Advances in Biological Research 11 (1): 41-50, 2017
ISSN 1992-0067

DOI: 10.5829/idosi.abr.2017.41.50

In sacco Dry Matter Degradability of Urea and Effective Microorganism (EM) Treated Sorghum (*Sorghum biclor* L. Moench) Stover

[1]Daniel Taddesse, [2]Mengistu Urge, [3]Gebeyehu Goshu and [4]Zemelak Goraga

[1]Department of Dairy and Meat Technology,
Haramaya University College of Agro-industry and Land Resource, Chiro, P.O. Box: 226, Ethiopia
[2]Haramaya University, School of Animal & Range Sciences, Dire Dewa, P.O. Box: 138, Ethiopia
[3]College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu, P.O. Box: 34, Ethiopia
[4]Ethiopian Institute of Agricultural Research (EIAR), Bishoftu, P.O. Box: 32, Ethiopia

Abstract: A study was conducted to evaluate the effect of urea and effective microorganisms (EM) on chemical composition and *in sacco* dry matter degradability of sorghum (*Sorghum biclor* L. Moench) stover. The treatments of the experiment included Untreated control (T1), Effective microorganism (EM) (T2), Urea (T3) and EM plus Urea treated sorghum stover (T4) and all were ensiled for 21 days. Chemical analysis and *in sacco* dry matter degradability (DMD) of the ensiled sorghum stover were conducted. The organic matter (OM) and neutral detergent fiber (NDF) of all treatment types decreased (90.80, 91.7 and 91.6%) and (73.83, 72.23 and 75.00%), respectively but the crude protein (CP) (5.33, 12.97 and 8.73%) and mineral matter (MM) (9.17, 8.30 and 8.33% for T2, T3 and T4, respectively) respectively increased as compared to the control (T1). The *in sacco* DM degradability parameters increased by the additives treatment as compared to T1. Urea treatment showed the highest soluble (29.85%), insoluble but potentially soluble (40.10%), potential degradable (69.69%) and effective degradability (51.34%) fractions than the other treatments. The DM degradation increased with increasing the incubation time across all treatments. The rate of degradation decreased in the order of T3 > T4 > T2 > T1. All the treatments had improved the nutritive value of the sorghum stover. However, the urea treatment was more effective in improving the chemical composition and degradability of sorghum stover. Therefore, we recommend treatment of sorghum stover with urea for dry season feeding of cattle.

Key words: Dry Matter · Effective Microorganisms · In Sacco Degradation · Sorghum Stover · Urea

INTRODUCTION

The major source of feed in Ethiopia is cereal straw/stover comprising about 48.2 % of the feed available. Pasture, aftermath, fallow land and wood land grazing comprise 17.2, 13.4, 10.8 and 2.5 %, respectively. About 7.9 % the remaining available feed are contributed by other feeds [1]. The amount of crop residues produced from cereal straws (barely, wheat, tef, oats, rice and maize) and stovers (millet, sorghum and pulse crops) per annum dry matter is 29,155,077 ton dry matter (tDM) and it has the highest contribution to the total feed supply in Ethiopia. As a result, most cereal straws and stovers have lower nutritive value. Therefore, poor nutrition and feed shortages are main causes for the poor performance of the livestock sector in Ethiopia [1]. Like most parts in Ethiopia, in West Hararghe feed shortage, livestock diseases, market, land and water related problems are persistent challenges of cattle production [2]. The major livestock feed sources in this area are crop residues, natural pasture hay and commercially available industrial by products [3,4]. Among the crop residues, maize and sorghum stover are predominantly found in West Hararghe [2].

