mean		87.78	10.28	55.20	35.05	26.04	20.15	6.39
SN: AL 50: 50		88.62	13.74	64.46	39.42	31.69	25.04	6.82
SN: Al 75: 25		89.60	7.87	58.26	39.10	26.10	19.16	10.11
Mean		89.11	10.81	61.36	39.26	28.90	22.10	8.47
SN: HB 50: 50		89.39	6.04	53.62	35.59	25.15	18.03	7.36
SN: HB 75: 25		87.97	5.50	62.17	40.44	28.74	21.73	7.69
Mean		88.68	5.77	57.90	38.02	26.95	19.88	7.53
SN: AP 50: 50		90.69	5.86	53.19	35.82	26.91	17.37	6.58
SN: AP 75: 25		87.76	5.25	61.55	40.80	30.75	20.75	5.64
Mean		89.23	5.56	57.37	38.31	28.83	19.06	6.11
SN: GO 50: 50		89.17	9.80	52.29	31.81	23.62	20.48	5.87
SN: GO 75: 25		86.47	7.17	61.28	39.56	30.92	21.72	5.56
Mean		87.82	8.49	56.79	35.69	27.27	21.10	5.72
Ratio mean	50:50	89.36	8.35	54.11	34.04	24.65	20.07	7.34
	75:25	88.19	5.99	62.00	39.78	29.44	22.32	6.98
SEM	50:50	0.26	0.85	1.33	0.94	1.01	0.68	0.60
	75:25	0.28	0.43	0.72	0.39	0.69	0.65	0.44
Diets mean		88.77	7.20	58.05	36.90	27.04	21.20	7.16
SEM		0.29	0.72	1.39	1.00	0.96	0.64	0.50
Diet		NS	*	*	*	*	NS	*
Ratio		NS	*	*	*	*	NS	NS

goat (Table 2). Contrary lower degradability of these nutrients was recorded for SN-AC, SN-DC and SN-HB diets. Degradability of CP from SN-LL, SN-GO and SN-SV diets was higher (P<0.05) than SN-HB, SN-AP diets in rumen inoculums of both species. Grass: tree leaves/ shrubs ratio in different diets had no effect on mean nutrients digestibility in both species except CP which was higher at 50:50 ratio in both sheep and goats. Mean degradability of DM, CP, NDF and ADF from diets tended to be more in goats (59.51, 63.48, 48.55 and 43.37) than sheep (57.33, 62.79, 46.39 and 41.74 %) but the differences were non-significant.

The digestibility of CP, NDF and ADF in sheep on Rhode grass diet supplemented with 450g air dried moringa leaves is more or less similar to the present findings (Gebregiorgis *et al*. 2012). The digestibility of DM, CP, NDF and ADF observed by Alemu *et al.* (2014) in sheep fed natural pasture grass hay *ad lib* supplemented with 150, 300, 450 g dried *Millettia ferruginea* leaf is identical to present observations. Ondiek *et al*. (2013) reported that maize stover diet supplemented with different tree

Table 2. Nutrients degradability (%) of *Sehima nervosum*- tree foliage diets in sheep and goat inoculums

