Effect of Concentrate Mix Supplementation to Urea-Treated and Ensiled Maize Stover on Feed Intake, Digestibility and Nitrogen Balance of Hararghe Highland Sheep

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Abstract: The effects of feeding different levels of concentrate mixture to sheep fed urea treated maize stover basal diet on feed intake, digestibility, and nitrogen balance were evaluated at Haramaya University. The experiment was conducted in a randomized complete block design using twenty male Hararghe Highland sheep with a mean initial body weight (BW) of 17.2 ± 1.74 (mean ± SD) kg. The animals were grouped into five blocks based on their initial BW and randomly assigned to four treatments within the block. The levels of supplementation were 0 g (control, T1), 150 g (low, T2), 250 g (medium, T3) and 350 g (high, T4) of the concentrate mix prepared from brewers dried grain, peanut cake and wheat bran at a ratio of 1:1:3 on dry matter basis, respectively. Hundred kg (dry matter basis) of chopped maize stover was treated with 4 kg of urea dissolved in 100 liters of water and ensiled for 21 days before used as a basal diet. The urea treated maize stover (UTMS) was offered *ad libitum* and water and mineral block were available to the experimental animals all the time throughout the experiment. Intake trial was conducted for 90 days. Digestibility and nitrogen balance trials were carried out for 7 days following 3 days of adaptation to the metabolic cage and carrying of the fecal collection bag following 15 days of adaptation. Urea treatment improved the crude protein (CP) content of maize stover by about 33% (from 5.8 to 7.7%). The UTMS intake was lower ($P < 0.05$) for the sheep in T4 (665 ± 16 g DM day^{-1}) than in T1 (768 ± 16 g DM day^{-1}) and T3 (754 ± 16 g DM day^{-1}). Daily DM intake per kg $W^{0.75}$ was higher ($P < 0.01$) for T3 (105.7 ± 1.7 g day^{-1}) and T4 (104.1 ± 1.7 g day^{-1}) than T1 (91.9 ± 1.7 g day^{-1}). Total CP intake per kg $W^{0.75}$ (7.8, 10.4, 12.7, and 13.8 (SEM = ± 0.16), for T1, T2, T3, and T4, respectively) increased with increasing level of supplementation ($P < 0.01$). Crude protein digestibility was lower ($P < 0.05$) in non-supplemented sheep (0.42 ± 0.04) than the supplemented sheep (0.65, 0.71, and 0.70 (SEM = ± 0.04) for T2, T3 and T4, respectively). Nitrogen intake during digestibility trial (6.4, 11.2, 14.4, and 17.5 (SEM = ± 0.3) g day^{-1} for T1, T2, T3 and T4, respectively) increased with increasing levels of supplementation ($P < 0.001$). Nitrogen retention was positive and higher in the supplemented groups (8.2, 7, and 4.4 (SEM = ± 0.63) for T4, T3, and T2, respectively) than in T1 (-0.02 ± 0.63 g day^{-1}), which has a negative nitrogen balance ($P < 0.01$). The result indicated that supplementation improved feed intake, digestibility and nitrogen balance, but feeding sole urea treated maize stover failed to support sufficient nitrogen intake which might have resulted in body reserve mobilization to meet the maintenance requirement of the animal.

Keywords: Concentrate Mix; Digestibility; Hararghe Highland Sheep; Maize stover; Nitrogen Balance; Urea Treatment

1. Introduction

Small ruminants are important protein sources and cash income for many farmers in the tropics and sub-tropics. Among the small ruminants, sheep contribute a substantial amount to the farm household income, mutton and non-food products, such as manure, skin and coarse wool. However, the productivity of indigenous sheep breeds is low as compared to temperate breeds due to limited genetic capacity and mainly environmental factors. Among the environmental factors, the main bottleneck for the small holder livestock production in numerous tropical countries like Ethiopia is the inadequate supply and low level of feeding due to serious shortage of feedstuffs.

Currently, crop residues are becoming the most important feed resources, because of the expansion of cropping land, and it is particularly utilized during the dry season (Alemayehu, 2004). The scenario holds true in Hararghe highlands where limited areas of permanent grazing land are available and livestock depend upon crop residues and stubble grazing during the dry season. Quality of these crop residues is limited due to their deficiency in crude protein (CP), metabolisable energy (ME), minerals and vitamins. Indeed, a major limiting factor to the utilization of straw is its bulkiness and low concentration of digestible nutrients.