In West Hararghe, along with the crop production farmers give more emphasis for livestock feed. They cultivate sorghum and maize with high seeding rate in order to have high biomass for thinning and feeding to cattle. Thinned sorghum and maize seedlings and defoliated leaves after maturity, sweet potato leaves,

Corresponding Author: Daniel Taddesse, Departement of Dairy and Meat Technology, Haramaya University College of Agro-Industry and Land Resource, Chiro, Ethiopia.

haricot bean leaves and weeds are common during the wet season and sorghum and maize stover is stored after harvest for dry season feeding. Cut and carry system of feeding was a common practice both in the wet and dry season of the year. Feed shortage becomes critical during the dry season (March to June). Thus, the dry season feeding depended mainly on maize and sorghum stover. Most often fattening cattle are tied up and fed near the crop land or at backyard [5,6]. Although crop residues are generally poor in their nutritional value but they are the available one to feed the livestock in the high to middle altitude areas, particularly during the dry season when the biomass of the natural grazing lands is very minimal [1,7]. [8] noted that improvement of the nutritive value of dry roughages could be estimated by using physical, chemical or biological treatments. Elnazeir and Suaad [9] indicated that such improvement can be effected by correct harvesting and storage, supplementation and physical and chemical treatment. Improvement in nutritive value was estimated by chemical analysis, which was useful to measure the components of crop residues. However, both digestibility and the degradability were used to measure the overall nutritive values of *in sacco* digestibility [10].

In Ethiopia, several studies were conducted for improving crop residues through chemical treatments of maize stover and other cereal straws with urea [11- 15], but only few studies assessed to study the effect of treating of sorghum stover with urea [16] or treating wheat, barley and oats with effective microorganisms (EM) [17] on their nutritive value. Low nutritive quality, lack of chemical and biological treatment and dependence on stover for cattle feeding specially during the dry season in the area draws the attention of this research intervention. Therefore, the objective of this study was to evaluate the effect of urea and effective microorganisms (EM) treatment on chemical composition and *in sacco* dry matter degradability of sorghum stover.

MATERIALS AND METHODS

Description of Study Areas: The chemical composition analysis was carried out in National Veterinary Institute (NVI) laboratory, Bishoftu. The detergent and *in sacco* rumen degradation study was carried at Holeta Agricultural Research Center (HARC), Animal Nutrition Laboratory Whereas, the crop residue sample was collected from West Hararghe districts. These districts were selected based on the abundance of crop residues and fattening practices in consultation with WHZLDHO [6].

Sample Collection, Preparation and Treatment: The sorghum stover was the harvested during December 2016. The standing stover was collected from the fields immediately after harvesting of the seed head to avoid leaf loss [18] and transported to the experiment site. The whole stover, with all the leaf, leaf sheath and the stalk was chopped manually at approximately 3 cm size using locally made axe (*Softu*) and exposed to sun for five days and with frequent manual turning to keep uniformity in drying. Finally the dried sample was measured with a calibrated hanging balance and put in plastic bags per treatment.

An adequate quantity of plastic bottle packed activated EM (EM-2) and molasses was purchased from Weljeji PLC found in Bishoftu town. The EM consists of mixed cultures of beneficial and naturally-occurring microorganisms that can be applied as inoculants to increase the microbial diversity of soils and plant [19]. The EM solution was prepared by mixing one liter of EM with one kg of molasses and 18 liters of chlorine free water in the ratio of 1:1:18. The molasses serves as energy for further activation and multiplication of the microorganisms and the water as a carrier to uniformly distribute the solution over the chopped sorghum stover according to Kassu *et al*. [20].

The chopped sorghum stover was treated with urea-water mix at the ratio of 20:1:20 (Water: urea: stover). Fertilizer grade urea (46% N) was purchased from the district agricultural and rural development office. Accordingly, 0.75 kg of u rea mixed with 15 liters of water was used to treat 15 kg of sorghum stover. Accordingly, three replicates of 5 kg chopped stover each was sprinkled separately with 5 liters of the urea-water mix solution to have 5 % urea treated stover [10, 18, 21].

