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RESEARCH ARTICLE

Feeding Value of Maize Stover Treated with Urea or Urea Molasses for Hararghe Highland Sheep

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Abstract:

Introduction:

The present trial was designed to investigate the effect of urea or urea molasses treatment of maize stover (MS) on feed intake, nutrient digestibility and profitability of sheep. Twenty yearling male lambs of Hararghe Highland breed at the initial body weight of 15.4 ± 0.57 (mean ± SD) kg.

Experiment:

The experimental animals were sorted into five blocks based on the initial weight and assigned randomly to four treatments; namely, untreated maize stover ad libitum (T1); urea treated maize stover (UTMS) ad libitum (T2); urea-molasses treated maize stover (UMTMS) ad libitum (T3); all of which were supplemented with 300g concentrate mix of wheat bran (WB) and noug seed cake (NSC) at the ratio of 2:1 and only urea-molasses treated maize stover ad libitum (T4). Feeding trial was carried out for ninety days and digestibility trial for seven days following 3 days of adaptation to the metabolic cage and carrying the fecal collection bag.

Results:

The result depicted that the content of crude protein (CP) is 5.9, 8, 10, 30.1, and 17.2%, for MS, UTMS, UMTMS, NSC and WB respectively. Total DM intake was higher for T2 (700.7 g/day) and T3 (770.9 g/day) than sheep fed T1 (538.28 g/day) and T4 (481.4 g/day). Apparent DM and CP digestibility were higher for T2 and T3 than T1 and T4. Hence, urea or urea-molasses treated maize stover with concentrate supplement had a good impact on feed intake and digestibility. Conversely, urea-molasses treated maize stover alone failed to improve the feeding value of MS. Therefore, MS treatment with urea and urea-molasses with energy and protein source of supplement has a desirable alternative in enhancing the utilization of maize stover.

Keywords: Urea, Urea molasses, Maize stover, (UTMS), (UMTMS), Wheat bran.

1. INTRODUCTION

In the tropics, low feeding value of roughage, crop residue and agro-industrial by-products are predominant feed resources for ruminant animal [1]. The livestock feed supply in Ethiopia is based on natural pasture, hay and crop residues. Likewise, sheep are kept mostly on these feed sources which are poor in quality, seasonally variable and insufficient [2, 3]. Residues from cereal crops have low crude protein gratified in the range of 3-13% of the dry matter [2]. Among crop residues, maize Stover is described by low protein, low digestibility and high fiber or lignin content [4].Its crude protein and neutral detergent fiber contents range from 2.5-6.3% and 73.8-89.1%, respectively [5, 6]. Moreover, it has about 60 g CP per kg dry matter and energy value of about 9 ME MJ/kg dry matter [7]. The crude

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protein content is below the threshold required for proper function of rumen microbes [8], whereas the neutral detergent fiber and acid detergent fiber contents are above the level that normally limits the feed intake. These prevent microbial digestion of cellulose and hemicelluloses and restrict microbial activity in the rumen. Thus, this might render the feed to be categorized as a low quality, since roughage with neutral detergent fiber content greater than 65% is classified as low-quality feed [9]. This implies that the utilization of this residue as animal feed would be low unless it is treated or supplemented with protein and energy-rich feeds [7].

Enhancing the nutritive value of poor quality feed resources is a major part of feeding management practice. Among the technologies available to improve the nutritive value of low quality of the crop residues, there is ammonia treatment and supplementation with agro-industrial by-products [10].

There are consistent responses in terms of the performance of animals to supplementation with concentrate, but the effects are more pronounced when the poor quality roughages are chemically treated [11]. 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 [12].

Therefore, the present experiment was designed to investigate the effects treated and untreated feed with and without concentrate mixer on the feed intake, nutrient digestibility and profitability of Hararghe Highland sheep.