In Ethiopia, there is a scope for improvement in small ruminant productivity by employing better feeding, reproductive, and health care management practices (Kassahun, 2000). The efficiency of growth to attain the desired market weight, and the economic return from sheep production can be enhanced through better feeding practices. One of the feeding management practices is improving the nutritive value of low quality feed resources. Among the technologies available to improve nutritive value of poor quality roughages, such as crop residues are ammonia treatment and supplementation with agro-industrial by-products (Ben Salem *et al*., 2004). There are consistent responses in performance of animals to supplementation with concentrate, but the effects are more pronounced when the poor quality roughages are chemically treated (Liu and Meng, 2002). For better utilization of urea treated roughages, some amount of protein supplementation should be present in the feed, part of which can be provided by energy sources, and frequently some oil meals are used in preparing the formula feeds (Ensminger, 2002).

In the Hararghe highland, different agro-industrial by-products are available in the market and urea treatment is possible. However, information available on the effects of

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supplementing urea treated maize stover with concentrate mixtures of agro-industrial by-products on nutrient utilization and sheep performance is scanty and variable, hindering the wider use of the technology. Therefore, the experiment was conducted with the aim to determine the effects of supplementing different levels of concentrate mix on feed intake, digestibility and nitrogen balance of Hararghe Highland sheep fed urea treated maize stover.

2. Materials and Methods

2.1. Study Area

The experiment was conducted at Haramaya University which is located 515 km east of Addis Ababa. The site is located at an altitude of 1950 m above sea level at 9.0° N and 42.0° E. The mean annual rainfall and temperature of the study area is 790 mm and 16 °C, respectively (Mishra *et al*., 2004). The major feed resource for livestock in the area is crop thinning and residues of mainly maize and sorghum. Wheat bran, brewers dried grain, and noug seed cake are the most widely used supplement agro-industrial by-products in the area, particularly in areas closer to towns (Tsigereda, 2010).

2.2. Animals and Management

Twenty male Hararghe Highland Sheep with intact milk teeth and a mean initial body weight of 16.3 ± 1.45 kg (mean ± SD) were purchased from *Kulubi* and *Lange* markets. They were quarantined for three weeks to acclimatize the animals to the environment and to monitor for any health problem. The basal diet used for the experiment was urea treated maize stover (UTMS). The concentrate mixtures (CM) were prepared from peanut cake (PNC), brewers dried grain (BDG) and wheat bran (WB) at a ratio of 1:1:3, respectively. Higher proportion of WB was used to provide higher energy source for rumen microbes in order to efficiently utilize the urea in the treated maize stover. All animals were offered UTMS *ad libitum* but the CM in two equal portions at 0800 hours and 1600 hours according to the treatment. The UTMS offer was adjusted once every week based on previous week intake allowing a 30% refusal rate. All animals had free access to water and mineral blocks throughout the experimental period.

2.3. Urea Treatment of Maize Stover

Maize stover was chopped using tractor mounted chopper. Hundred kilogram dry matter (DM) of the chopped stover was treated with a solution of 4 kg urea in 100 liters of water (Sundstøl and Coxworth, 1984; Dolberg, 1992). The application of urea solution to the stover was made on a plastic sheet placed on a floor. Twenty five liters of the prepared urea solution was uniformly sprayed using garden watering cans and mixed with 25 kg DM of the chopped stover, and rubbed with hand to ensure proper penetration of the solution. The treated stover was placed in a pit with a dimension of 2m x 2m x 2m, and its floor and sides lined by a polyethylene sheet. The treated stover was placed in the pit and trampled with human foot to ensure proper packing. Following similar procedure, layers of such treated stover were placed until the pit was full. After filling, the pit was covered with plastic sheet and compacted with soil and stone and was left to incubate. After twenty one days, the pit was opened and aerated for a day in order to remove excess ammonia (Zhang and Qiaojuan, 2002).