The third treatment was the combination of the two additives into one solution. The EM-Urea solution was prepared by combining 2.25 liters of EM with 2.5 liters of urea solution in order to treat three replicates of each five kilogram chopped sorghum stover.

The solution was poured accordingly on each of the 5 kg of dried sorghum stover stored for each type of treatment using a plastic can while turning and rubbing it manually to achieve uniform wetting. The three replicates of each treatment were separately put in a transparent plastic bag by layer and pressed by hand so as to avoid air space [18,22]. The treated and untreated stover in three replication was placed for 21 days in a clean storage room that could facilitate the anaerobic fermentation.

Table 1: Physical description of the study districts

Study Districts	Geographical Co-ordinates	Annual Temperature (°C)	Altitude. (m.a.s.l)	Annual Rain Fall (mm.)
Chiro	34°18'43" – 43°04' 33" E longitude and 10° 09' 24"- 30° 18'43'' N latitude	27-38.5	1500-2800	900-1800
Gemechis	40° 49' 46'- 41° 11' 26'' E longitude and 8° 40' 25''- 9° 3' 42'' N latitude	15-30	1300-2400	850
Habro	7°55'–9°33'N latitude and 40°01' and 41°39'E longitude	20-22.5	1200-2590	650-1050
Tullo	9° 1' 45''- 9° 18' 48'' N and 40° 58' 24'' 41° 16' 49'' E longitude	23-32	1500-2797	800

m.a.s.l = meter above sea level

Chemical Analysis: The untreated and treated sorghum stover silage were analyzed for dry matter (DM), crude protein (CP), Ash and ether extract (EE) according to AOAC [23]. The detergent analysis was conducted at Holeta Agricultural Research Center (HARC). Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) were analyzed according to Van Soest and Robertson [24]. The dry matter content of the treated and untreated samples was determined by drying oven at 105°C for 24 hours. Whereas, the organic matter (OM) was determined by subtracting the ash value from 100%. The nitrogen (N) content was analyzed according to the procedure of AOAC [23]. Crude protein (CP) was determined by multiplying N by a factor of 6.25. Ash content was determined by igniting the sample at 600°C for 2 hours. The ether extract was determined by heating the dry sample with petroleum ether for 8 hours [24] and the extracted material for fiber estimation.

***In sacco* DM Degradability Procedure:** The sorghum stover silage sample of each treatment were ground using Wiley mill to pass 2 mm screen. The *in sacco* DM degradability was determined by incubating about 3 g of sample in a nylon bag (40 to 60 μ (Micron) pore size and 4.5 x 18 cm dimension) in three rumen fistulated F_1 Boran Fresian breed steer at Holeta Agricultural Research Center. The animals were fed supplement diet of 2 kg concentrate per head per day (50% wheat bran, 1% salt and 49% Noug seed cake) per day and grass hay *ad libitum*. The samples were incubated for 0, 6, 12, 24, 48, 72 and 96 hours. For each sample, two bags were used for each incubation time and repeated in three fistulated animals. The bags were inserted sequentially and removed at the same time [25]. Upon removal from the rumen, bags were washed in running tap water while rubbing gently between thumb and fingers until the water becomes clear. Zero time disappearances (Washing losses) was obtained by washing un-incubated bags in a similar fashion. The washed bags were dried in an oven at 60°C for 48 hours. The dried bags were then taken out of the oven and allowed to cool down in desiccators and weighed immediately to determine the dry weight of the incubation residues.

The disappearance of DM was expressed as percentages and determined for each bag using the following formula described by Osuji *et al.* [25]:

$$\text{Dry matter disappearance (DMD)} = ((BW+S_1) - (BW+RW))/(S_1 \times DM_1) \times 100,$$

where:

BW = Bag weight
RW = Residue weight
S_1 = Sample weight
DM_1 = Dry matter content of the original sample

Data for ruminal disappearance characteristics of DM was fitted to the exponential equation following the procedure described by Ørskov and Mc Donald [26]:

$$Y= a + b\,(1-e^{-ct})$$, where:

Y = Degradability of DM at time t
a = soluble fraction (Intercept)
b = insoluble but potentially degradable fraction
c = degradation rate constant of the b fraction
t = degradation time (0, 6, 12, 24, 48, 72 and 96 h)
e = (2.7182) base for natural logarithm

The nonlinear parameters a, b and c were estimated using non-linear procedures of SAS [27].

