Tropical and Subtropical Agroecosystems, 7 (2007): 201 - 209

Tropical and Subtropical Agroecosystems

EFFECT OF INCREMENTAL DIETARY LEVEL OF *Vicia villosa* Roth ON INTAKE, DIGESTIBILITY AND NITROGEN BALANCE IN SHEEP FED *Sorghum almum*

[EFECTO DE LA INCLUSIÓN DE *Vicia villosa* Roth SOBRE EL CONSUMO, DIGESTIBILIDAD Y BALANCE DE NITRÓGENO DE OVINOS ALIMENTADOS CON *Sorghum almum*]

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SUMMARY

To evaluate the effect of increasing dietary level of *Vicia villosa* Roth on intake, digestibility and N balance of *Sorghum almum* based diets twelve wethers (6 months; 18.6 ± 1.8 kg LW) fitted with rumen canula were housed in metabolic crates and allotted to 4 treatment diets (V0, V10, V20, V30) in a randomized complete block design. The diets were constituted from fresh *S. almum* (61.1 g CP kg^{-1} DM and 178.5 g DM) and *V. villosa* (211.9 g CP kg^{-1} DM and 153.2 g DM). Control diet (V0) comprised of 3 kg fresh *S. almum* (≈ 535.5 g DM $head^{-1}$ d^{-1} *c.* 3% LW), whereas V10, V20 and V30 were V0 + 300, 600 or 900 g of fresh *V. villosa* ((≈ 45.96, 91.92 or 137.88 g DM $head^{-1}$ d^{-1}), respectively. Wethers on V10, V20 and V30 recorded 31.0, 23.28 and 19.9% higher fresh matter intake than V0 respectively. Mean DMI and OMI for the 4 treatments were 306.2, 391.9, 364.6, 356.3 and 257.9, 327.9, 304.1 297.6 g d^{-1}, respectively. Dry matter digestibility, N intake and VFA increased with level of *V. villosa* in the diet up to V20, then declined. NH_3-N however increased steadily with level of *V. villosa* in the diet. It is concluded that, though *V. villosa* has a potential for used as a protein supplement for ruminants on low quality feeds, its proportion in the diet should not exceed 25%.

Key words: Digestibility, sheep, nitrogen balance; *Sorghum almum*; *Vicia villosa.*

RESUMEN

Se evaluó el efto de la inclusion de *Vicia villosa* Roth (V) sobre el consume, digestibilidad y balance de nitrógeno de una dieta basada en *Sorghum almum.* Se emplearon doce ovinos (6 meses edad; 18.6 ± 1.8 kg PV) con canula ruminal y alojados en jaulas metabólicas. Los tratamientos fueron V0, V10, V20, V30 en un diseño de bloques al azar. Las dietas fueron *S. almum* fresco (61.1 g PC kg^{-1} MS y 178.5 g MS) y *V. villosa* (211.9 g PC kg^{-1} MS y 153.2 g MS). La dieta control (V0) fue de 3 kg *S. almum* (≈ 535.5 g MS d^{-1} *c.* 3% PV), mientras que V10, V20 y V30 fueron V0 + 300, 600 o 900 g *V. villosa* ((≈ 45.96, 91.92 o 137.88 g MS d^{-1}), respectivamente. Ovinos en V10, V20 y V30 tuvieron un mayor consumo a V0 (31.0, 23.28 y 19.9% base fresca). El consumo de MS y MO fue de 306.2, 391.9, 364.6, 356.3 y 257.9, 327.9, 304.1 297.6 g d^{-1}, para los cuatro tratamientos respectivamente. La digestibilidad de la MS, consume de N y AGV's se incrementaron con el nivel de *V. villosa* hasta V20, posteriomente declinaron. N-NH_3 se incremento con el nivel de *V. villosa.* Se conluye que *V. villosa* tiene potencial como suplemento proteico para ruminates, pero su inclusion en la dieta no debe exceeder 25%.