2.4. Experimental Design and Treatments

The experiment was conducted in a randomized complete block design with four treatments and five replications. The sheep were blocked based on their initial body weight into five blocks of four animals each. Each animal within each block were randomly assigned to one of the four dietary treatments. The four dietary treatments were, UTMS alone and UTMS supplemented with 150, 250 and 350 grams of the CM expecting the basal diet to fulfill the maintenance requirement, and the lowest level of concentrate mix supplementation to provide additional nutrients to support 50 g average daily gain. The concentrate mix was formulated according to the growth requirements of the sheep based on the recommendations of the National Research Council (NRC) and by considering the expected body weight gain of sheep (NRC, 1985).

2.5. Digestibility and Nitrogen Balance Trial

The experiment duration consisted of 7 days of digestibility and nitrogen balance trials, and 90 days of growth trial followed by carcass evaluation at the end of the experiment. Data of live weight change and carcass were published elsewhere (Hirut *et al*., 2011). The animals were kept in individual pens and offered the respective treatment diet for fifteen days to adapt them to the feed. Following this, the animals were moved to individual metabolic cages equipped with feeding and watering troughs.

The digestibility and nitrogen balance trials were conducted before the growth trial by using all experimental sheep. The animals were adapted to the metabolic cages as well as the carrying of fecal bags for three days, and were followed by collection of feces and urine for seven consecutive days. Feces were collected into a fecal collection bag harnessed on the animal. Urine was collected into a bucket placed underneath the metabolic cage through a hole on the floor of the metabolic cage. During urine collection, one hundred ml of H_2SO_4 (10%) was added to each urine collection bucket daily to trap the nitrogen that may escape as NH_3 from the urine. The total amount of feces and urine voided were collected and weighed every morning starting at 0800. About 20% sample of the total feces and urine collected daily were taken into a plastic bottle and kept in a deep freezer adjusted at -20 °C.

At the end of the experiment, the samples were bulked per animal and kept until required for analysis. The refusal of the UTMS were collected every day, pooled per treatment, and then bulked over the seven days of digestibility trial. Finally, the sub-samples of urine, feces and feeds were taken and transported in ice box filled with chilled ice bags to ILRI laboratory Addis Ababa for chemical analysis. Apparent DM and nutrient digestibility coefficient (DC) of the treatment diets were calculated as a proportion of nutrient intake not recovered in feces on dry matter basis using the following formula:

$$DC = \frac{\text{(Total amount of nutrients in feed consumed-Total amount of nutrients in feces voided)}}{\text{Total amount of nutrients in feed consumed}}$$

2.6. Feed Intake Measurement

Following the digestibility and nitrogen balance trial, the sheep were weighed and re-blocked based on their initial body weight into five blocks. The mean initial body weight of the sheep was 17.2 ± 1.74 (mean ± SD). Feed intake was evaluated for 90 days. The basal diet and concentrate mixture were offered in a separate feeding trough. The concentrate mixture was offered after about 30 minutes of UTMS feeding. The amounts of feed dry matter offered and refused were recorded daily for each experimental animal to determine daily feed dry matter intake. Daily feed dry matter intake was calculated as a difference between the feed dry matters offered and refused. Feed samples were taken following similar procedures indicated under section 2.5.

2.7. Chemical Analysis

The sample of feed offered, refused and feces were analyzed for DM, ash and nitrogen (N) according to the procedures of AOAC (1990). The crude protein (CP) content was estimated as N*6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) were analyzed by the method of Van Soest and Robertson (1985). Organic matter was calculated by subtracting the ash content from the DM.

2.8. Statistical Analysis

The data was subjected to analysis of variance in a randomized complete block design using the general linear model procedure of SAS (1998). The treatment means were separated using Tukey honestly significant difference test. The model for data analysis was:

$$Y_{ij} = \mu + t_i + b_j + e_{ij},$$

where Y_{ij} = response variable; μ = overall mean; t_i = treatment effect; b_j = block effect; eij = random error.

3. Results

3.1. Chemical Composition of the Experimental Feeds

Although sensory evaluation test by employing recommended procedures were not conducted, the researchers observed that the treated stover has a strong pungent smell with brownish yellow color and soft texture with no mould appearance. Urea-treatment increased CP content of the stover from 5.8 to 7.7%. There were also slight increments in ADF, ADL and ADL-ash, but NDF decreased by about 12.7% (Table 1). The UTMS refusals contained lower CP than in the UTMS offer in all treatments, whereas NDF, ADF and ADL were higher in feed refusal than the offer in all treatments.