The potential degradability *(PD)*, $PD = a+b$; whereas: Effective degradability (*ED*) is calculated following the method of Ørskov and Mc Donald [26] assuming a passage rate of 4 %/h.

$$ED = a + bc / k+c$$

where:

a = soluble fraction
b = insoluble but potentially degradable fraction
c = degradation rate constant of the b fraction
k = passage rate

Statistical Analysis: All data obtained from chemical analysis of the experimental feeds including *in sacco*

DMD was analyzed using the general linear model (GLM) procedure of the statistical analysis system [27]. Least Significant Difference (LSD) procedure was followed to separate the means when the F value shows significant differences. The model used for analysis of the chemical composition and *in sacco* dry matter digestibility data was:

$Y_{ijk} = \mu + T_i + \beta_j + A_k + e_{ijk}$ *where;*

Y_{ijk} = response variable
μ = overall mean
T_i = treatment (Additives) effect
β_j = replication effect
A_k = Animal effect
e_{ijk} = the random error

RESULTS AND DISCUSSION

Chemical Composition of Silage: There was significant increase in CP values of treated sorghum stover (P< 0.05). The CP content was highest in T3 followed by T4, T2 and T1 (Table 2). The CP value obtained of the current study for T1 tended (P>0.05)to be low compared to the 3.1% reported by Bediye *et al.* [28] but this value is higher than the value (2.54%) obtained by Akinfemi *et al.* [29] for untreated sorghum stover. ElObied and Ali [30] reported CP value of 4.3% for sorghum straw used as basal roughage for feeding calves. However, a CP value of 4.7% from a sample collected from field; 5.6% from a sample collected after harvesting the seed and a range of 7.3-8.3% from sorghum stover collected during the dry season, were also reported [1, 16, 31]. The CP content of EM treated sorghum stover increased by 81.9% as compared to the untreated which could be due to the microbial growth and proliferation during the ensiling process. Kassu [32] noted increased CP inoculation of coffe husk and coffee pulp with local grass and attributed the change to bacterial growth and a decrease in the concentration of cellulose as a result of utilizing enough water soluble carbohydrate. Similar to the current result, Akinfemi *et al.* [29] reported 4.5 and 4.6% CP for *Pleurotus ostreatus* and *Pleurotus pulmonarous* fungal treated substrates, respectively as compared to 2.54% for the untreated control, respectively.

Batool *et al.* [33] reported that treatment of *Sorghum halepense* with EM and molasses has increased the value of the CP from 7.62 (Control) to 10.37%. Samsudin *et al.* [34] also noted increased CP for fungal-treated and EM inoculated rice straw. Coffee pulp mixed with different proportion of grass dominated by *Pennisetum clandestinum* ensiled with EM improved the CP content from the range of 10.7-11.5 (Control) to 12.8 – 14% [32]. EM treated dry maize stovers ensiled with spent brewers' grains has shown good silage stability and improved CP content [35]. Although there were variability in the magnitude of increase in CP, treatment with all the additives increased the value of the CP and the variability could be an attribute of the type and stage at harvest of crop residue, the dose of EM and molasses used and the management of the silage.

Mahesh and Madhu [36] indicated biologically treated roughages have higher digestibility for most of the nutrients (Both cell walls and cell solubles) with an increase in crude protein content as compared to untreated material, besides ensuring more fermentable substrates in the rumen. Maqbool *et al.* [37] noted treatment of stover with white rot fungi degrade the lingo-cellulosic contents of rice straw and make more nutrients are made available for ruminal micro flora and thereby sustain longevity of the microbes.

