Trop Anim Health Prod (2009) 41:579–586
DOI 10.1007/s11250-008-9227-1

Effect of supplementing urea-treated barley straw with lucerne or vetch hays on feed intake, digestibility and growth of Arsi Bale Sheep

Dawit Abate · Solomon Melaku

Accepted: 19 August 2008 / Published online: 31 August 2008

Abstract The study was conducted at Sinana Agricultural Research Center, Ethiopia to assess the supplementation of graded levels of vetch (*Vicia dasycarpa* `lana') and lucerne (*Medicago sativa*,' Hunter river') hay on feed intake, digestibility and body weight (BW) change of Arsi-Bale sheep fed urea treated barley straw (UTBS). A 7 day- digestibility and a 90 day- feed intake trials were conducted using 28 and 35 sheep, respectively. The experimental design was a randomized complete block design with seven dietary treatments that consisted of feeding UTBS (T1) as the control treatment, UTBS plus 150, 250 and 350 g dry matter (DM) per day of vetch for T2, T3, T4, respectively and UTBS plus 150, 250 and 350 g DM per day of lucerne for T5, T6 and T7, respectively. Intake of UTBS was not affected ($P>0.05$) by inclusion of lucerne hay at 25–35% of daily DM intake. The supplements increased daily intake of total DM, organic matter (OM), neutral detergent fiber (NDF), acid detergent fiber (ADF) and metabolizable energy (ME) ($P<0.001$) as well as apparent digestibility of DM, OM ($P<0.001$), NDF ($P<0.01$), ADF, crude protein (CP) ($P<0.05$) and daily BW gain ($P<0.001$). Supplementation with lucerne than vetch hay promoted higher ($P<0.001$) CP and ME intakes and daily BW gain. Feeding with the UTBS without supplementation was enough to meet the maintenance requirements of the sheep and allow small BW gain. The results of the study showed that urea treatment of barley straw in conjunction with supplementation of lucerne or vetch hay could serve as a useful strategy in improving smallholder sheep production in the tropics.

Keywords Arsi Bale sheep · Body weight · Digestibility · Feed intake · Lucerne · Urea treated barley straw · Vetch

Abbreviations

ADF	acid detergent fibre
ADL	acid detergent lignin
CP	crude protein
DM	dry matter
FCE	feed conversion efficiency
IVOMD	*in vitro* organic matter digestibility
ME	metabolizable energy
NDF	neutral detergent fibre
OM	organic matter
UTBS	urea treated barley straw

Introduction

Crop residues are gaining importance as animal feeds in topical countries, especially during the dry season

D. Abate
Sinana Agricultural Research Center,
P.O. Box 208, Bale Robe, Ethiopia

S. Melaku (✉)
Haramaya University,
P.O. Box 138, Dire Dawa, Ethiopia
e-mail: solmelay@yahoo.com

because of expansion of cereal cultivation on traditional livestock grazing areas (Mengistu 2004; Bogale et al. 2008). However, the feeding value of crop residues is limited by deficiencies of crude protein (CP), metabolizable energy (ME), minerals and vitamins, and therefore can only supply sub- maintenance nutrient requirements of animals when they are offered as sole feeds (Kebede 2006). Several strategies were developed to overcome deficiencies of nutrients in crop residues, and thereby improve their utilization in livestock feeding. Urea treatment offers greater promise among the methods so far developed in improving the nutritive values of crop residues, since it is easy to apply under smallholder farmers' conditions in tropical countries as well as being a relatively cheap source of non protein nitrogen (Sundstøl 1988). Feeding urea treated straw reduces the need for concentrate supplementation and limits animal weight loss during seasons of feed shortage. However, the improvement in the nutritive value of straws resulting from urea treatment can only support a little more than maintenance requirements of animals (Castrillo et al. 1995; Kebede 2006). Therefore, further improvement in animal performance can be achieved when urea treated straw is supplemented with dietary protein, energy and vitamin sources such as forage legumes. Animal response to supplementation with forage legumes has been attributed to the increased supply of dietary nitrogen or easily degradable fibre (Melaku et al. 2004; Melaku et al. 2005). Hence, this study was conducted to assess the effect of including different levels of vetch (*Vicia dasycarpa* `lana') and lucerne (*Medicago sativa* 'Hunter river') hay on feed intake, digestibility and BW gain of Arsi-Bale sheep fed urea treated barley straw (UTBS).