3.2. Feed dry matter and Nutrient Intake

The daily UTMS DM intake of T1 and T3 were higher ($P < 0.05$) than that of T4 (Table 2). Urea treated maize stover DM intake decreased by 6.4, 1.8 and 15.4% for T2, T3 and T4, respectively as compared to that consumed by T1. However, the total DM intake was lower ($P < 0.001$) in T1 than in T3 and T4, and T2 has statistically similar dry matter intake with all treatments. The concentrate mix DM intake of T2, T3 and T4 accounted for about 17.5, 25.6 and 35.7% of the total DM intake, respectively. Substitution of UTMS with concentrate mix was not different between treatments, although T3 has numerically lower substitution rate. The total OM intake followed similar trend with DM intake. The total OM intake was higher ($P < 0.01$) for T3 and T4 than T1. The CP intake was significantly ($P < 0.01$) different among the treatments in the order of T4 > T3 > T2 > T1. The CP intake was 8.0, 10.5, 11.6 and 13.1% of the total DM intake for T1, T2, T3 and T4, respectively. Feed dry matter and nutrient intake during the seven days of digestibility trial (Table 3) followed similar trend with that during the 90 days of growth period intake (Table 2).

Table 1. Chemical composition of concentrate mixtures, untreated and urea treated maize stover.

		Urea treated maize stover					Concentrate ingredients			
			Refusal							
Nutrients	UMS	Offer	T1	T2	T3	T4	WB	PNC	BDG	CM
DM (%)	91.5	95.6	96.5	96.5	96.9	96.6	90.4	90.8	90.2	89.8
OM (%)	93.1	89.0	91.3	92.0	90.4	89.6	94.1	94.0	94.8	93.9
CP (% DM)	5.8	7.7	6.5	7.0	6.8	7.1	16.3	62.5	27.4	23.8
NDF (% DM)	86.6	73.9	77.8	77.7	76.7	75.2	55.5	27.3	79.9	53.5
ADF (% DM)	49.1	53.6	57.3	58.0	56.5	51.7	14.6	12.8	27.1	16.9
ADL (% DM)	4.7	5.4	7.6	7.5	7.6	7.1	3.5	4.1	6.8	4.6
ADL-ash (% DM)	1.6	3.6	0.9	1.9	1.6	1.8	0.1	0.4	2.1	0.7

DM = Dry matter; OM = Organic matter; CP = Crude protein; NDF = Neutral detergent fiber; ADF = Acid detergent fiber; ADL = Acid detergent lignin; UMS = Untreated maize stover; T1 = UTMS alone; T2 = UTMS + 150 g CM; T3 = UTMS + 250 g CM; T4 = UTMS + 350 g CM; WB = Wheat bran; PNC = Peanut cake; BDG = Brewers dried grain; CM = Concentrate mix.

Table 2. Dry matter and nutrient intake of Hararghe Highland Sheep fed a basal diet of urea treated maize stover and supplemented with different levels of concentrate mix during the growth period.

Parameter	T1	T2	T3	T4	SEM	SL
Basal DMI (g/head/d)	767.5^{a}	721.8^{ab}	753.7^{a}	665.0^{b}	15.69	*
Supplement DMI (g/head/d)	0	134.6	224.4	314.1	-	-
Total DMI (g/head/d)	767.5^{b}	856.4^{ab}	978.1^{a}	979.1^{a}	16.79	***
DMI (g/kg $W^{0.75}$)	91.9^{b}	96.5^{ab}	105.7^{a}	104.1^{a}	1.72	**
OMI (g/kg $W^{0.75}$)	83.3^{b}	88.0^{ab}	97.0^{a}	95.8^{a}	1.58	**
CPI (g/kg $W^{0.75}$)	7.8^{d}	10.4^{c}	12.7^{b}	13.8^{a}	0.16	**
CPI (% TDMI)	8.0^{d}	10.5^{c}	11.6^{b}	13.1^{a}	1.41	**
NDFI (g/kg $W^{0.75}$)	69.5	69.7	74.0	70.8	1.34	ns
ADFI (g/kg $W^{0.75}$)	41.8	39.8	40.9	38.3	0.92	ns
ADLI (g/kg $W^{0.75}$)	3.0^{b}	3.5^{ab}	4.0^{a}	4.0^{a}	0.10	**
Substitution rate	-	0.34	0.1	0.29	0.09	ns