Diets		Sheep				Goat			
		DM	CP	NDF	ADF	DM	CP	NDF	ADF
SN: AC 50: 50		49.4	59.6	39.8	31.9	50.5	53.4	47	39.3
SN: AC 75: 25		52.7	60.7	44.6	38.7	56.4	56.1	45	41.1
Mean		51.05	60.15	42.20	35.30	53.45	54.75	46.00	40.20
SN: ZX 50: 50		57.8	65.7	42	37.6	60.3	67.9	49.8	39.3
SN: ZX 75: 25		59.1	55.2	49.4	44.7	55.3	58.1	43.2	37.8
Mean		58.45	60.45	45.70	41.15	57.80	63.00	46.50	38.55
SN: HI 50: 50		66.1	55.7	51.8	49.9	67.7	67	53	49.3
SN: HI 75: 25		61.5	61.4	52.7	48.7	65.2	61.5	53	46.8
Mean		63.80	58.55	52.25	49.30	66.45	64.25	53.00	48.05
SN: SV 50: 50		66.5	74.5	46.6	49.5	67.7	75.75	58.4	52.6
SN: SV 75: 25		65.5	76.2	58.5	56.1	65.1	70.4	55	51
Mean		66.00	75.35	52.55	52.80	66.40	73.08	56.70	51.80
SN: DC 50: 50		46.4	57.7	35.2	28.5	53.2	61.3	43	38.5
SN: DC 75: 25		50.8	55.3	39.7	32.8	54.4	60.8	42.9	34.9
Mean		48.60	56.50	37.45	30.65	53.80	61.05	42.95	36.70
SN: LL 50: 50		69.8	76.3	58.7	57.5	63.1	79.4	54.4	50.7
SN: LL 75: 25		55.4	71	44.4	41.2	63.6	69.8	50	47.7
Mean		62.60	73.65	51.55	49.35	63.35	74.60	52.20	49.20
SN: AL 50: 50		49.8	69.8	44.5	39.9	61.3	71.4	57.4	47.1
SN: Al 75: 25		56.9	57.2	43.9	38.3	58.4	60.6	45.2	40.6
Mean		53.35	63.50	44.20	39.10	59.85	66.00	51.30	43.85
SN: HB 50: 50		47.8	52.6	37.3	30.3	53.5	43.8	31.9	28.1
SN: HB 75: 25		50.1	53.7	39.6	35.1	52.2	51.1	39.8	36.7
Mean		48.95	53.15	38.45	32.70	52.85	47.45	35.85	32.40
SN: AP 50: 50		53.9	58.7	49.4	46.4	55.1	61.2	51.5	47.6
SN: AP 75: 25		59.4	53.1	45.9	43.8	60.5	56.2	49.8	45.9
Mean		56.65	55.90	47.65	45.10	57.80	58.70	50.65	46.75
SN: GO 50: 50		66.2	73.5	53	47.1	65.2	73.1	50.2	45.7
SN: GO 75: 25		61.5	67.8	50.8	46.8	61.5	70.8	50.4	46.7
Mean		63.85	70.65	51.90	46.95	63.35	71.95	50.30	46.20
Ratio mean	50:50	57.37	64.41	45.83	40.86	59.76	65.43	49.66	43.82
	75:25	57.29	61.16	46.95	42.62	59.26	61.54	47.43	42.92
Ratio SEM	50:50	2.86	2.73	2.37	2.96	2.00	3.42	2.45	2.36
	75:25	1.60	2.52	1.87	2.19	1.46	2.14	1.55	1.71
Diet mean		57.33	62.79	46.39	41.74	59.51	63.48	48.55	43.37
SEM		2.17	2.61	2.00	2.41	1.61	2.74	2.01	2.01
Diet		*	*	*	*	*	*	*	*
Ratio		NS	*	NS	NS	NS	*	NS	NS

***** Differ significantly at $P<0.05$; NS-Non-significant

leaves (*Balanites aegyptiaca* and *Acacia tortilis*) had different nutrients digestibility in African goats and the extent of digestion is similar to the present findings. Similarly Isah *et al.* (2013) reported difference in the nutrients digestibility in East African dwarf goats fed *Pennisetum purpureum* basal diet supplemented with 4 different tree leaves (*Merremia aegyptia, Aspilia Africana, Alchornea cordifolia and Newbouldia laevis*) further supports the present observations. Nutrient constituents of different foliage/grasses may better explain the pattern of nutrient degradability; the associative effect may further explain the digestive effects.

Total-N, ammonia-N and total volatile fatty acid production: Mean concentration of total volatile fatty acids (TVFA), total-N and ammonia-N from fermentation of SN-tree foliage diets in rumen inoculums of sheep (69.75, 43.83 and 9.73) and goats (68.95 meq/l, 45.17 and 10.25 mg/100ml) was comparable (Table 3). Total-N and ammonia-N production was more at 50:50 ration of SN:

Table 3. Rumen metabolites concentration on incubation of *Sehima nervosum*- tree/shrubs foliage diets in sheep and goat inoculums