Materials and methods

The study site

The study was conducted at Sinana Agricultural Research Center, Ethiopia. The site is located at 7° 7′ N latitude, 40° 10′ E longitude and at an elevation of 2400 meters above sea level. The rainfall pattern is bimodal with total annual rainfall ranging from 750–1000 mm. Average annual maximum and minimum temperature are 21°C and 9°C, respectively (SARC 2005).

Preparation of experimental feeds

The forage legumes, vetch (*Vicia dasycarpa,* 'lana') and lucerne (*Medicago sativa* 'Hunter river') were established during the main rainy season between March–July. They were harvested at 50% flowering, field-cured and stored in a hay barn. The forage legumes were chopped to 3–5 cm size. Urea treated barley straw was prepared by applying 5 kg of urea (fertilizer grade) dissolved in 100 liter of water to 100 kg dry matter (DM) of barley straw (CTA 1992). The treated straw was compacted layer by layer and filled in pits with dimensions of 2×2×2 m (length, width and height) that were covered with polyethylene sheet on all sides. The pit containing the urea treated straw was then sealed with polyethylene sheet and loaded with soil to make it airtight and left to incubate for twenty-one days as recommended by Sundstøl (1988). The stack was allowed to aerate for two days to allow release of volatile ammonia (Shuang et al. 1995).

Animals, experimental design and feeding management

Twenty eight and thirty- five yearling intact male Arsi-Bale sheep were used in digestibility and feeding trials, respectively. The sheep were vaccinated against pasteurellosis, sprayed and drenched against external and internal parasites. The animals were housed in individual pens during the trial. The experimental design was a randomized complete block design. The dietary treatments were offering sole UTBS which was the control treatment (T1), UTBS plus 150 (low), 250 (medium) and 350 (high) g DM per day of vetch for T2, T3, T4, respectively and UTBS plus 150 (low), 250 (medium) and 350 (high) g DM per day of lucerne for T5, T6 and T7, respectively. Water, UTBS and salt blocks were offered *ad libitum* allowing 30% refusal. The forage legumes were offered at 0800 and 1600 h in two equal portions. The amount of feed offered and left over were collected and recorded daily for each sheep. Samples of offered and refused UTBS were collected in bags, sealed and placed in deep freezer to prevent ammonia loss until sub-sampled for chemical analysis.

Feeding trial

The feeding trial was conducted using thirty five sheep with mean initial BW of 16.4±0.56 kg (mean ±

SD) arranged in five blocks of seven animals based on their initial BW that was determined as a mean of two consecutive weighing after overnight fasting. Each animal within a block was randomly assigned to one of the experimental treatments. Substitution rate of UTBS with the forage legumes was calculated as the difference in UTBS intake between the control and the diets with forage legumes inclusion divided by the intake of the forage legumes. Body weight was recorded every ten days after overnight fasting. Feed conversion efficiency (FCE) was calculated as a proportion of daily BW gain to daily feed intake. Mean of initial and final BW were used to calculate feed intake as percent of BW.

Digestibility trial

The digestibility trial was conducted using twenty eight sheep. The sheep were blocked by initial BW into four blocks of seven animals. They were adapted to the experimental feeds for fifteen days and to the fecal collection bags for three days followed by seven days of total collection of feces. Daily feed offer, refusals and feces voided per animal were weighed. The daily fecal excretion per animal was thoroughly mixed and 20% were sub-sampled and kept frozen at −4°C. At the end of the collection period, feces collected from each animal over the experimental period were thoroughly mixed and two sub-samples were taken. One of the samples was used for estimating DM by oven drying at 105°C for 24 hours, while the second sample was oven dried at 60°C for 72 hours for later chemical analysis. Apparent digestibility coefficient was calculated as the proportion of nutrients recovered in feces to nutrients consumed. The ME content of the feeds was estimated from *in vitro* organic matter (OM) digestibility as described by McDonald et al. (2002). ME (MJ/kg) = 0.016 DOMD, where DOMD = g digestible organic matter per kg DM.