*$^{a, b, c, d}$ Means within a row not bearing a similar superscript letter significantly differ; * = (P < 0.05); ** = (P < 0.01); *** = (P < 0.001); DMI = Dry matter intake; OMI = Organic matter intake; CPI = Crude protein intake; NDFI = Neutral detergent fiber intake; ADFI = Acid detergent fiber intake; ADLI = Acid detergent lignin intake; SEM = Standard error of means; SL = Significance level; ns = Not Significant.*

3.3. Nutrient Digestibility

Supplementation improved only CP digestibility (Table 3). The CP digestibility was lower ($P < 0.05$) for the non-supplemented sheep than all the supplemented groups. Digestible CP intake (DCPI) increased with increasing levels of CP intake with the lowest recorded in T1 (17 g day^{-1}) as compared to the other treatments ($P < 0.001$).

3.4. Nitrogen Balance

There was difference between treatments in nitrogen intake ($P < 0.001$), fecal nitrogen ($P < 0.05$), total nitrogen excreted ($P < 0.05$), nitrogen balance ($P < 0.01$) and nitrogen retained as percent of nitrogen intake ($P < 0.01$) (Table 4). Sheep supplemented with high level of concentrate mix recorded higher ($P < 0.01$) nitrogen retention than those in T1 and T2. Feeding UTMS as a sole diet resulted in a negative nitrogen balance. Nitrogen intake was significantly ($P < 0.001$) different among the treatments in the order of T4 > T3 > T2 > T1. Nitrogen absorbed and retained expressed as percent of nitrogen intake was higher ($P < 0.01$) in the supplemented sheep than those fed only UTMS. Fecal nitrogen loss was the lowest ($P < 0.05$) in T1 as compared to T4.

Table 3. Apparent DM and nutrient digestibility of Hararghe Highland Sheep fed a basal diet of urea treated maize stover and supplemented with different levels of concentrate mix.

Parameters	Experimental treatments				SEM	SL
	T1	T2	T3	T4		
Digestibility coefficients						
DMD	0.54	0.56	0.56	0.48	0.04	ns
OMD	0.66	0.64	0.63	0.57	0.03	ns
CPD	0.42^{b}	0.65^{a}	0.71^{a}	0.70^{a}	0.04	*
NDFD	0.76	0.71	0.68	0.63	0.02	ns
ADFD	0.77	0.72	0.69	0.63	0.02	ns
Intake during digestibility period (g day^{-1})						
DMI	592^{b}	722^{ab}	776^{a}	838^{a}	31.79	*
DDMI	320	399	434	407	30.69	ns
OMI	520^{b}	640^{ab}	698^{a}	760^{a}	28.85	*
DOMI	339	406	443	437	24.50	ns
CPI	40^{d}	70^{c}	90^{b}	109^{a}	1.80	***
DCPI	17^{d}	45^{c}	64^{b}	76^{a}	2.24	*
NDFI	425^{b}	494^{ab}	519^{ab}	551^{a}	24.31	*
DNDFI	320	349	356	350	21.26	ns
ADFI	305	323	320	323	17.97	ns
DADFI	235	231	221	204	15.14	ns

*$^{a, b, c, d}$ Means within a row not bearing a similar superscript letter significantly differ; * = (P < 0.05); *** = (P < 0.001); ns = Non-significant; DMI = Dry matter intake; OMI = Organic matter intake; CPI = Crude protein intake; NDFI = Neutral detergent fiber intake; ADFI = Acid detergent fiber intake; DDMI = Digestible dry matter intake; DOMI = Digestible organic matter intake; DCPI = Digestible crude protein intake; DNDFI = Digestible neutral detergent fiber intake; DADFI = Digestible acid detergent fiber intake; SEM = Standard error of means; SL = Significance level.*

Table 4. Nitrogen balance of Hararghe Highland sheep fed a basal diet of urea treated maize stover and supplemented with different levels of concentrate mix.