Diets		Sheep			Goat	
	TVFA	**Total-N**	**NH3-N**	**TVFA**	**Total-N**	**NH3-N**
SN: AC 50: 50	60	39.2	7.7	63	42	9.1
SN: AC 75: 25	63	42	8.4	56	39.2	8.4
Mean	61.50	40.60	8.05	59.50	40.60	8.75
SN: ZX 50: 50	67	42	8.4	63	46.7	9.8
SN: ZX 75: 25	72	44.8	9.1	60	42	8.4
Mean	69.50	43.40	8.75	61.50	44.35	9.10
SN: HI 50: 50	70	47.6	12.6	76	50.4	11.9
SN: HI 75: 25	68	42	9.8	73	44.8	9.1
Mean	69.00	44.80	11.20	74.50	47.60	10.50
SN: SV 50: 50	90	53.2	13.3	86	64.4	15.4
SN: SV 75: 25	69	47.6	11.9	61	50.4	11.9
Mean	79.50	50.40	12.60	73.50	57.40	13.65
SN: DC 50: 50	60	42	9.1	67	47.6	11.2
SN: DC 75: 25	72	44.8	8.4	64	42	8.4
Mean	66.00	43.40	8.75	65.50	44.80	9.80
SN: LL 50: 50	78	50.4	11.9	81	50.4	11.2
SN: LL 75: 25	69	36.4	9.1	74	39.2	9.1
Mean	73.50	43.40	10.50	77.50	44.80	10.15
SN: AL 50: 50	61	46.7	9.1	73	44.8	11.2
SN: AL 75: 25	68	42	8.4	71	39.2	9.8
Mean	64.50	44.35	8.75	72.00	42.00	10.50
SN: HB 50: 50	63	39.2	9.1	74	42	9.8
SN: HB 75: 25	70	44.5	9.8	65	39.2	8.4
Mean	66.50	41.85	9.45	69.50	40.60	9.10
SN: AP 50: 50	66	44.5	9.1	71	47.6	11.9
SN: AP 75: 25	70	42	8.4	62	42	9.1
Mean	68.00	43.25	8.75	66.50	44.80	10.50
SN: GO 50: 50	68	46.7	11.9	76	47.6	11.2
SN: GO 75: 25	71	39	9.1	63	42	9.8
Mean	69.50	42.85	10.50	69.50	44.80	10.50
Ratio mean 50:50	68.3	45.15	10.22	73	48.35	11.27
75:25	71.2	42.51	9.24	64.9	42	9.24
Ratio SEM 50:50	2.97	1.47	0.83	2.34	2.01	0.56
75:25	2.44	1.01	0.34	2.88	1.10	0.34
Diet mean	69.75	43.83	9.73	68.95	45.17	10.25
SEM	2.40	1.15	0.48	2.13	1.76	0.51
Diets	*	*	*	*	*	*
Ratio	NS	NS	NS	NS	*	NS

* Differ significantly at P<0.05; NS-Non-significant

tree foliage diets in both species rumen inoculums. Mean TVFA concentration was more at 75:25 ratio of SN: tree foliage diets in sheep (71.2) and at 50:50 in goats (73.0 meq/l), respectively. Within the diets fermentation of SN-SV (79.50, 50.40 and 12.60 and 73.50,57.40 and 13.65) and SN - LL (73.50, 43.40 and 10.50 and 77.50, 44.80 and 10.15) resulted in higher (<0.05) TVFA, total-N and ammonia-N production than SN-AC (61.50,40.60 and 8.05 and 59.50, 40.60 and 8.75) and SN-HB diets (66.50 meq/l, 41.85 and 9.45 mg/100ml and 69.50 meq/l, 40.60 and 9.10 mg/100 ml) in sheep and goat inoculums, respectively. Goats exhibited higher (P<0.05) total-N contents on SN: foliage diets at 50:50 (48.35) than at 75:25 ratio (42.00 mg/100 ml). TVFA and NH_3-N concentration observed by Osakwe and Steingass (2013) in rumen liquor of African Dwarf goats fed grass hay supplemented with *Dialium guineense* leaves is similar to present study. However, Alemu *et al.* (2014) observed

Table 4. Gas production, *in vitro* dry matter digestibility and partition factor of *Sehima nervosum* grass-tree foliage diets in sheep goat rumen inoculum