2. MATERIALS AND METHODS

2.1. Study Area

The experiment was carried out at Haramaya university goat farm which is located at about 527km east of Addis Ababa. The area is situated 041°59'58" latitude and 09°24'10"longitudes.The altitude of the area is 2000m above the sea level. The district receives an average annual rainfall approximately 900mm and climatically, there are two ecological zones, of which 66.5% is midland and 33.5% is lowland. The district has about 63,723 cattle, 13,612 sheep, 20,350 goats, 15, 975 donkeys, 530 camels and 42,035 chickens [14].

2.1.1. Animals and Their Management

The study was conducted on twenty male Hararghe Highland lambs with the initial weight of 15. 4 ± 0.57 kg (Mean ± SD) were purchased from Chelenko and kulubi local market. The age of the experimental animals was determined by their dentition and from the owner information. The animals were ear tagged and kept in quarantine for three weeks to adapt the environment and to determine the health status. During this time, the animals were treated for internal and external parasites and vaccinated against common diseases before the actual commencement of the experiment.

2.1.2. Preparation of Experimental Feed

Maize stover was collected after grain harvest from Haramaya University. The collected stover was chopped into 3-5 cm cuts using a tractor mounted chopper. Four pits were prepared; 2 pits for urea treatment and 2 pits for urea or/and molasses mixture treatment, each pit of 6m3 size. The wall of the pits was lined with the plastic sheet material.

Four kilograms of urea was used for 100 liters of water to make a solution and urea-water solution was used to treat 100 kg of maize stover based on the dry matter [15]. To prepare urea-molasses treated maize stover, 4kg of urea was added to 100 liters of water and blended very well until the urea disappeared from the solution. Then 10 liter of molasses was added into urea solution being excited until the molasses and the urea solution was mixed up [16]. This solution was uniformly distributed and thoroughly mixed with chopped stover. The treated stover was well compacted by using foot before adding the next layer and finally, the top of the pit was covered by using a plastic sheet and placing soil and stone on the top to make it airtight. It was then remained for three weeks as per the recommendations [17]. The pit was opened from one part and enough amount of treated maize stover was taken daily and aerated for overnight before feeding to the experimental sheep. Nouge seed cake was purchased from Adiss Abeba oil extraction factory, while wheat bran was purchased from Dire Dawa flour mill factory. The concentrate mixture 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 [17].

2.1.3. Experimental Design and Treatments

The experimental period consisted of ninety days of growth trial and 7 days of actual digestibility trials. There were four treatments in this experiment. Treatments were: untreated maize stover with 300g concentrate mix(CM), 4% urea treated maize stover with 300g CM, 4% urea- 10 lit/100kg molasses treated maize stover with 300gCM and 4% urea-10 lit/100kg molasses treated maize stover alone. The amount of urea and molasses used in the present study was decided based on the in sacco dry matter degradability and in vitro organic matter digestibility results obtained from different scholars who used different levels of urea and molasses treatment of maize stover. Randomized complete block design (RCBD) was used in this study. After the completion of three week quarantine period, the sheep were ranked in the order of initial weight and blocked based on the initial body weight into five blocks of four animals each. Each experimental sheep within each block was allocated randomly to one of the 4 dietary treatments. Animals were housed in separate pens, with feed troughs and drinker.

2.1.4. Feed Intake

Quantities of feed provided and refused were recorded daily until the end of the experiment to determine daily intake. Refusals were collected and weighed daily before the morning feeding. Samples from the offer and refusals of basal diet and supplement feeds from each treatment were collected and at the end of the experiment, pooled per animal and sub-sampled for chemical analysis.

2.1.5. Digestibility Trial

Towards the end of the feeding trial, experimental animals carrying the fecal collection bag were kept in individual metabolic cages equipped with feeding and watering troughs. After 3 days of the harness and metabolic cages adaptation period, daily total feces excretion per animal was collected for seven consecutive days. Twenty percent of voided feces were sampled pooled for each animal over the collection period and stored in a deep freezer at –20°C. Feeds offered and refused were sampled daily for the determination of DM and N.