Chemical analysis

Composite samples of feed offer, refusals and feces were ground to pass a 1 mm sieve screen using a laboratory mill and analyzed for DM, nitrogen, and ash (AOAC 1990), acid detergent fiber (ADF), acid detergent lignin (ADL) and neutral detergent fiber (NDF) (Van Soest and Robertson 1985). Hemicellulose and cellulose contents were calculated as the difference between NDF and ADF, and ADF and ADL, respectively. *In vitro* organic matter digestibility (IVOMD) was determined according to Tilley and Terry (1963).

Statistical analysis

Data were subjected to the analysis of variance using the general linear model procedure of SAS (1999). Treatment means were separated by Duncans multiple range test. The model used for the analysis of data on feed intake, digestibility and BW change was: $\Upsilon_{ij} = \mu + B_i + T_j + e_{ij,}$ where; Υ_{ij} = response variable; μ = overall mean; B_j = block effect; T_i = treatment effect; e_{ij} = random error.

Results

Nutritive value of the treatment feeds

The nutritive value of the experimental feeds is presented in Table 1. The CP contents of vetch and lucerne hay were higher by 134 and 145% than that of UTBS, respectively. The content of NDF was high in UTBS followed by vetch hay and then lucerne hay. The trend in ADF, hemicellulose and cellulose contents was similar to that of NDF content in the treatment feeds. The ADL content of UTBS was slightly lower than that in vetch hay, but higher than in lucerne hay. The IVOMD and ME contents were lowest in UTBS and similar in vetch and lucerne hay. The CP content and IVOMD were higher in UTBS offer than in the refusal, whereas the contrary was true for NDF, ADF and ADL contents.

Feed intake

Supplementation with 350 g DM per day of both forage legumes reduced ($P<0.001$) UTBS DM intake compared to the control treatment (Table 2). Total DM intake increased ($P<0.001$) with increase in the level of supplementation with both forage legumes. The high level of supplementation was associated with partial replacement of UTBS intake at a substitution rate of 0.043 and 0.039 for vetch and lucerne, respectively. This indicated that when vetch and lucerne hay were included at 350 g DM per day

Table 1 Nutritive value of experimental feeds

Components	Untreated barely straw	UTBS	Refusal	Vetch hay	Lucerne hay
DM (g kg^{-1})	903	550	630	850	875
OM (g kg $^{-1}$DM)	912	901	922	887	873
CP (g kg $^{-1}$DM)	39	82	73	192	201
NDF (g kg $^{-1}$DM)	861	831	840	584	414
ADF (g kg $^{-1}$DM)	628	633	622	455	290
ADL (g kg $^{-1}$DM)	113	116	124	166	90
Hemicellulose (g kg $^{-1}$DM)	233	198	218	129	124
Cellulose (g kg $^{-1}$DM)	515	517	497	289	200
IVOMD (g kg $^{-1}$DM)	446	503	434	658	671
EME (MJ kg $^{-1}$DM)	7.13	8.05	6.94	10.53	10.74

ADF= acid detergent fiber; ADL= acid detergent lignin; CP= crude protein; DM= dry matter; EME= estimated metabolisable energy; IVOMD= *in vitro* organic matter digestibility; NDF= neutral detergent fiber; OM= organic matter; UTBS= urea treated barley straw.

in the diets of the sheep, the DM intake of UTBS was reduced by 14.9 and 13.9 g DM per day, respectively.

Both forage legumes improved total CP, OM and ME intake (P<0.001) (Table 3), and these increased with the level of the forage legumes inclusion. Intake of CP, OM and ME were higher (P<0.001) for lucerne as compared to vetch at the same level of supplementation. The total NDF and ADF intakes were lower (P<0.001) in the control compared to the treatments with forage legumes supplementation, and increased (P<0.001) with the level of forage legumes. Intake of NDF and ADF were higher (P<0.001) for vetch as compared to lucerne hay supplementation.

Apparent digestibility of nutrients

Supplementation with the forage legumes in UTBS based feeding of Arsi-Bale sheep increased (P<0.001) the apparent digestibility of DM (Table 4). Higher (P<0.001) DM digestibility was observed for T3, T4, T6 and T7 compared to T2 and T5. Similarly, T4 and T7 resulted in higher OM digestibility (P<0.001) compared to T2 and T5. The control treatment had lower (P<0.05) CP digestibility compared to T3, T4, T6 and T7. Supplementation with the high level of lucerne (T7) resulted in higher (P<0.05) CP digestibility than similar level of vetch supplementation.