Diets		Goats			Sheep		
		Gas (ml /g)	IVDMD %	PF (ml/g)	Gas (ml/g)	IVDMD %	PF (ml/g)
SN: AC 50:50		160	44.1	3.13	122	42.3	4.10
SN: AC 75:25		155.7	47.3	3.21	144.6	45.7	3.46
Mean		157.85	45.70	3.17	133.30	44.00	3.75
SN: ZX 50:0		134.5	52.3	3.72	129.2	48.3	3.87
SN: ZX 75:25		147.9	50.4	3.38	137.7	51.1	3.63
Mean		141.20	51.35	3.54	133.45	49.70	3.75
SN: HI 50: 50		149	54.8	3.36	147.6	54.1	3.39
SN: HI 75:25		159.8	53.1	3.13	145.1	50.2	3.45
Mean		154.40	53.95	3.24	146.35	52.15	3.42
SN: SV 50:50		168.5	55.4	2.97	152	53.9	3.29
SN: SV 75:25		164.2	52.8	3.05	156.2	52.7	3.20
Mean		166.35	54.10	3.01	154.10	53.30	3.24
SN: DC 50:50		111.3	48.5	4.49	103.5	40.3	4.83
SN: DC 75:25		134.5	47.8	3.72	132.6	45.7	3.77
Mean		122.90	48.15	4.07	118.05	43.00	4.24
SN: LL 50: 50		148.7	59.4	3.36	142	60.3	3.52
SN: LL 75: 25		150.5	56.9	3.32	148.2	52.7	3.37
Mean		149.60	58.15	3.34	145.10	56.50	3.45
SN: AL 50:50		142.5	58.2	3.51	122.2	52.3	4.09
SN: AL 75: 25		137	53.7	3.65	127	55.7	3.94
Mean		139.75	55.95	3.58	124.60	54.00	4.01
SN: HB 50:50		121	50.2	4.13	124	43.2	4.03
SN: HB 75:25		131.2	51.3	3.81	149.5	47.5	3.34
Mean		126.10	50.75	3.97	136.75	45.35	3.66
SN: AP 50:50		108.8	52.1	4.60	103.8	51.2	4.82
SN: AP 75:25		140.5	57.4	3.56	131.6	54.3	3.80
Mean		124.65	54.75	4.01	117.70	52.75	4.25
SN: GO50:50		165.3	59.2	3.02	156.1	58.4	3.20
SN: GO75:25		167	53	2.99	158.6	50.5	3.15
Mean		166.15	56.10	3.01	157.35	54.45	3.18
Mean ratio	50:50	140.96	53.42	3.63	130.24	50.43	3.91
	75:25	148.83	52.37	3.38	143.11	50.61	3.51
SEM	50:50	6.83	1.57	0.187	5.93	2.15	0.185
	75:25	4.03	1.06	0.092	3.36	1.09	0.083
Mean diet		144.90	52.90	3.51	136.68	50.52	3.71
SEM		5.47	1.13	0.14	4.91	1.53	0.14
Diets		*	*	*	*	*	*
Ratio		NS	NS	NS	*	NS	NS

relatively lower NH_3-N contents in Washera sheep fed natural pasture grass hay supplemented with various levels of *Millettia ferruginea* (Birbra) foliage and also there was difference (P<0.05) between diets due to foliage supplementation. Diets with more proportion of foliage had higher NH_3-N concentration like the observation of present study. Type of basal diet, level of tree foliage supplementation and animal species influences the rumen metabolites production (Molina *et al.* 2000; Ondiek *et al.* 2013; Isah *et al.* 2013).

Gas production, dry matter digestibility and partition factor: Total gas production (ml/g), *in vitro* dry matter digestibility and partition factor differed (P<0.05) amongst the SN-tree foliage based diets (Table 4). *In vitro* gas production and *IVDMD* also varied (P<0.05) between the sheep and goats. Gas production was higher from diets incubated in goat's inoculum. Mean gas production, *IVDMD* and partition factor from tested diets were 144.90, 52.90 and 3.51 in goats and 136.68, 50.52 and 3.71 in sheep, respectively. Sheep exhibited higher ($P<0.05$) mean gas production at 75:25 (143.11) ratio of SN-tree foliage diets than 50:50 ratio (130.24 ml/g). The *IVDMD* and gas production values in the range of 51-85 % and 122-196 ml/g of different foliage and grass (Purcell *et al*., 2012) are identical to our results. *In vitro* dry matter degradability, total gas production and partition factor of different dietary combinations of *Lespedeza cuneata* with maize stover and dry grass hay reported by Ouda *et al.* (2006) are within the range of our findings. These workers reported *IVDMD*, gas production and partition factor in the range of 53.3-67.9 %, 160.4-216.6 and 3.13-3.62 which are consistent to our findings. Sheep fed maize stover supplemented with various multipurpose trees having tannin and other plant secondary metabolites had degradability varying between 490 to 518 g/kg (Hindrichsen *et al*., 2004) substantiates the *IVDMD* values of present study.