2.1.6. Body Weight and Average Daily Gain

The initial body weights of experimental sheep were taken at the beginning of the growth experiment and at the interval of every ten days throughout the experiment. Average daily gain (ADG) was calculated as the difference between the final and initial BW divided by the number of feeding days. The feed conversion efficiency (FCE) was calculated as the proportion of ADG to daily DM intake of experimental animals.

2.1.7. Chemical Analysis

Feed offered, refused and fecal samples were determined in a forced-draught oven set at 60°C for 48 h, ground to pass 1 mm screen using a Willey mill and stored for pending chemical analysis. Dry matter (DM), ash and nitrogen (N) were analyzed using the method adopted in a study [18]. The crude protein (CP) content was determined by multiplying N content by a factor of 6.25. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed by the procedure used in a study [19]. Hemicellulose and cellulose contents were determined as a difference between neutral detergent fiber and acid detergent fiber and acid detergent fiber and acid detergent lignin, respectively.

2.2. Partial Budget Analysis

The partial budget analysis was performed to determine the profitability of the experimental feeding by considering the main component cost. Variable cost partial budget was determined as the difference between the feed cost and selling price of sheep [20]. Before slaughtering, three experienced animal dealers estimated the market charge of each experimental animal. Net income (NI) was calculated as the amount of money left when total variable costs (TVC) were subtracted from the total returns (TR)

$$NI=TR-TVC,$$

$$\Delta NI= \Delta TR- \Delta TV,$$

$$MRR= \frac{\mathbf{NI}}{\mathbf{TVC}}$$

2.3. Statistical Analysis

One-way analysis of Variance (ANOVA) was carried out using the General linear model (GLM) procedure in Statistical Analysis System (SAS) [21] to determine the significant (P<0.05) effect of treatment. Least square means significantly ($P<0.05$), different treatments were compared using least significance difference (LSD) test.

The model for data analysis was: Yij = m + ti + bj + Îij, where, Yij = is the response variable, m = the overall mean, ti = the treatment effect, bj = the block effect, and Îij = is the random error.

3. RESULTS AND DISCUSSION

3.1. Chemical Composition of Experimental Feeds

Chemical compositions of the experimental diets and concentrate mix used in this study are shown in Table **1** The crude protein content (5.9%) of untreated maize stover (UMS) was higher than the 3.1-3.8% reported by other authors [22 - 24] but lower than 6.3-7.4% [25, 26]. On the other hand, comparable crude protein contents (5.6-6%) have been reported in the references [6, 27, 28]. The neutral detergent fiber content of untreated maize stover was higher than the value of 73.8 and 76% reported in other studies [22, 23]. However, it was lower than 86.6 and 89.1% reported in other studies [6, 29]. The acid detergent fiber content was comparable with 53.1-53.8% reported in a study [24, 30], but higher than 43.9- 49.3% reported by other authors [6, 23, 31]. Urea treated maize stover (UTMS) had 8.6% crude protein, which was comparable with 8.7 and 8.3% reported in some studies [32, 33], respectively. Lower crude protein content (4.4%) in urea treated maize stover was reported [34]. The crude protein content of urea treated maize stover was lower than the 14.9 and 14.2% reported in references [35, 36], respectively. The lower crude protein content of urea treated maize stover in the current study might be due to the difference in urea dose, the moisture content of the stover, temperature and treatment time, which are responsible for the effectiveness of urea treatment. Likewise [11], a study reported that two-thirds of the ammonia generated is usually evaporated (volatile nitrogen loss) to the environment in the course of urea treatment and until feeding to the animals, which is also another factor responsible for the lower crude protein content of the treated stover in the present finding.

Table 1. Chemical composition of experimental feed offered.