Parameter	NI (g/d)	Fecal N (g/d) lose	Urinary N (g/d) lose	Total N (g/d) lose	NR (g/d)	NR/NI
T 1	6.4[d]	3.5[b]	2.9	6.4[b]	-0.02[c]	-0.03[b]
T 2	11.2[c]	4.0[ab]	2.8	6.8[ab]	4.4[b]	0.4[a]
T 3	14.4[b]	4.1[ab]	3.2	7.4[ab]	7.0[ab]	0.5[a]
T 4	17.5[a]	5.2[a]	4.1	9.3[a]	8.2[a]	0.5[a]
SEM	0.29	0.32	0.64	0.63	0.63	0.06
SL	***	*	ns	*	**	**

*[a, b, c, d] Means within a column not bearing a similar superscript letter significantly differ; * = (P < 0.05); ** = (P < 0.01); *** = (P < 0.001); NI = Nitrogen intake; NR = Nitrogen retention; SEM = Standard error of means; SL = Significance level.*

4. Discussion

The strong pungent smell of the treated stover and no mould growth indicated the efficiency of the ensiling process. The brownish yellow color and soft texture shows the uniform application of urea solution to the stover. Zhang and Qiaojuan (2002) reported that properly ammoniated stover to be soft and fragile, brownish yellow or light brown in color, and with a light fragrance after excess ammonia has evaporated.

The CP value obtained in the current study for untreated maize stover was comparable with the values of 5.6 and 5.1% reported by Bareeba and McClure (1996) and Wambui *et al.* (2006), respectively. However, Zhang and Qiaojuan (2002) and Weldegebriel (2007) reported lower CP contents of 3.7 and 2.9%, respectively for untreated maize stover. The CP content of UTMS was comparable with that reported by previous studies (Maphane and Mutshewa, 1999; Wambui *et al.*, 2006; Zhang and Qiaojuan, 2002). However, Bareeba and McClure (1996) reported higher (14.2%) CP value in UTMS than the result obtained from the current study. Lower CP content of UTMS in the current study might be due to volatile nitrogen loss while ventilating the silo for a day in preparation for feeding to the animal. Other factors such as urea dose, moisture content of the stover, temperature and treatment time that are responsible for the effectiveness of urea treatment might have contributed to the difference in CP content of UTMS between the different experiments. Indeed, Sundstøl and Coxworth (1984) reported that two-thirds of the ammonia generated is usually evaporated to the environment in the course of urea treatment and until feeding to the animals.

The increase in CP content of the stover as a result of urea treatment was in accordance with previous similar studies (Getahun, 2006; Dawit, 2007). The reduction in NDF was in line with previous reports (Bareeba and McClure, 1996; Misra *et al.*, 2006; Weldegebreil, 2007) and it could be due to the dissolving effect of urea on the hemicellulose fraction and subsequent removal from cell wall constituents (Givens *et al.*, 1988). The slight increase of other cell wall components in UTMS is similar with the results reported by Smith *et al.* (1989) and Weldegebriel (2007). Lower CP and higher NDF, ADF and ADL contents in UTMS refusals than in the UTMS offer in all treatments indicates the selective feeding behavior of sheep on portions of feeds with better nutritive value. The concentrate mix used for the experiment contained more than 3 fold protein and lower NDF and other fibers than the basal feed (Table 1).

The lower UTMS DM intake in T4 could be attributed to the high intake of the supplement DM as a proportion of total DM intake. Topps (1997) indicated that if the level of supplementation is about 30-40% of the total DM intake of the animal, there is an increase in the intake of the basal diet. But, if it is more than this, it will have a reduction effect in the intake of the basal diet. Thus, the high level of concentrate mixture (36% of the total dry matter intake) in the present experiment seems to be too high and prevented maximum intake of the basal feed. The similar intake of UTMS of low and medium level of concentrate mix supplementation with the control sheep might have arisen from the more balanced intake of nutrients (CP and ME) that have led to a more efficient utilization of the fiber in the total diet. In the current study, substitution of UTMS with concentrate mix was lower in T3 and this might have resulted due to similar UTMS DM intake in T3 and T1. In line with this, Getahun (2006) also indicated that 200 and 300 g *Leucaena* supplementation resulted in a replacement of urea treated wheat straw at a ratio of 0.13 and 0.27, respectively.