Urea treatment in the present study quadrupled the CP content of sorghum stover. The increase in the CP value of urea treated sorghum stover is comparable to the report of Mehari and Asghedom [38] who stated urea treatment of sorghum stover to be effective in upgrading the CP content by 79.7% (from 6.25% to 11.12%). Bareeba and McClure [39] reported 14.2% CP value in urea treated maize stover. Fernandes *et al*. [40] reported CP values of 7.9, 15.9, 23.8 and 31.8% in sorghum silage treated with urea at a dose of 0, 2.5, 5.0 and 7.5%, respectively. Ngele *et al*. [41] reported that urea treatment of rice straw had remarkably enhanced the CP value from 4.44 to 12.35%. Fonseca *et al*. [42] also reported that urea-treated rye and wheat straw had CP value of 10.4 and 11.5%, respectively. However, Ali [43] obtained a CP value of 6.06 and 7.35% after treating sorghum stover with 2 and 4% urea, respectively. Similarly, Wambui *et al*. [44] reported that the urea treatment improved the CP content of maize stover from 5.1 to 8.3%. Batool *et al*. [33] also reported a range of CP values of 7.61 – 9.24% for different species of matured grasses which were initially having a range of 5.70 – 8.51% CP.

The significant increment of CP value for urea treated sorghum stover in the current and previous study shows the effectiveness of urea treatment in improving the low quality roughages such as sorghum stover. Nguyen *et al.* [45] indicated that ammoniation of low quality feed with urea or ammonia solution increases levels in protein content. Chenost [46] reported that treatment with urea enriches the nitrogen content of the feed, multiplying it by two or three times of its initial value at the average urea

Table 2: Chemical composition of treated and untreated sorghum stover

Treatment	DM	MM	OM	CP	EE	NDF	ADF	ADL
T1	96.23[a]	7.20[c]	92.80[a]	2.93[d]	1.17	77.77[a]	54.97[b]	9.63[bc]
T2	96.43[a]	9.17[a]	90.83[c]	5.33[c]	1.23	73.83[b]	51.20[c]	8.50[c]
T3	95.20[b]	8.30[b]	91.7[b]	12.97[a]	1.33	72.23[c]	56.60[ab]	11.10[a]
T4	95.87[ab]	8.33[b]	91.67[b]	8.73[b]	1.27	75.00[b]	58.33[a]	10.10[ab]
SEM	0.19	0.24	0.24	1.16	0.06	0.63	0.90	0.33
Significance	ns	**	**	***	ns	***	**	*

[a-d] Means with different superscript letters in a column within a category differ at 5% level of significance; * = $P < 0.05$; ** = $P < 0.01$; *** = $P < 0.001$; ns = Non-significant ; SEM = Standard error of the mean;T1=Sorghum stover; T2=Effective micro-organisms treated sorghum stover; T3= Urea treated sorghum stover; T4= Effective micro-organism plus urea treated sorghum stover; DM=Dry matter; OM=Organic matter; MM=Mineral matter(Ash); CP=Crude protein; EE=Ether extract; NDF=Neutral detergent fiber; ADF=Acid detergent fiber; ADL=Acid detergent lignin.

dose of 5-6 % of the DM. In general, the type and quality of crop residue, the temperature, dose of urea applied, duration of treatment, the moisture level of the stover are important factors that contribute to the effective fermentation as indicated by Derso *et al.* [47] and Cañeque *et al.* [48]. Additionally, sorghum variety and stage of maturity are other factors which affect silage quality [49]. Similarly effective micro-organism plus urea treated (T4) sorghum stover in this study had increased the CP value of from 2.93 to 8.73%.This improvement in CP is higher than the value in T2 (5.33%). The microbes found in EM synthesize protein by breaking down the carbohydrates [20] and nitrogen released from urea through the process bound to the straw thus adding up the total nitrogen content [21]. Batool *et al.* [33] reported that treatment of four different species of matured grasses with EM, molasses and urea had increased the CP value from the initial range of 5.70 to 8.57 to 10.45 to 12.42%.