Item	Chemical composition (DM %, other nutrient as % DM)					
	DM	OM	CP	NDF	ADF	ADL
Feeds offered						
UMS	90.8	93.3	5.9	85.5	54.7	5.2
UTMS	71.7	82.5	8.6	80.4	52.2	4.1
UMTMS	63.7	83.0	10.0	80.0	50.1	4.0
WB	90.3	84.9	17.2	47.8	16.4	3.0
NSC	92.0	83.7	30.2	32.9	23.0	6.3

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; UTMS= urea-treated maize stover; UMTMS = urea-molasses treated maize stover;

Urea-treatment increased CP content of the stover by about 48.8% which is in accordance with the previous studies [37, 38] with the improved content of crude protein as a result of urea treatment of crop residues. Similarly, urea treatment decreased neutral detergent fiber content in this study which was almost the same with those found by the previous reports [13, 34, 39]. The reduction in neutral detergent fiber is attributed to the dissolving effect of urea on the hemicellulose fraction and subsequent removal from cell wall constituents [40]. The ADF and ADL contents also slightly decreased with urea treatment. In this study, NDF concentration of the stover was more affected by urea treatment than ADF and ADL, probably because hemicellulose is most sensitive to delignification. This result is in agreement with that obtained by reference [38] but in disagreement with reference [13] reporting the increased concentration of ADF and ADL in urea treated barley and teff straw. Urea-Molasses treatment increased the crude protein content of the stover by about 69.5%. Urea-molasses treated maize stover (UMTMS) had 10% crude protein, which was lower than 15.4% reported in a study [40]. The neutral detergent fiber content of urea-molasses treated maize stover found in this study was 76.1% which was higher than those reported by others [40]. The crude protein content of noug seed cake (NSC) in the current finding was comparable to 30- 32% noted by different studies [41, 42]. However, lower [43] and higher [44, 45] values than that noted in the current study were reported previously. The range of values being 15-23% of crude protein for wheat bran (WB) has been reported in earlier studies [46] and the result obtained in the current study was within this range.

3.2. Feed Intake

The daily mean dry matter and nutrient intake of the sheep during the 90 days of feeding trial are presented in Table **2**. The daily basal dry matter intake was significantly higher (p<0. 001) for sheep in T2, T3 and T4 than in T1, where there was no significant difference between T2, T3 and T4. This indicates that treating maize stover with urea or urea molasses mixture improved intake of the basal diet.

Table 2. Feed intake of hararghe highland sheep.

Parameter	Treatment				SEM	SL
	T1	T2	T3	T4		
Basal feed DM intake (g/d)	238.3[b]	400.7[a]	470.9[a]	481.4[a]	25.72	***
Concentrate DM intake(g/d)	300.0	300.0	300.0	-	-	-
Total DM intake (g/d)	538.3[b]	700.7[a]	770.9[a]	481.4[b]	25.72	***
DM intake (% BW)	3.2[b]	3.9[a]	4.2[a]	2.9[b]	0.13	***
DM intake (g/kg $W^{0.75}$)	65.3[b]	79.4[a]	86.5[a]	58.5[b]	2.62	**
OM intake (g/d)	455.9[b]	580.0[a]	646.8[a]	396.2[b]	22.29	***
ME (MJ/d)	4.9[a]	5.8[a]	6.1[a]	3.2[b]	0.25	***
CP intake (g/d)	86.6[c]	103.4[b]	120.6[a]	56.9[d]	2.55	***
NDF intake (g/d)	323.3[c]	441.1[ab]	504.3[a]	377.5[bc]	21.07	**
ADF intake (g/d)	177.0[b]	251.1[a]	277.1[a]	225.7[ab]	14.64	*

[a,b,c] means with different superscripts in a row are significantly different. *= (P<0.05); **= (P<0.01); ***= (P<0.001); ADF= acid detergent fiber; BW= body weight; CM= concentrate mix (67 wheat bran:33 noug seed cake); CP= crude protein; DM= dry matter; EME=estimated metabolisable energy; NDF= neutral detergent fiber; OM= organic matter; SEM= standard error of mean; SL=significant level; T1=untreated maize stover fed *ad libitum* +300 g DM CM/d; T2= Urea treated maize stover *ad libitum* + 300 g DM CM/d; T3= urea-molasses treated maize stover *ad libitum* +300 g DM CM/d; T4= sole urea-molasses treated maize stover *ad libitum*.