Palabras clave: Digestibilidad, ovinos, balance de nitrógeno; *Sorghum almum*; *Vicia villosa.*

INTRODUCTION

With the steady decline in farm size per household in Kenya, availability of adequate feeds has become a major setback to increased ruminant livestock production (Muriuki 2003; Lanyasunya et al., 2005). It has not only diminished land for fodder production, but also resulted in unprecedented decline in soil fertility leading to low forage yields, quality and therefore poor animal performance (Omore et al., 1996). The situation is worsened by the frequent dry season spells (Lanyasunya et al., 2006b), during which ruminant livestock heavily rely on low quality roughages (Thorpe et al., 2000) without supplementation. These feeds are fibrous and devoid of most essential nutrients (especially proteins and energy), which are required for increased rumen microbial

fermentation and performance of the host animal (Larbi et al., 1992). Lack of protein supplements is recognized as the most critical (Muia, 2000; Lokwaleput, 1999; Lanyasunya et al., 2005). To improve the situation, fodder crops capable of yielding high amount of good quality (particularly protein rich) herbage within the wet season period are urgently required.

Even more desirable are those forages that can integrate synergistically with the important food crops and have positive impact on soil fertility. Columbus grass (*Sorghum almum*) is a vigorous grower and high yielder of palatable herbage (Duke, 1983) within a short period after planting; hence suitable for use in sown fodder production on smallholder farms (Mohammad, 1993; Mohammad et al., 1994; Kallah et al., 1999).

On the other hand, contribution of Vetch (*Vicia spp*) in crop-livestock production systems in different parts of the world is well recognized (Caballero et al., 2001; Ennecking, 2001). One attraction of vetch is its versatility, which permits diverse utilization as either ruminant feed or green manure. Its high value, as protein supplement for ruminants on low quality diets, has been recorded (Alzueta et al., 2001; Chowdhury et al., 2001; Gebrehedhin et al., 2003; Pariyar, 2002; Hadjipanayiotou and Economides, 2001). As a green manure cover crop, vetch has gained popularity for its reputed ability to improve soil fertility through fixation of atmospheric nitrogen to the soil and grow in synergy with both grass fodder and cereal crops (Rathjen, 1997; Ennecking, 2001; Sattell et al., 1998). These attributes are important for ruminant livestock production on smallholder farms in Kenya and other tropical and sub-tropical regions. Available literature indicates that cultivation and utilization of *S. almum* and *Vicia spp* in Kenya has remained low (Orodho, 2006). This is largely attributed to lack of essential information on their forage potential (nutritive value and effect on animal performance) under Kenyan conditions.

The present paper reports results of a study on effect of incremental dietary level of *Vicia villosa* Roth on intake, digestibility and N utilization in sheep fed a basal diet of *S. almum*.

MATERIALS AND METHODS

Experimental feeds

The basal diet was a green chop (2 cm diameter) of Columbus grass (*S. almum*) harvested at the age of 12 weeks (approx. 180 cm height). Grass harvesting was synchronized to minimize quality variability. The supplement was fresh *V. villosa* Roth harvested at the age of 10 weeks and chopped to pieces of 2 cm long before feeding.

Intake, in vivo digestibility and N balance

Twelve castrated (wethers) male sheep (Red Maasai) aged about 6 months (18.6 ± 1.8 kg Live weight [LW]) fitted with rumen canula were used to measure intake, *in vivo* digestibility, N intake and rumen fermentation at the National Animal Husbandry research Centre in Naivasha, Kenya. The wethers were kept in well-ventilated metabolic crates (Size: 120 cm L x 50 cm W and 90 cm H) raised 60 cm above a concrete floor. Prior to the studies, all the wethers were drenched with a broad-spectrum anthelminth, Valbazen (Smith-kline, Switzerland) and sprayed with an accaricide to eradicate both internal and external parasites. They were then allotted to 4 treatment diets (comprising of 0, 10, 20 or 30% *V. villosa* on fresh matter basis and denoted as V0, V10, V20, V30) of 3 wethers each in randomized complete design. Control diet (V0) comprised of 3 kg fresh *S. almum* (≈ 535.5 g DM d^{-1} about 3% LW) alone, whereas V10, V20 and V30 comprised of V0 plus 300, 600 or 900 g of fresh *V. villosa* Roth (≈ 45.96, 91.92 or 137.88g DM d^{-1} of *V. villosa* Roth), respectively.