Table 2 Dry matter intake of Arsi Bale sheep fed urea treated barley straw basal feed supplemented with graded levels of vetch and lucerne hay

Treatment	UTBS intake (g day^{-1})	SI (g day^{-1})	Total DMI (g day^{-1})	DMI (% BW)	SI (% total DMI)
UTBS	446.2^{b}	–	446.2^{d}	2.7^{d}	–
UTBS + 150 g vetch	451.6^{a}	150.0^{c}	601.6^{c}	3.6^{c}	24.9^{c}
UTBS + 250 g vetch	446.3^{b}	250.0^{b}	696.6^{b}	4.1^{b}	35.9^{b}
UTBS + 350 g vetch	431.3^{c}	350.0^{a}	781.3^{a}	4.5^{a}	44.8^{a}
UTBS + 150 g lucerne	447.8^{ab}	150.0^{c}	597.8^{c}	3.5^{c}	25.1^{c}
UTBS + 250 g lucerne	449.0^{ab}	250.0^{b}	699.0^{b}	4.1^{b}	35.7^{b}
UTBS + 350 g lucerne	432.3^{c}	350.0^{a}	782.3^{a}	4.4^{a}	44.7^{a}
EMS	13.1	0.00	12.1	0.05	0.03
Significance level	***	***	***	***	***
Control vs. Forage legumes	NS	***	***	***	
Control vs. Vetch	NS	***	***	***	
Control vs. Lucerne	NS	***	***	***	
Vetch vs. Lucerne	NS	NS	NS	NS	NS

^{abcdef} = means with different superscripts in a column are significantly different; *= P<0.05; **= P<0.01; ***= P<0.001; BW= body weight; DM= dry matter; DMI= dry matter intake; EMS= error mean square; NS= not significant; SI= supplement intake; UTBS= urea treated barley straw.

Table 3 Intake of crude protein, organic matter, metabolizable energy and fiber in Arsi Bale sheep fed urea treated barley straw supplemented with graded levels of vetch and lucerne hay

Treatment	CP (g day^{-1})	OM (g day^{-1})	ME (MJME day^{-1})	NDF (g day^{-1})	ADF (g day^{-1})
UTBS	36.2^{g}	401.7^{e}	3.6^{f}	370.8^{g}	282.6^{f}
UTBS + 150 g vetch	64.9^{f}	539.5^{c}	5.2^{e}	462.8^{b}	354.1^{d}
UTBS + 250 g vetch	84.1^{d}	623.5^{b}	6.22^{d}	516.9^{b}	395.5^{b}
UTBS + 350 g vetch	102.3^{b}	698.6^{a}	7.15^{b}	562.8^{a}	432.2^{a}
UTBS + 150 g lucerne	66.9^{e}	533.9^{d}	5.21^{e}	342.2^{f}	326.6^{e}
UTBS + 250 g lucerne	86.5^{c}	622.4^{b}	6.29^{c}	476.6^{d}	356.7^{d}
UTBS + 350 g lucerne	105.4^{a}	694.6^{a}	7.23^{a}	504.1^{c}	375.1^{c}
EMS	0.09	10.6	0.001	9.0	5.25
Significance level	***	***	***	***	***
Control vs. Forage legumes	***	***	***	***	***
Control vs. Vetch	***	***	***	***	***
Control vs. lucerne	***	***	***	***	***
Vetch vs. lucerne	***	**	**	***	***

^{abcdef} = means with different superscripts in a column are significantly different; *= P<0.05; **= P<0.01; ***= P<0.001; ADF= acid detergent fiber; CP= crude protein; EMS= error mean square; NDF= neutral detergent fiber; ME= metabolizable energy; NS= not significant; OM= organic matter; UTBS= urea treated barley straw.

Forage legume supplementation increased the digestibility of NDF (P<0.01) and ADF (P<0.05). Higher digestibility of NDF (P<0.05) and ADF (P<0.001) were observed due to supplementation with vetch as compared to lucerne hay. Digestibility of DM, OM, NDF and ADF of the experimental feeds was positively correlated (P<0.001) with DM intake.