Untreated maize stover fed ad libitum +300 g DM CM/d; T2= Urea treated maize stover ad libitum + 300 g DM CM/d; T3= urea-molasses treated maize stover ad libitum +300 g DM CM/d; T4= sole urea-molasses treated maize stover ad libitum. Total intake of dry matter was lower in animals fed with sole Urea-molasses treated maize stover (T4) and the group fed untreated maize stover basal diet and supplemented with concentrate mix (T1) than that fed treated stover and supplemented with a similar amount of concentrate mix (T2 and T3). Although total dry matter intake was higher in magnitude by about 15% in T3 compared to T2, the difference did not reach the level of statistical significance (P<0.01), but this difference could be indicative of the advantage of treating stover with the combination of urea-molasses than with urea alone. The total dry matter intake of T1 and T4 was lower than 567 g/day reported for urea treated wheat straw in sheep [38]. Feeding of sole urea-molasses treated stover to sheep improved basal dry matter consumption by about 51% compared with dry matter intake of untreated stover. In accordance with the present finding, the increased dry matter intake (by 13%) was observed in sheep when fed with urea treated wheat straw [47] and sorghum stover [48]. Likewise, some studies pointed out that urea treatment [6, 38] and supplementation of crop-residues based diet with molasses-urea mixture [49] improved the intake of feed by cattle and sheep. The total dry matter intake across the treatments (481.4-770.9 g/day) observed in the present study was comparable to the value of 463.9-826.2 g/day reported in reference [50] in sheep fed urea treated barley straw plus concentrate mixture. The total dry matter intake per unit metabolic body weight of T2 and T3 sheep was significantly higher (p<0.05) as compared to T1 and T4 animals. The value for T4 in the current study is comparable to 54.9 g/w0.75 reported by a study [45] in sheep fed urea treated maize cob, but the result is lower than the value of 91 .9 g/w0.75 reported by a study [6] in Hararghe highland sheep fed only urea treated maize stover. Total intake per metabolic body weight for T2 in the current study is comparable with total dry matter intake per unit metabolic body weight reported for Menz (75.5 g/kg) and Horro (75.5 g/kg) sheep, when they were supplemented with 300 g/day concentrate feed [51]. Moreover, the results of the daily feed intake per unit metabolic body weight of the current study were within the range of 58-86 g dry matter /kgW0.75 [52] for Ethiopian sheep fed a basal diet of teff straw. The variability in dry matter and nutrient intakes reported in the literature for sheep is presumably attributed to variation in the nutrient composition of the feed used as a basal diet, supplementation strategy and differences between animals in terms of age and other factors. The higher ME intake in T3, T2 and T1 groups as compared to T4 as suggested improved energy availability due to the supplement used. The dry matter intake of sheep as a percent of body weight was significantly higher (P<0.05) for T3 and T2 compared to T1 and T4. The result of the current study agreed with 2-4% body weight dry matter intake suggested by a study [53] for tropical sheep. It is also comparable to the values of 3.3 - 4% body weight reported by reference [54] for sheep fed urea treated Finger Millet straw basal diets. Fed sole urea- molasses treated stover (T4) and untreated maize stover supplemented with 300 g/day concentrate mix (T1) consumed lower total dry matter compared with those in T2 and T3. According to reference [7], fibrous feeds have to spend a longer time in the digestive tract for their digestible components to be extracted, since rumination and fermentation are relatively slow processes, which bring about the slow passage rate of digesta. The low basal and total dry matter intake in T1 groups compared to the other supplemented group is also attributable to the tendency of the animals to substitute the concentrate for the basal diet. The total neutral detergent fiber intake of sheep in T3 was higher ($p<0.001$) than sheep in T1 and T4 but not significantly different from those in T2. Similarly, total acid detergent fiber intake of T1 sheep was significantly lower ($p<0.05$) than sheep in T2 and T3, but comparable with the group in T4. Variation in the fiber intake is in accordance with the total basal dry matter intake.