The diets were offered daily in 2 equal amounts at 07:30 and 16:30 h, each time providing the supplement first. All animals had free access to drinking water and mineral supplements (Maclick supper from Unga feeds Ltd). The experimental period lasted 28 days comprising of 14 days for adaptation to the diets. During this period and to allow measurement of voluntary intake, daily rations were proportionately increased to ensure small leftovers. This was followed by 7 days of total urine and faecal collection, during which daily rations were proportionately reduced to maintenance level.

Samples of feeds offered (and leftovers for 1st 14 d) and faeces were taken daily and bulked over the 7 d period. Urine samples were also taken daily and acidified (using 0.1 N H_2SO_4) to prevent N loss. Samples of rumen liquor (75 ml per wether) were taken at alternate days (at 23rd, 25th and 27th day) during the sampling period by suction tubing through the canula, strained through 2 layers of cheesecloth and divided into 3 portions (25 ml). Portion 1 was used for pH determination (immediately using a lab pH meter) and portion 2 was acidified with chilled metaphosphoric acid (1 ml 25% H_3PO_4/5 ml of rumen liquor) and kept frozen (-20^{o}C) for subsequent analysis of volatile fatty acids (VFA) and portion 3 was acidified with sulphuric acid (1 ml 20% H_2SO_4/5 ml rumen liquor) to stop further fermentation and deep frozen (-20^{o}C) while awaiting for ammonia (NH_3) determination.

Laboratory analysis

Samples of feeds and faeces were dried in a forced-air oven at 65°C for, respectively 24 and 48 h and the dry matter (DM) content calculated and then grounded to pass 1 mm screen. Ash was determined (AOAC, 1990, ID 942.05) and micro-Kjeldahl N in feed, faecal and urine (AOAC, 1990, ID 954.01). Crude protein was calculated as Kjeldahl N x 6.25. Neutral-detergent fibre (NDF), acid-detergent fibre (ADF) and acid-detergent lignin (ADL) were determined by the procedures of Goering and Van Soest (1970) and Van Soest and Robertson (1985). Ether extract (EE) was determined by extracting the sample with petroleum ether using a Gerhart Soxtherm 2000 Automated (AOAC 1990, ID 920.39). Frozen rumen liquor (portion 2) was thawed and centrifuged at 20000x g for 20 minutes and the VFA separated and quantified using gas liquid chromatography (Varian Star 3400 CX GLC (Varian Associates, Palo Alto, CA). Portion 3 was also thawed and after settling 5 ml of the upper clear layer was mixed with 10 ml of NaOH (40%) and steam distillated (Kjeldahl) to determine NH_3-N.

Calculations

Fresh matter intake (FMI) per animal was calculated as the difference between feed offered and leftovers during the first 21 days. DM intake (DMI) and organic matter intake (OMI) were derived from FMI using the DM and ash values. Hemicellulose and cellulose were calculated as described by Abdulrazak and Fujihara (1999). Other related feed quality parameters were also determined (*see foot notes* Tables 1 and 2). N intake was determined as the Kjeldahl N in DMI and N balance as the difference between N intake and total N loss (through urine and faeces). DM, OM and N digestibility were determined by expressing the retained proportions as percentage (%) of intake. The determined mean values were also expressed in g per kg metabolic weight (g kg $W^{-0.75}$) and as %LW.