Findings of present study showed that diets consisting SN grass with LL and GO leaves in their 50:50 and 75:25 ratios had better nutritive value in terms of nutrients content (CP 10.28 and 8.49%), DM and CP digestibility (63.85 and 70.65 in sheep and 63.75 and 71.95% in goats) and metabolites concentration in rumen inoculum of both species. Foliages from these trees shrubs thus can be used as supplement of protein and minerals to SN grass in lean periods for sustainable small ruminant production.

Acknowledgement
Authors are thankful to the Indian Council of Agricultural Research for providing financial assistance to carry the work. Facilities provided by Director of Institute are gratefully acknowledged.

References

A. O. A. C. 1995. *Official Methods of Analysis*. 13th Edn. Association of Official Analytical Chemists, Washington, D. C.

Alemu, B., G. Animut and A. Tolera. 2014. Effect of Millettia ferruginea (Birbra) foliage supplementation on feed intake, digestibility, body weight change and carcass characteristics of Washera sheep fed natural pasture grass hay basal diet. *Springer Plus* 3: 50.

Aregheore, E. M. 2007. Voluntary intake, nutrient digestibility and nutritive value of foliage of fluted pumpkin (*Talfairia occidentialis*) - haylage mixtures by goats. *Livestock Research for Rural Development 19 (4):* http://www.lrrd.org/lrrd19/4/areg19056.htm.

Assefa, G. 2007. Evaluation of Tagasaste (*Chamaecytisus palmensis*) as forage for ruminants. PhD dissertation. Humboldt-University of Berlin, Germany, p 213.

Bakshi, M. P. S. and M. Wadhwa. 2007. Tree leaves as complete feed for goat bucks. *Small Ruminant Research* 69:74-78.

Barakat, N. A. M., V. Laudadio, E. Cazzato and V. Tufarelli. 2013. Potential contribution of retama raetam (Forssk.) Webb & Berthel as a forage shrub in Sinai, Egypt. *Arid Land Research. Management* 27: 257-271.

Ben Salem, H. S., S. Abidi, H. P. S. Makkar and A. Nefzaoui. 2005. Wood ash treatment, a cost-effective way to deactivate tannins in *Acacia cyanophylla* I Lindl. Foliage and to improve digestion by Barbarine sheep. *Animal Feed Science and Technology* 123: 93-108.

Blümmel, M. and P. Lebzien. 2001. Predicting ruminal microbial efficiencies of dairy ration by in vitro techniques. *Livestock Production Science* 68: 107-117.

Briggs, P. K., J. P. Hogen and R. I. Reid. 1957. Effect of volatile fatty acids, lactic acid and ammonia on rumen pH in sheep. *Australian Journal of Agricultural Research* 8: 674.

Conway, E. J. 1957. *Micro-diffusion Analysis and Volumetric Error*. 4th Ed. Crossby Lockwood and Sons Lords, England.

Gebregiorgis, F., T. Negesse and A. Nurfeta. 2012. Feed intake and utilization in sheep fed graded levels of dried moringa (*Moringa stenopetala*) leaf as a supplement to Rhodes grass hay. *Tropical Animal Health and Production* 44: 511-517.

Goering, H. K. and Van P. J. Soest. 1970. *Forage Fibre Analysis*. Agriculture Hand Book N0 379, ARS-USDA, Washington, D. C., pp 20.

Hindrichsen, I. K., P. O. Osuji, A. A. Odenyo, J. Madsen and T. Hvelplund. 2004. Effect of supplementation of maize stover with foliage of various tropical multipurpose trees and Lablab purpureus on intake, rumen fermentation, digesta kinetics and microbial protein supply of sheep. *Animal Feed Science and Technology* 113: 83-96.

Isah, O. A., S. A. Oguntuyo, R. O. Dawodu, O. O. Diya, M. O. Afolabi and L. A. Omoniyi. 2013. Feed Utilization, Rumen Parameters, and Microbial Profile of Goats fed Different Tropical Browse Plants with *Pennisetum purpureum* as Basal Diet. *The Pacific Journal of Science Technology* 14: 397-405.