Therefore, the result of the current study shows that treating low quality feeds with urea and urea-molasses can increase the total DM and nutrient intake of sheep.

3.3. Apparent Digestibility of Dry Matter and Nutrients

The dry matter and organic matter digestibility were significantly higher (P<0. 001) for sheep fed T2 and T3 than T1 and T4 (Table **3**).

Table 3. Nutrient digestibility coefficients in hararghe highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mixture.

Digestibility Coefficient	Treatment				SEM	SL
	T1	T2	T3	T4		
DM	0.61^{b}	0.67^{a}	0.68^{a}	0.59^{b}	0.028	**
OM	0.62^{b}	0.70^{a}	0.71^{a}	0.62^{b}	0.013	**
CP	0.65^{b}	0.71^{ab}	0.76^{a}	0.54^{c}	0.016	***
NDF	0.47^{c}	0.57^{b}	0.64^{ab}	0.67^{a}	0.022	**
ADF	0.47^{b}	0.61^{ab}	0.61^{ab}	0.68^{a}	0.029	*

^{a,b,c,} means with different superscripts in a row significantly differ. *= (P<0.05); **= (P<0.01); ***= (P<0.001); ADF= acid detergent fiber; CP= crude protein; DM= dry matter; NDF= neutral detergent fiber; ns=non-significant; OM= organic matter; SEM= standard error of mean; SL=significant level; T1=untreated maize stover +300 g DM CM/d; T2= Urea treated maize stover + 300 g DM CM/d; T3= urea-molasses treated maize stover +300 g DM CM/d; T4= only urea-molasses treated maize stover.

The high digestibility value observed for T2 and T3 could be attributed to the high CP contents of the diets and the high quality of the supplement diet which might have improved nutrient supply to ruminal microbes and consequently dry matter and nutrient digestibility.

A significant difference was not detected in dry matter digestibility between sheep fed T1 and T4 diets, showing that urea molasses treatment of stover enhanced digestibility as much as feeding untreated stover and supplementing with concentrate as in the present study. The reason could be that such treatment has supplied both protein (from urea) and energy (from molasses) to the microbial population, hence enhanced the digestibility of the fibrous straw. The crude protein digestibility was in the order of T3≥T2≥T1>T4.

This appears to be consistent with differences in the level of crude protein and/ or energy from the supplement and/or urea molasses treatment among the treatments. This result was supported by a study [55] reporting improved N digestibility in goat by feeding high protein diet as compared with a low protein diet. Comparable results to this were also reported by reference [6]. Digestibility of NDF was the lowest for T1, while ADF digestibility differed only between T1 and T4, being lower for the former [44]. A study also reported better digestibility of DM, OM, CP, NDF and ADF when sheep were fed finger millet straw basal diet supplemented with different protein sources.

3.4. Body Weight Change

Final body weight of sheep fed T3 and T2 was greater (P<0.001) than that of T1 and T4 (Table **4**). The average daily body weight gain (ADG) was significantly (P<0.001) affected by treatments and it was higher for T3 and T2 than T4 and T1. Feed conversion efficiency was higher (P<0.001) for T3, T2 and T1 compared to T4. Differences observed in final body weight and consequently in ADG appear to be consistent with differences in nutrient intake and nutrient digestibility observed among treatments.

Table 4. Growth parameters and feed conversion efficiency of Hararghe highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mixture.