Statistical analysis

Data was analyzed using GLM procedures of SAS (2002). The statistical model applied was $Y_{ijk} = \mu + T_i + A_j + T_i * A_j + E_{ij}$; Where Y_{ij} is the dependent variable (parameters under investigation); μ is the overall mean; T_i is the fixed effect of treatment (i = 1, 2, 3, 4); A_j is the fixed effect of the animal (j = 1, 2,…11, 12), $T_i * A_j$ is the interaction effect and E_{ij} is the error term. For rumen fermentation characterization, the model components were: Y_{ij} - the rumen fermentation parameter under investigation; μ is the overall mean; T_i is treatment (i = 1, 2, 3, 4); A_j is the animal (j = 1, 2,.., 3 per treatment, with rumen sampling done on 3 alternate days per animal [N = 9]); $T_i * A_j$ is the interaction and E_{ij} is the error term. Correlations between the parameters under study were also investigated.

RESULTS

Chemical composition

In Table 1 chemical compositions of *S. almum* and *V. villosa* Roth forage used in the study are summarized. As can be seen *S. almum* herbage used had low concentration of CP and high concentration of fibre. Non-structural carbohydrate (g NSC kg^{-1} DM) content was also high whereas that of total carbohydrates (g CHO kg^{-1} DM) was low. Relative feed value (RFV) was generally low. As expected, CP concentration in *V. villosa* was significantly high. RFV was also high. In contrast, the concentration of fibre was generally low. Results presented in Table 2 shows that FMI values in V10, V20 and V30 were higher than that of V0. FMI was highest in V10 and tended to decline as the level of supplement in the diet increased. DMI and OMI being derivatives of FMI followed the same pattern. This pattern was further reflected in DMI and OMI expressed as %LW or g kg $W^{-0.75}$.

Mean DMI for V10, V20 and V30 were 27.99 ($P < 0.01$), 19.07 ($P < 0.05$) and 16.36% ($P < 0.05$) higher than that of V0 (Table 2). DMD (%) and OMD (%) increased steadily with level of *V. villosa* up to 20% (V20) and then declined (Table 2). Dry and organic matter intake and DOMI, being derivatives of DMD and OMD followed the same pattern. Correlation existed between level of *V. villosa* in the diet and FMI ($P < 0.0001$), DMI ($P < 0.0001$) and DMD ($P < 0.0001$). Wethers on V10, V20 and V30 recorded 72.15 ($P < 0.0001$), 80.48 ($P < 0.0001$) and 67.54% ($P < 0.0001$) higher N intake than those under V0 respectively (Table 3). Faecal N loss was inconsistent, whereas that through the urine increased steadily with the level of *V. villosa* in the diet. N balance for V10, V20 and V30 were significantly higher than that of V0. About 61.18% of N intake in V0 was lost, whereas in V10, V20 and V30 the total N losses were 31.08, 27.22 and 35.21% of N intake respectively. N digestibility, estimated microbial yield and biological values were significantly high for V10, V20 and V30 compared with V0. Strong correlation was noted between level of *V. villosa* in the diet and N intake ($r = 0.710$; $P < 0.0001$), N balance ($r = 0.705$; $P < 0.0001$) and N digestibility ($r = 0.608$; $P < 0.0001$), but not total N loss ($r = -0.141$; $P > 0.05$).

Though mean daily rumen pH was strongly affected by increased level of *V. villosa* in the diet ($r^2 = 0.8822$; $P < 0.0001$; Table 4) it remained within the normal range. Concentrations of both NH_3-N and VFA in the rumen liquor were higher for V10, V20 and V30 than V0. Concentration of NH_3-N increased steadily with the level of *V. villosa* in the diet (Table 4), whereas that of VFA showed increase between V0 and V20 from 93.73 to 122.71 mmol L^{-1}, but decline to 103.38 mmol L^{-1} in V30. A:P ratios were lower in V10, V20 and V30 compared to

V0. Though between subjects effects were widely variable (Tables 2, 3 and 4), treatment effect was strongly evident across all the parameters.

Table 1. Chemical composition and quality index of *S. almum* and *Commelina benghalensis* forage used in the study (g kg^{-1} DM except were stated).