Body weight change

Supplementation with the forage legumes resulted in increased (P<0.001) daily BW gain, which also increased with the level of supplementation. The daily BW gain was higher (P<0.001) for equal level of lucerne than vetch hay supplementation (Table 5).

Table 4 Apparent digestibility coefficient of feed nutrients in Arsi Bale sheep fed urea treated barley straw and supplemented with graded levels of vetch and lucerne hay

Treatment	DMD	OMD	CPD	NDFD	ADFD
UTBS	0.49^{d}	0.53^{d}	0.73^{c}	0.57^{c}	0.53^{d}
UTBS + 150 g vetch	0.58^{bc}	0.62^{b}	0.72^{c}	0.65^{ab}	0.60^{ab}
UTBS + 250 g vetch	0.63^{a}	0.64^{ab}	0.74^{b}	0.66^{a}	0.62^{ab}
UTBS + 350 g vetch	0.65^{a}	0.66^{a}	0.74^{b}	0.66^{a}	0.63^{a}
UTBS + 150 g lucerne	0.55^{c}	0.59^{c}	0.72^{c}	0.62^{b}	0.56^{c}
UTBS + 250 g lucerne	0.64^{a}	0.66^{a}	0.76^{a}	0.66^{a}	0.60^{ab}
UTBS + 350 g lucerne	0.62^{ab}	0.66^{a}	0.76^{a}	0.64^{ab}	0.59^{bc}
EMS	0.06	0.04	0.005	0.04	0.05
Significance level	***	***	*	**	*
Control vs. Forage legumes	***	***	**	***	***
Control vs. Vetch	***	***	*	***	***
Control vs. lucerne	***	***	***	***	***
Vetch vs. lucerne	NS	NS	**	*	***

^{abcdef} = means with different superscripts in a column are significantly different; *= P<0.05; **= P<0.01; ***= P<0.001; ADFD= acid detergent fiber digestibility; CPD= crude protein digestibility; DMD= dry matter digestibility; EMS= error mean square; NDFD= neutral detergent fiber digestibility; OMD= organic matter digestibility; NS= not significant; UTBS= urea treated barley straw.

Table 5 Body weight parameters and feed conversion efficiency of Arsi Bale sheep fed urea treated barley straw supplemented with graded levels of vetch and lucerne hay

Treatment	IBW (kg)	DBWG (g day^{-1})	FBW (kg)	DBWG (g g^{-1}SDMI)	FCE
UTBS	16.2^{a}	7.9^{f}	16.6^{b}	–	0.016^{e}
UTBS + 150 g vetch	16.4^{a}	15.1^{e}	17.2^{ab}	0.1^{b}	0.024^{d}
UTBS + 250 g vetch	16.3^{a}	18.7^{d}	17.5^{ab}	0.07^{c}	0.026^{d}
UTBS + 350 g vetch	16.5^{a}	33.7^{b}	18.2^{a}	0.09^{b}	0.044^{b}
UTBS + 150 g lucerne	16.5^{a}	21.2^{d}	17.3^{ab}	0.14^{a}	0.034^{c}
UTBS + 250 g lucerne	16.4^{a}	26.5^{c}	17.7^{ab}	0.11^{b}	0.040^{b}
UTBS + 350 g lucerne	16.6^{a}	38.9^{a}	18.6^{a}	0.11^{b}	0.05^{a}
EMS	0.05	10.4	0.08	0.004	0.003
Significance level	NS	***	**	**	***
Control vs. Forage legumes		***	***		***
Control vs. Vetch		***	***		***
Control vs. Lucerne		***	***		***
Vetch vs. Lucerne		***	*	NS	***

^{abcdef} = means with different superscripts in a column are significantly different; *= P<0.05; **= P<0.01; ***= P<0.001; DBWG= daily body weight gain; DM= dry matter; EMS= error mean square; FBW= final body weight; FCE= feed conversion efficiency; IBW= initial body weight; NS= not significant; SDMI= supplement dry matter intake; UTBS= urea treated barley straw.

The highest (P<0.001) BW gain was recorded for sheep supplemented with lucerne at 350 g DM per day. The mean daily BW gain per gram forage legume DM supplementation showed higher (P<0.01) gain of 0.14 for alfalfa hay supplementation at 150 g DM per day compared to the other levels of forage legumes supplementation. The FCE was higher (P<0.001) for the treatments with forage legumes supplementation compared to the control, and the highest (P<0.001) FCE was recorded at high level of lucerne hay supplementation (T7).