Parameters	Treatment				SEM	p-value
	T1	T2	T3	T4		
Initial BW (kg)	15.0	15.5	15.4	15.7	0.185	0 .2692
Final BW (kg)	19.0^{b}	21.2^{a}	21.6^{a}	17.6^{b}	0.361	<0.0001
ADG (g/day)	45.1^{b}	62.8^{a}	69.1^{a}	20.7^{c}	2.697	<0.0001
FCE (g ADG/g DMI)	0.084^{a}	0.089^{a}	0.089^{a}	0.042^{b}	0.0002	<0.0001

^{a,b} means within a row not bearing a similar superscript letter significantly differ. BW= body weight; DMI= dry matter intake; DM= dry matter; ADG= average daily gain; FCE= Feed conversion efficiency; SEM= standard error of means; T1=maize stover +300 g DM CM/d; T2= Urea treated maize stover + 300 g DM CM/d; T3= urea-molasses treated maize stover +300 g DM CM/d; T4= only urea-molasses treated maize stover.

Sheep fed sole urea-molasses treated stover (T4) exhibited the lowest ADG. Nevertheless, the positive gain in T4 indicated that stover treated with a combination of urea and molasses improved the content of nutrients such as CP and energy in excess of the maintenance requirements of the animals. Van Soest demonstrated that body weight gain is impaired if the level of protein in a given diet is below 8% [9]. Since the CP content of urea-molasses treated maize stover in the current study exceeded the minimum limit, the observed positive ADG of sheep is expected. In previous studies, feeding sole urea treated barley straw [56] to Awassi sheep and urea treated maize stover to Hararghe highland sheep [7] did not fulfill the maintenance requirement, hence resulted in body weight loss. Thus, the positive weight gain of sheep fed with sole urea-molasses treated maize stover showed a considerable importance of this method of stover treatment in increasing the nutritive values of poor quality roughages. Thus, it may be used as a feeding strategy during the dry season to alleviate weight loses as a result of the poor nutritional quality of the available straw.

The ADG obtained in T2 and T3 was in line with the value (63.8 g/d) reported by Testaye in sheep fed teff straw basal diet and supplemented with 350 g concentrate mixture [57]. The growth rate obtained for sheep fed urea-molasses treated MS with supplementation in the current study was higher than the ADG values of 31.3, 47.2 and 54.4 g/day reported for Washera sheep fed urea treated rice straw supplemented with 300 g/day of noug seed cake and wheat bran [58], for Arsi-Bale lambs consumed urea treated wheat straw supplemented with 300 g/day of *Leucaena leucocephala* foliage hay [40], and Hararghe highland sheep fed a basal diet of urea treated maize stover supplemented with 250 g/day of concentrate mix [7].

The body weight gain of T1, T2 and T4 in the present study was lower than the daily body weight gain (67.8 - 83 g/day) reported by [45] for Hararghe highland sheep fed natural pasture grass hay basal diet and supplemented with mixtures of onion leaves, noug seed cake, and wheat bran at different proportions. On the other hand, lower ADG (less than 21 g/d) was reported for Blackhead Somali sheep fed with natural grass hay consisting between 9.2 and 9.9% [59]. Awet and soloman reported that supplementation of wheat bran with urea-treated teff straw improved the efficiency of nutrient utilization of intact and castrated Afar sheep at 250 g and 350 g supplementation levels, which is in accordance with improved nutrient utilization and growth observed in groups fed with basal diet of treated maize stover and supplemented with concentrate at a rate of 300 g/day [60]. In general, in agreement with the present finding, previous studies reported increased ADG with an increase in nutrient intake such as CP [39].

Feed conversion efficiency (FCE) was higher ($P<0.001$) in T1, T2 and T3 as compared to T4. The improved FCE seemed to be related to higher nutrient concentration in these treatment groups and the consequent increase in BW gain and better feed conversion efficiency. High protein and energy levels in the diet improved ADG and FCE of animals [60]. Feed conversion efficiency of sheep in T1, T2 and T3 was higher than the result of 0.028-0.052 obtained by Taferi *et al.* for sheep fed with urea-treated sesame straw and that of 0.04-0.07 obtained by Hirut *et al*. for Hararghe highland sheep fed with a basal diet of urea treated maize stover [7, 61]. But it is comparable to the result of 0.08 obtained by Melese *et al*. for Washera sheep fed with urea-treated finger millet straw as basal diet supplemented with noug seed cake, wheat bran and their mixtures [62]. The difference observed between the treatment groups in FCE might be associated with the efficiency of utilization of different amounts of feed DM and nutrients, such as CP and energy for a unit of body weight gain.