	Mean ± S.D.	
	S. almum	*V. villosa*
Air Dry matter (g kg^{-1})(65 ^{o}C)	178.5 ± 6.9	170.2 ± 4.7
Analytical Dry matter (g kg^{-1})(105 ^{o}C)	929.1 ± 2.4	916.4 ± 1.72
Organic matter	802.9 ± 4.4	753.3 ± 9.6
Crude protein	61.1 ± 4.6	214.6 ± 2.3
Crude fibre	356.4 ± 6.6	252.3 ± 6.5
Neutral detergent Fibre	687.6 ± 23.7	368.3 ± 9.9
Acid detergent Fibre	406.1 ± 11.9	320.9 ± 5.6
Acid detergent Lignin	44.1 ± 4.0	63.3 ± 2.5
Ether extract	12.6 ± 1.7	25.1 ± 0.7
Hemicellulose	281.5 ± 33.1	53.7 ± 12.9
Cellulose	365.3 ± 6.5	252.9 ± 5.8
Crude ash	126.2 ± 3.5	163.1 ± 11.2
Nitrogen free extract [1]	372.8 ± 11.8	161.3 ± 3.1
Non structural carbohydrate [2]	729.2 ± 5.2	513.6 ± 8.2
Total carbohydrates [3]	112.5 ± 25.3	228.9 ± 3.6
Relative feed value [4]	77.5 ± 2.1	161.5 ± 3.9

[1]**NFE** (g kg^{-1} DM) = DM – (EE + CP + Ash + CF) (Van Soest 1982); [2]**NSC** was calculated as 100% - (CP% + NDF% + EE% +Ash%); [3]**CHO** (g kg^{-1} DM) = OM content – (CP + EE) Arieli et al. (1999); [4]**RFV** = [(88.9 – (0.78 x ADF%)) x (120/NDF%)]/ 1.29 (Agric-facts 2006); **S. D** – Standard deviation; **n** = 12

DISCUSSION

The recorded DM content of *S. almum* was similar to the 174.9 g kg^{-1} DM reported by Muia et al. (1999) in Napier grass (*Pennisetum purpureum*) but lower than the 287 g kg^{-1} DM reported by Resende et al. (2003) in forage Sorghums which may be due to variety differences, prevailing edaphic factors and stage of growth at harvest. CP content is similar to those reported by Resende et al. (2003) in forage Sorghums (67 g kg^{-1} DM), Keftasa (1990) in Rhodes grass (*Chloris gayana*)(53 g kg^{-1} DM) and Mata and Combellas (1992) in Star grass (*Cynodon plectostachyus*)(66 g kg^{-1} DM). The CP content of *S. almum* at the time of feeding was within the range reported to limit feed intake (Minson, 1990; Leng, 1990; Larbi et al., 1992). This perhaps partly explains the lower intake observed in wethers offered *S. almum* (V0) as a sole diet (Table 2).

Content of cell wall fractions was found to compare well with earlier reports on tropical grasses (Aganga and Tshwenyane, 2004; Keftasa, 1990; Mata and Combellas, 1992). NDF content is above the 600 g kg^{-1} NDF DM suggested by Van Soest (1982) and Muia (2000) as the critical limit for efficient utilization of roughages. RFV value is below the 86 taken to indicate poor quality forage (Canbolat et al., 2006; Agric–Facts, 2006).

The DM, CP and CF values obtained in this study for *V. villosa*, were consistent with 170 g DM, 230 and 290 g kg^{-1} DM reported by Gohl (1981) for freshly harvested vetch and Lanyasunya et al. (2006a) in *V. sativa* L. Hadjipanayiotou and Economides (2001) and Pinkerton and Pinkerton (2000) also reported similar values in Mediterranean region and Australia respectively. The results indicate that *V. villosa* is a protein rich legume with low-medium fibre content. RFV (161.5) value of *V. villosa* herbage used in this study is above the 151 taken as an indicator of prime quality fodder (Canbolat et al., 2006; Agric–Facts, 2006) suggesting that the supplement was of high quality.