Discussion

Chemical composition of experimental feeds

Urea treatment improved the CP content of barley straw used in this study by 110% and this could be attributed to the fixation of urea nitrogen into the barley straw which according to Hadjipanyiotou et al. (1997) could be as high as 50% of the nitrogen in urea. The improvement in CP content of the straw in this study is comparable to the improvement in CP content from 3.7–12.2% for untreated barley straw due to urea treatment (Hadjipanyiotou et al. 1993). The CP content of vetch hay used in this study is comparable with 19.9% CP reported by Kitaw (2006), whereas the CP content of lucerne hay obtained in this study is higher than 18.1% reported by Poland et al. (2003). The reduction in NDF and hemicellulose components of UTBS (Table 1) as the result of urea treatment was in agreement with the results of Mesfin and Ledin (2004). The reduction in NDF and hemicellulose may be due to the dissolving effect of urea on the hemicellulose fraction, and subsequent removal from the cell wall constituents (Givens et al. 1988). The increase in IVOMD as a result of urea treatment was in agreement with that reported by Hadjipanyiotou et al. (1997) in which the IVOMD of UTBS increased by 8 units from 64–72%. The higher CP, and lower NDF and ADF contents qualifies the forage legumes as supplements to UTBS. The low IVOMD and CP and high NDF, ADF and ADL contents in UTBS refusal compared to the offer confirms the selection behavior of sheep (McDonald et al. 2002) for the most nutritious components of the feed on offer.

Feed intake

The low intake of UTBS at high level of forage legumes supplementation could be due to high proportion of the forage legumes in the total diet which caused larger rumen fill, thus limiting feed intake (Van Soest 1994) and preventing maximum intake of the UTBS. Kebede (2006) and Mesfin and Ledin (2004) showed that when treated straws were supplemented with protein and energy sources, the

daily DM intake improved much more as compared to feeding non-supplemented basal diets. The positive effect of low level of forage legume supplementation on the UTBS intake observed in this study could be the result of reduced rumen retention allowing for greater feed intake (Melaku 2004). The increased total DM intake with increased level of forage legumes supplementation could be attributed to a more balanced intake of nutrients that led to better efficiency in the utilization of the fiber in the total diet. Moreover, increased availability of nutrients due to the supplementation of the forage legumes might have promoted the observed higher total DM intake in the supplemented sheep. The increase in OM, CP and ME intake observed in diets containing the forage legumes could also be due to the combined effect of the higher total DM intake and digestibility associated with forage legumes intake. Tolera and Sundstøl (2000) reported similar observations, whereby sheep supplemented with *Desmodium intortum* hay had higher total DM intake, although the intake of the basal feed, maize stover, was reduced with supplementation. One of the limitations of forage supplements is that they can cause a substitution of the basal feed. Topps (1997) reported that substitution of the basal feed usually occurs when the forage legumes make up at least 30–40% of the total DM intake. In this study, increasing the level of vetch and lucerne hay to 350 g DM per day resulted in partial substitution of the UTBS. The higher intake of NDF and ADF in vetch containing treatments might be associated with the higher concentration of these constituents in vetch hay compared to that in lucerne hay. Kitaw (2006) also reported higher intake of NDF in cows fed urea treated wheat straw supplemented with vetch hay. The positive associations between DM intake and nutrient digestibility observed in this study reflected the improved fermentation and passage rate as the result of the dietary treatments.

Apparent digestibility of nutrients

The lower DM digestibility for sole UTBS as compared to the treatments with forage legumes supplementation may be explained in part by high fiber content (Table 4) in the UTBS. The lower digestibility of CP in the UTBS as compared to the treatments with the higher level (T4 and T7) of forage legumes supplementation might not only be related to the lower CP content of the basal diet, but also to the lower digestive utilization of nitrogen or higher microbial synthesis in the lower gut (Hassen and Chenost 1992). In agreement with Kitaw (2006), the lack of response in terms of NDF and ADF digestibility with increased intake of the forage legumes could be associated with the corresponding increase in lignin and NDF intake arising from the basal straw diet and the forage legumes, which also contain relatively high proportion of cell walls.