3.5. Partial Budget Analysis

The partial budget analysis was used to calculate the potential profitability of the experimental feed (Table **5**). The results of this study express that the highest total return (370.7 Ethiopian birr (ETB)/sheep) and (469.88 Ethiopian birr (ETB)/sheep) was obtained from sheep consumed urea and urea-molasses treated maize stover supplemented with concentrate mix (T2) and (T3). The least total return (188.13 and 147.98 Ethiopian birr (ETB)/sheep) was obtained from T1 and T2 sheep fed untreated maize stover with concentrate mix and sole urea-molasses treated diet, respectively.

Table 5. Partial budget analysis for hararghe highland sheep fed untreated, urea or urea-molasses treated maize stover basal diet supplemented with concentrate mix.

Variables	T1	T2	T3	T4
Number of sheep	5	5	5	5
The purchase price of sheep (Birr/head)	410	410	410	410
Total basal diet intake (kg/head)	21.45	36.06	42.39	43.32
Price basal diet intake(Birr / kg) stover + urea+ molasses	0.6	0.84	0.97	0.97
Total cost of basal diet (Birr/head)	12.87	30.3	41.12	42.02
Total concentrate mix intake (kg/head)	27	27	27	-
Price concentrate mix intake (Birr / kg)	7	7	7	
Total cost of concentrate (Birr/head)	189	189	189	-
Total feed cost (Birr/head)	201.87	219.3	230.12	42.02
Total VC (Birr/head)	611.87	629.3	640.12	452.02
Selling price of sheep (Birr/head)	800	1000	1110	600
Net Income (Birr/head)	188.13	370.7	469.88	147.98
MRR	0.31	0.6	0.73	0.33

CM= concentrate mix; DM= dry matter; MRR= marginal rate of return; ΔNR= change in net return; ΔTVC= change in total variable cost; T1=maize stover +300 g DM CM/d; T2= Urea treated maize stover + 300 g DM CM/d; T3= urea-molasses treated maize stover +300 g DM CM/d; T4= only urea-molasses treated maize stover.

The difference in the NR among the treatments was due to the difference in the selling price of the animals in each treatment. The higher profit obtained in T2 and T3 is due to better feed conversion efficiency and body weight gain of the sheep in this treatment, which resulted in estimated higher selling price. The marginal rate of return implied that each additional unit of 1 Birr/ sheep cost increment resulted in 1 Birr and additional 0.6 and 0.73 Birr profit for T2 and T3. Therefore, the results of this study indicated that treated stover with 300 g dry matter/day/head concentrate mixture (67% wheat bran and 33% noug seedcake) is potentially profitable and economically beneficial than the feeding of growing Hararghe Highland sheep on T1 and T4 diets under the conditions of this experiment.

CONCLUSION

The present finding supported that urea or urea -molasses treated maize stover with concentrate supplement had a positive impact on intake and digestibility of hararghe highland sheep.

Conversely, urea-molasses treated maize stover alone does not enhance the feeding value of maize stover to sheep.

Therefore, the current study indicated that maize stover treatment with urea and urea-molasses with concentrate mix of energy and protein source is a considerable option for improving the utilization of maize stover.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable

HUMAN AND ANIMAL RIGHTS

The reported experiments are in accordance with the standards of The US Public Health Service's “Policy on Humane Care and Use of Laboratory Animals,” and “Guide for the Care and Use of Laboratory Animals.”

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The author report no conflicts of interest and responsible for the content and writing of this article.

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