Increased intake and digestibility recorded by the supplemented wethers indicated that *V. villosa* had a positive effect on the rumen environment. Increased nutrient intake with incremental level of forage legumes as supplement to low quality roughages has also been recorded earlier (Smith et al., 1989; Kitalyi and Owen, 1993; Pathirana and Ørskov, 1995; Minson and Milford, 1967). Pathirana and Ørskov (1995) reported 48% increase in intake of rice straw as the amount of *Glyricidia sepium* was raised from 0% (Control) to 15% in the diet. This report strongly supports the findings of the present study. The observed increase in intake is attributed to increased N in the diet and availability of fermentable fibre. It has been reported that, if the basal diet has such a low N content as to constraint rumen microbial activity, the addition of a forage legume will increase the N content of the total diet, which in turn is likely to increase the rate of degradation of the basal diet in the rumen and so increase feed intake (McMeniman et al., 1988; Ndlovu and Buchanan–Smith, 1985). Leng (1990) further suggested that the beneficial effects of the incorporation of highly digestible legume forage in an otherwise low digestible basal diet could be that, this exerts a large effect on digestibility by providing a highly colonized fibre source to “seed” bacteria onto the less digestible fibre.

Table 2. Effect of incremental levels of *Vicia villosa* Roth on intake and digestibility in sheep fed *Sorghum almum.*

	Least square means					ANOVA					
	Vicia villosa level (%)					Model			Subject effects		
Parameter	V0	V10	V20	V30	SEM	*P*[a]	R^2	*CV*	T	A	A*T
FM intake (g d^{-1})	1516^{a}	1986^{c}	1869^{b}	1818^{b}	35.03	****	0.7721	10.88	****	***	NS
DM intake (g d^{-1})	306.2^{a}	391.9^{c}	364.6^{b}	356.3^{b}	6.99	****	0.7497	10.93	****	***	NS
DMI kg $W^{-0.75}$ (g d^{-1})	35.86^{a}	44.19^{c}	42.33^{bc}	40.25^{b}	0.80	****	0.7256	10.64	****	***	NS
DM intake as % LW	1.76^{a}	2.14^{c}	2.07^{bc}	1.95^{b}	0.04	****	0.7504	10.83	****	***	NS
DMD (%)	60.8^{a}	65.7^{a}	75.2^{b}	72.9^{b}	1.95	****	0.5691	15.61	****	**	NS
DDM intake (g d^{-1})	187.5^{a}	260.9^{b}	273.4^{b}	259.4^{b}	8.79	****	0.6541	20.59	****	***	NS
OM intake (g d^{-1})	257.9^{a}	327.9^{c}	304.1^{b}	297.6^{b}	5.87	****	0.7432	10.94	****	***	NS
OMI kg $W^{-0.75}$ (g d^{-1})	30.21^{a}	36.97^{c}	35.30^{bc}	33.61^{b}	0.67	****	0.7184	10.87	****	***	NS
OMD (%)	64.4^{a}	70.5^{a}	78.5^{b}	76.2^{b}	1.55	****	0.5162	11.24	****	**	NS
DOMI (g d^{-1})	166.5^{a}	233.8^{b}	238.3^{b}	226.4^{b}	6.86	****	0.6218	17.48	****	***	NS
DOMR (g d^{-1})	118.7^{a}	151.9^{b}	154.8^{b}	147.1^{b}	4.46	****	0.6218	17.48	****	***	NS

T – Treatment; **A** – Animal nested in treatment; **A*T** – Treatment – time interaction; ***CV*** – Coefficient of variation; **SEM** – Standard error of the mean; **FM** – Fresh matter; **DMI** – Dry matter intake; **OMI** – Organic matter intake; **DMD** – Dry matter digestibility; **OMD** – organic matter digestibility; **DOMR** – Estimated quantity of digestible organic matter fermented in the rumen (Chen & Gomes 1992; ARC 1984); **** $P < 0.0001$ and * $P < 0.05$; **NS** – Not significant ($P > 0.05$) **N**=21

Table 3. Effect of incremental levels of *Vicia villosa* Roth on nitrogen utilization by sheep fed *Sorghum almum.*