Higher total DM intake (g kg^{-1} $W^{0.75}$) in T3 and T4 than in non-supplemented Sheep indicated that supplementation has a positive effect on daily total DM intake and it could be attributed to the ability of the medium and high level of supplementation to provide CP and energy for the cellulolytic microbes up on degradation in the rumen than the other treatments. In agreement with the present study, Bonsi *et al.* (1996) indicated that supplementation with protein sources improved total DM intake of sheep. The lowest CP intake as % DM in T1 was less than the minimum requirement for adequate microbial synthesis in the rumen (ARC, 1980). Greater values of CP intake as % DM in the supplemented treatments is attributed to concentrate mix supplementation which increases the supply of nitrogen to the rumen microbes, which can bring a positive effect by increasing microbial population and efficiency, thus enabling them to increase the rate of fermentation of the digesta, consequently feed intake increased (Van Soest, 1994). The lower digestibility of CP in sheep fed only UTMS compared to all the supplemented diet might be related to the lower CP content of the basal diet. Similarly, the intake of digestible CP in T1 was below 38 g day^{-1} which is recommended for growing sheep in the tropics (NRC, 1985). This indicates that concentrate feed which is rich in protein content promotes high microbial population (McDonald *et al.*, 2002) which facilitates rumen fermentation. The overall mean CP digestibility recorded in the present experiment were similar with the mean CP digestibility value (62.8%) reported by Bareeba and McClure (1996) for growing lambs fed UTMS supplemented with alfalfa at 20% of the total DM intake. But Dawit (2007) reported higher values of mean CP digestibility (74%) for Arsi Bale sheep fed a basal diet of urea treated barley straw supplemented with vetch and alfalfa hay. The variation in CP digestibility between the different studies might be due to the difference in the type, maturity and quality of the basal and supplement diet used in the particular experiment. Advanced plant maturity could also contribute to high proportion of cell wall, which has a negative role on digestibility and as a result part of the proteins might have been bound in lignocellulose and cannot be degraded by microbes (Cheeke, 1999) and the total protein in the diet may not be available to the animal.

The DM and OM digestibility in the current experiment were in a range reported by Smith *et al.* (1989) for UTMS. The mean NDF digestibility recorded in this particular study in general was slightly higher than 63.1% reported by Weldegebriel (2007) for urea treated maize stover supplemented with molasses and/or sweet potato vines. It was also higher when compared with the digestibility value of NDF (45.4%) reported by Bareeba and McClure (1996) for urea treated maize stover supplemented with 20% alfalfa. Fiber digestibility is known to influence voluntary intake (Van Soest, 1994). The better values of NDF and ADF digestibility in the current experiment may contribute to the better total DM intake.

The excretion of fecal nitrogen is more closely related to DM intake (Tegene *et al.*, 2001). Thus, the higher fecal nitrogen excretion in T4 could be due to the higher total DM, as a result the higher N intake. Moreover, it may indicate the inefficient utilization of nitrogen in T4, perhaps due to lack of sufficient energy substrate matching nitrogen available from supplementation. Getahun (2006) noted that sheep supplemented with Leucaena showed a higher nitrogen intake and nitrogen retention as the level of supplement increased. Negative nitrogen balance in sheep fed with sole UTMS is due to the low nitrogen content and poor digestibility of nitrogen in the diet. Weldegebriel (2007) also noted negative nitrogen balance when UTMS was fed to sheep without supplementation. Lower nitrogen supply to rumen microbes hinders animal performance (McDonald *et al.*, 2002). Similarly, groups fed with sole UTMS in the present experiment lost weight at the end of 90 days growth trial (Hirut *et al.*, 2011).

5. Conclusion

The result suggested that feeding sole urea treated maize stover cannot supply sufficient nitrogen for normal rumen microbial function, hence cannot support maintenance requirement of the growing animal. Supplementation of UTMS with 350 g concentrate mixture resulted in improved feed intake, digestibility, and positive nitrogen balance indicating an enhanced animal growth. Therefore, we recommend concentrate supplementation to UTMS basal diet for improved animal performance.

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