Ismail, A.O., M. Fatur, F. A. Ahmed, E.O. Ahmed and M. E. E. Ahmed. 2014. Nutritive value and palatability of some range grasses in low rainfall woodland savanna of South Darfur in Sudan. *Range Management and Agroforestry* 35: 193-197.

Lu, C. D., J. R. Kawas and O. G. Mahgoub. 2005. Fibre digestion and utilization in goats. *Small Ruminant Research* 60: 45-52.

Makkar, H. P. S. 2003. Effects of fate of tannins in ruminant animals, adaptation to tannins, and strategies to overcome detrimental effects of feeding tannin-rich feeds. *Small Ruminant Research* 49: 241-256.

McKenzie, H. A. and H. S. Wallace. 1954. The kjeldahl determination of nitrogen. *Australian Journal of Chemistry* 7: 55-61.

Molina, E. A., A. I. M. Garcia and J. F. Aguilera. 2000. A comparative study of nutrient digestibility, kinetics of degradation and passage and rumen fermentation pattern in goats and sheep offered good quality diets. *Livestock Production Science* 64: 215-223.

Ngwa, A. T., D. K. Pone and J. M. Mafeni. 2000. Feed intake and dietary preferences of forage by small ruminants grazing natural pastures in the Sahelian zone of Cameroon. *Animal Feed Science and Technology* 88: 253-266.

Nurfeta, A. 2010. Feed intake, digestibility, nitrogen utilization and body weight change of sheep consuming wheat straw supplemented with local agricultural and agro-industrial by-products. *Tropical Animal Health and Production* 42: 815-824.

Olafadehan, O. A. 2013. Feeding value of *Pterocarpus erinaceus* for growing goats. *Animal Feed Science and Technology* 185: 1-8.

Ondiek, J. O., P. B. Ogore, E. K. Shakala and G. M. Kaburu. 2013. Feed intake, digestibility and performance of growing small East African goats offered maize (*Zea mays*) stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages. *Basic Research Journal of Agricultural Science and Review* 2: 21-26.

Osakwe, I. I. and H. Steingass. 2013. Ruminal Fermentation and Nutrient Digestion in West African Dwarf (WAD) Sheep Fed *Dialium guineense* Supplemental Diets. In: proceedings Tropentag 2013, Conference on International Research on Food Security, *Natural Resource Management and Rural Development* (Sep.17-19, 2013), Stuttgart, Germany http://www.tropentag.de/2013/abstract/full/445.pdf.

Osakwe, I. I. and R. N. Udeogu. 2007. Feed intake and nutrient digestibility of West African dwarf (WAD) goat fed *Pennisetum purpureum* supplemented with *Gmelina arborea*. *Animal Research International* 4: 724-727.

Ouda, J. O., I. V. Nsahlai and P. M. Mahundu.2006. *In vitro* degradability and gas production parameters of Sericea lespedeza (*Lespedeza cuneata*) mixed with varying types and levels of roughages. *South African Journal of Animal Science* 36: 111-121.

Purcell, P. J., T. M. Boland, M. O'Brien and P. O'Kelly. 2012. In vitro rumen methane output of forb species sampled in spring and summer. *Agricultural and Food Science* 21: 83-90.

Rubanza, C. D. K., M. N. Shem, S. S. Bakengesa T., Ichinohe and T. Fujihara.2007. Effects of Acacia nilotica, A. polyacantha and Leucaena leucocephala leaf meal supplementation on performance of Small East African goats fed native pasture hay basal forages. *Small Ruminant Research* 70: 165-173.

Theodorou, M. K., B. A. Williams, M. S. Dhanoa, A. B. Mc Allan and J. France. 1994. A simple gas production method using pressure transducer to determine the fermentation kinetics of ruminant feeds. *Animal Feed Science and Technology* 48: 185-197.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for the *in vitro* digestion of forage crops. *Journal of British Grassland Society* 18: 104-111.

Tolera, A. 2007. Forage: A Pathway to Prosperity for Smallholder Farmers. In: Proceedings of an *international Forage Symposium*. Ubon Ratchathani University, Thailand, pp 165-186.

Van Soest, P. J., J. B. Robertson and B. A. Lewis.1991. Method for dietary fibre, neutral detergent fibre and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science* 74: 3588-3597.