	Least square means					ANOVA					
	Vicia villosa level (%)					Model			Subject effects		
Parameter	V0	V10	V20	V30	SEM	*P*[a]	R^2	*CV*	T	A	A*T
Nitrogen (N) intake (g d^{-1})	4.56^{a}	7.85^{b}	8.23^{c}	7.64^{b}	0.134	****	0.9075	11.41	****	****	NS
N intake kg $W^{-0.75}$ (g d^{-1})	0.53^{a}	0.89^{b}	0.96^{c}	0.87^{b}	0.015	****	0.9072	11.27	****	****	NS
Fecal Nitrogen loss (g d^{-1})	1.33^{a}	1.76^{b}	1.22^{a}	1.29^{a}	0.067	****	0.6451	25.88	****	****	**
Urine Nitrogen loss (g d^{-1})	1.46^{c}	0.68^{a}	1.02^{b}	1.41^{c}	0.091	****	0.6313	38.49	****	****	NS
Total Nitrogen loss (g d^{-1})	2.79^{b}	2.44^{a}	2.24^{a}	2.69^{b}	0.116	****	0.5353	23.35	***	****	*
Tot. N loss kg $W^{-0.75}$ (g d^{-1})	0.32^{b}	0.27^{ab}	0.26^{a}	0.31^{b}	0.014	****	0.4998	23.87	***	***	*
Nitrogen balance (g d^{-1})	1.78^{a}	5.41^{b}	5.99^{c}	4.95^{b}	0.169	****	0.8784	24.71	****	****	NS
N balance kg $W^{-0.75}$ (g d^{-1})	0.21^{a}	0.61^{c}	0.69^{c}	0.56^{b}	0.021	****	0.8726	24.98	****	****	NS
Nitrogen digestibility (%)	65.56^{a}	77.41^{b}	85.01^{c}	83.21^{c}	1.359	****	0.6557	9.43	****	****	NS
Feacal Nitrogen loss (%)	29.44^{c}	22.59^{b}	15.01^{a}	16.79^{a}	1.359	****	0.6557	30.23	****	****	NS
Urine Nitrogen loss (%)	32.11^{c}	8.67^{a}	12.91^{a}	19.10^{b}	1.625	****	0.7516	37.68	****	****	NS
Est. Microb. N yield (g d^{-1})	3.80^{a}	4.86^{b}	4.96^{b}	4.71^{b}	0.143	****	0.6218	17.48	****	****	NS
Biological value	55.11^{a}	88.76^{c}	84.89^{c}	76.74^{b}	2.497	****	0.7329	19.27	****	****	NS

T – Treatment; **A** – Animal nested in treatment; **A*T** – Treatment – time interaction; ***CV*** – Coefficient of variation; **SEM** – Standard error of the mean; **FMI** – Fresh matter intake; **DMI** – Dry matter intake; **OMI** – Organic matter intake; **DMD** – Dry matter digestibility; **OMD** – organic matter digestibility; **DOMR** – Estimated quantity of digestible organic matter fermented in the rumen (Chen & Gomes 1992; ARC 1984); **** $P < 0.0001$; *** $P < 0.001$; ** $P < 0.01$ and * $P < 0.05$; **NS** – Not significant ($P > 0.05$). **N**=21