Body weight change

The lower BW gain by the sheep in the control treatment could be attributed to low feed and nutrient intake as compared with those treatments supplemented with forage legumes. The highest daily BW gain and total BW change was recorded for the higher level of forage legumes supplementation, and this could be due to increased nutrient density as a result of higher protein in the forage legumes and a reflection of increased total feed DM and nutrient intake. It was also shown that supplementation of ammoniated rice straw with Chinese milk vetch silage markedly improved the BW gain of ruminants (Liu et al. 1997). Getachew et al. (1994) also reported higher BW gain in sheep supplemented with the forage legumes, *Desmodium intortum* and *Macrotyloma axillare*. The higher FCE recorded for sheep on the high level of alfalfa could be due to the higher content of energy and protein in the diet of sheep in this treatment. Kebede (2006) also showed the additive effect of combining supplementation of a forage legume (*Leucaena leucocephala*) and urea treatment of wheat straw in enhancing nutrient utilization in sheep. Improved trend in FCE was observed with increased proportion of forage legumes in the total DM consumed. This is due to better protein utilization as a result of forage legume inclusion that caused higher BW gain. In agreement with the results of this study, Klopfenstein and Owen (1981) indicated positive associative effects in terms of BW gain and DM intake when crop residues were supplemented with lucerne hay.

Conclusions

The results of this study suggested that supplementing UTBS with lucerne and vetch hays is a promising

feeding strategy to promote smallholder sheep production using feed resources available at the farm level in the tropics.

References

AOAC, 1990. Official Methods of Analysis 15th ed. Association of Official Analytic Chemists. AOAC. (Arlington, USA).

Bogale, S., Melaku, S. and Yami, A., 2008. Potential use of crop residues as livestock feed resources under conditions of smallholder farmers in the Bale highlands of Ethiopia. Tropical and Subtropical Agroecosystems, 8, 107–114

Castrillo, C., Funderella, M., Guada, J.A. and deVega, A., 1995. Effect of ammonia treatment and carbohydrate supplementation on the intake and digestibility of barley straw diets by sheep. *Animal Feed Science and Technology*, 51, 73–85. doi:10.1016/0377-8401(95)00682-D

CTA, 1992. Ruminant Nutrition. The Tropical Agriculturalist, CTA Publication.

Getachew, G., Said, A.N. and Sundstøl, F., 1994. The effect of forage legume supplementation on digestibility and body weight gain by sheep fed a basal diet of maize stover. *Animal Feed Science and Technology*, 46, 97–108. doi:10.1016/0377-8401(94)90068-X

Givens, D.I., Adamson, A.H., and Cobby, J.M., 1988. The effect of ammoniation on the nutritive value of wheat, barley and oat straws. II. Digestibility and energy value measurements in vivo and their prediction from laboratory measurements. *Animal Feed Science and Technology*, 19, 173–175. doi:10.1016/0377-8401(88)90065-X

Hadjipanayiotou, M., Verhaeghe, L., Kronfoleh, A.R., Labban, L.M., Shurbaji, A., Amin, M., Merawi, A.R., Harress, A.K., Houssein, M., Malki, G. and Dassouki, M., 1993. Feeding ammoniated straw to cattle and sheep in Syria. *Livestock Research for Rural Development*, 5, 1–7.

Hadjipanayiotou, M., Economides, S., Kyprianou, G., Antoniou, I., Photiou, A., 1997. Feeding urea treated barley straw to lactating Friesian cows. *Livestock Research for Rural Development*, 9, 1–13.

Hassen, L. and Chenost, M., 1992. Tentative explanation of the abnormally high fecal nitrogen excretion with poor quality roughages treated with ammonia. *Animal Feed Science and Technology*, 38, 25–34. doi:10.1016/0377-8401(92)90073-F

Kebede, G., 2006. Effect of urea-treatment and leucaena (*Leucaena leucocephala*) supplementation on the utilization of wheat straw as feed for sheep. MSc. Thesis. Haramaya University, (Haramaya, Ethiopia).

Kitaw, G., 2006. Replacement of formulated concentrate mix with vetch (*Vicia dasycarpa*) hay to lactating crossbred dairy cows fed on urea treated wheat straw. MSc. Thesis. Haramaya University, (Haramaya, Ethiopia).