This is perhaps because forage legumes are relatively good sources of degradable N and fermentable energy so their inclusion in the low quality diets is likely to increase the rumen population of cellulolytic microbes, thereby improving the rumen concentration of fermentable products (Topps, 1995; Silva and Ørskov, 1985; Bauchop, 1981) and N utilization (Ahamefule et al., 2006; Robinson et al., 2006; Mbuthia and Gachuiri, 2003). In consonance with these reports, increased rumen NH_3-N following supplementation with forage legume has been reported (Getachew et al., 1994; Manyuchi, 1994; Kimambo et al., 1991), the increase being a function of the degradability of the N in the forage legume. Ndlovu and Buchanan – Smith (1985) and Topps (1995), also stated that, forage legumes used as supplements increased the total VFA concentration in the rumen without affecting the relative molar proportions and rumen pH. This indicated that, *V. villosa* forage is likely to maintain a stable rumen fermentation environment, when used as protein supplements. The NH_3-N concentration levels recorded in this study were within the 50 – 70 mg L^{-1} (Satter and Slyter 1974) and 150 – 200 mg L^{-1} (Krebs and Leng 1984) suggested as the ideal N concentration in the rumen for efficient digestion. VFA concentration, its molar proportions and A:P ratios, were comparable to those reported by Said and Tolera (1993) and Muia et al. (1999). The N utilization and rumen fermentation characteristics observed in this study are quite in agreement with these observations, which suggest that *V. villosa* has a potential for improving performance of ruminant livestock on low quality diets (Van Soest, 1994; Klopfenstein et al., 2001).

Table 4. Concentration of rumen fermentation production in wethers fed *Sorghum almum* with varied levels of *Vicia villosa* Roth.

	Least square means					ANOVA				
	Vicia villosa inclusion level (%)					Model		Effects		
Parameters	V0	V10	V20	V30	SEM	P^a	R^2	T	A	T*A
Observations	12	12	12	12						
Rumen pH	6.68^b	6.65^b	6.76^c	6.58^a	0.017	****	0.8822	****	****	****
NH_3 – N (mg L^{-1})	66.27^a	84.63^b	113.88^c	139.54^d	0.141	****	0.9989	****	NS	***
VFA (mmol L^{-1})	88.72^a	93.73^b	122.71^d	103.38^c	0.295	****	0.9959	****	****	****
Acetate (*A*) (mmol L^{-1})	61.32^a	64.72^b	84.20^c	70.64^d	0.297	****	0.9910	****	**	****
Propionate (*P*) (mmol L^{-1})	15.43^a	17.41^b	22.47^d	19.17^c	0.139	****	0.9783	****	NS	***
Butyrate (mmol L^{-1})	9.24^a	9.17^a	12.41^c	10.46^b	0.101	****	0.9581	****	**	**
Isoacids[1] (mmol L^{-1})	2.73^{ab}	2.44^a	3.64^c	3.11^b	0.172	***	0.5132	***	NS	NS
A : *P* ratio	3.98^b	3.72^a	3.75^a	3.69^a	0.023	****	0.8083	****	**	*
Molar % of VFA:										
Acetate	69.12^c	69.05^{bc}	68.62^{ab}	68.33^a	0.171	**	0.5223	**	**	NS
Propionate	17.38^a	18.56^b	18.31^b	18.54^b	0.107	****	0.7772	****	NS	*
Butyrate	10.42^c	9.78^a	10.11^b	10.12^b	0.099	**	0.6296	**	*	*
Isoacids[1]	3.08^a	2.61^a	2.97^a	3.01^a	0.189	NS	0.2474	NS	NS	NS

CV – Coefficient of variation; **SEM** – Standard error of the mean; ***P*^a** – ANOVA model *p*-value; **T** – Treatment; **A** – Animal; **T*A** – Treatment – time interaction; **** P < 0.0001; *** P < 0.001; ** P < 0.01 and * P < 0.05

CONCLUSION

Results clearly demonstrated that inclusion of *V. villosa* in the diet increased intake, digestibility, N utilization and rumen fermentation in wethers fed *S. almum*. It was therefore concluded that *V. villosa* could be used as a protein supplement for ruminant on low quality roughages such as low quality tropical grasses and crop residues (Stover and straws). It was however noted that 30% proportion in the diet reduced intake and concentration of VFA perhaps due to other factors. Based on this therefore, it was further concluded that, higher benefit would be obtained when it is incorporated at about 20% of the total ruminant diet.

ACKNOWLEDGEMENT

This research work was financial supported by Kenya Agricultural Research Institute (KARI) through the Kenya Productivity Project (KAPP).

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Submitted April 18, 2007 – Accepted October 02, 2007
Revised received October 06,, 2007