Klopfenstein, T. and Owen, F.G., 1981. Value and potential use of crop residues and by-products in dairy rations. *Journal of Dairy Science*, 64, 1250–1268.

Liu, J.X., Ye, J.A. and Ye, H.W., 1997. Effects of supplementary Chinese milk vetch silage on straw intake and growth rate of Holstein heifers given ammoniated rice straw. *Animal Feed Science and Technology*, 65, 78–86. doi:10.1016/S0377-8401(96)01083-8

McDonald, P., Edwards, R.A., Greenhalgh J.F.D. and Morgan, C.A., 2002. Animal Nutrition. 6th ed., (Prentice Hall. London).

Melaku, S., 2004. Feed intake, digestion kinetics and rumen volatile fatty acids in Menz rams supplemented with *Lablab purpureus* or graded levels of *Leucaena pallida* 14203 and *Sesbania sesban* 1198. *Animal Feed Science and Technology*, 117, 61–73. doi:10.1016/j.anifeedsci. 2004.07.016

Melaku, S., Peters, K.J. and Tegenge, A., 2004. Effects of supplementation with foliages of selected multipurpose trees, their mixtures or wheat bran on feed intake, plasma enzyme activities, live weight and circumference gains in Menz sheep. *Livestock Production Science*, 89, 253–264. doi:10.1016/j.livprodsci.2004.01.003

Melaku, S., Peters, K.J. and Tegegne, A. 2005. Intake, digestibility and passage rate in Menz sheep fed tef (*Eragrostis tef*) straw supplemented with dried leaves of selected multipurpose trees, their mixtures or wheat bran. *Small Ruminant Research*, 56, 139–149. doi:10.1016/j.smallrumres.2004.06.008

Mengistu, A., 2004. Rangeland: Biodiversity concepts, approaches and the way forward. (Addis Ababa University, Faculty of Science, Addis Ababa, Ethiopia).

Mesfin, R. and Ledin, I., 2004. Comparison of feeding urea-treated teff and barley straw based diets with hay based diet to crossbred dairy cows on feed intake, milk yield, milk composition and economic benefits. *Livestock Research for Rural Development,* 16, Art. # 104. Retrieved January 25, 2008, from http://www.cipav.org.co/lrrd/lrrd16/12/mesf16104.htm

Poland, C., Faller, T., Tisor, L., 2003. Effect of chickling vetch (*Lathyrus sativus L.)* or alfalfa (*Medicago sativa*) hay in gestating ewe diets. Annual Report. (North Dakota State University).

SARC, 2005. Sinana Agricultural Research Centre, Annual Report. Oromia Agricultural Research Institute, Animal Feeds and Nutrition Research Division, (Sinana, Bale, Ethiopia).

SAS, 1999. Version 8. Statistical Analysis System Institute Inc., (NC., USA).

Shuang, G.T., J.K. Yuan, W.X. Zhang and J.L. Wu, 1995. Utilization of straws by Chinese yellow cattle. *Livestock Research for Rural Development*, 6, 3–6.

Sundstøl, F., 1988. Improvement of poor quality forage and roughages. In: E.R., Ørskov (ed.), World Animal Science, (Elsevier, Amsterdam).

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

Tolera, A. and Sundstøl, F., 2000. Supplementation of graded levels of *Desmodium introtum* hay to sheep fed on basal diet of maize stover harvested at three stages of maturity. Feed intake, digestibility and body weight change. *Animal Feed Science and Technology*, 85, 239–257. doi:10.1016/S0377-8401(00)00135-8

Topps, J.H., 1997. Forage legumes as protein supplement to poor quality diets in the semi-arid tropics. In: R.J., Wallace and A., Lahlou Kassi (eds.), Rumen Ecology Research Planning. Proceedings of a Workshop held at International Livestock Research Institute, (Addis Ababa, Ethiopia).

Van Soest, P.J., 1994. Nutritional Ecology of Ruminants. 2nd ed., (Cornell University Press, Ithaca, New York, USA).

Van Soest, P.J. and Robertson, J.B., 1985. Analysis of forage and fibrous foods. A laboratory manual for Animal Science 613, (Cornell University Press, Ithaca, New York, USA).