The EM treated sorghum stover (T2) showed lower values of NDF, ADF and ADL than the untreated (Control). This is due to degradation of cell wall components by the yeast and bacteria species in EM [35]. In consistent with these results, Abera [17] also obtained lower values for NDF, ADF and ADL in EM treated barley, wheat and oat straws, respectively than the untreated straw. Similarly, Akinfemi *et al.* [29] reported lower values of NDF, ADF and ADL in sorghum stover treated with white-rot fungi than the control. The authors further discussed that the decrease in the fiber fractions may be the result of cellulase enzyme secreted by cellulolytic fungi. Samsudin *et al.* [34] reported that among the rice straw groups treated with fungi and fungi and EM (T1 and T2), there was reduction in the mean values of NDF and ADF when compared to the untreated rice straw (T1) and Elkholy *et al.* [50] reported the same trend of decrease in crude fiber fractions in the corn silage.

The urea treated sorghum stover showed lower NDF value however, the ADF and ADL values for the same treatment are slightly higher than the untreated stover. This result is in agreement with Dejene *et al.* [13] who reported lower NDF value (75.9%) for urea treated than untreated (77.2%) wheat straw but ADF (54.6 vs 48.2) and ADL (9.9 vs 7.9 %) values were higher for the urea treated wheat straw than the untreated straw value. Cañeque *et al.* [48] noted a decrease in NDF of straws treated with urea, in comparison with untreated straws was essentially due to the partial solubilization of the hemicellulose in barely straw. In fact, the degree of solubilization increases with the initial moisture level of the straw. Whereas, Hassoun *et al.* [51] indicated ADF content of the straw generally increases with the urea treatment which is favored by a high moisture level. The same trend of lower NDF but higher ADF and ADL values were found in EM and urea treated sorghum stover in the present study. However, in contrast to the current study, Keskin *et al.* [49] reported NDF and ADF values of urea and urea plus molasses treated sorghum stalk to be lower than that of the control. Elkholy *et al.* [50] reported a decrease in the crude fiber content of corn silage treated with urea and yeast with molasses.

***In sacco* Dry Matter Degradability:** The rapidly soluble fraction (a), the insoluble but potentially degradable fraction (b), the potential and effective degradability (PD and ED) values are high in the order of T3>T4>T2>T1, respectively (Table 3). The difference in degradability values are attributed to the effect of the different additives used. The degradability fractions a, b and PD values for T1 (Untreated sorghum stover) in the present study are comparable to the results reported for degradation characteristics of rice offal reported by Ikhimioya *et al*. [52]. All treated sorghum stover showed higher degradability when compared with the untreated.

Table 3: *In sacco* dry matter degradability of sorghum stover treated with different additives

Treated feeds	a (%)	b (%)	c (%)	PD (%)	ED (%)
T1	21.24[c]	29.31[d]	0.049[a]	50.55[d]	39.44[d]
T2	24.47[b]	32.82[c]	0.042[b]	57.29[c]	43.58[c]
T3	29.85[a]	40.10[a]	0.036[c]	69.69[a]	51.34[a]
T4	28.85[a]	36.78[b]	0.037[c]	65.63[b]	49.11[b]
SEM	0.27	0.26	0.001	0.15	0.05
Significance level	***	***	***	***	**

[abcd] means in a column with different letters are significantly different (P < 0.05); a = soluble fraction; b = insoluble but potentially soluble fraction; c = rate of degradation; PD = potential degradability; ED = effective degradability. T1=Sorghum stover; T2=Effective micro-organisms treated sorghum stover; T3= Urea treated sorghum stover; T4= Effective micro-organism plus urea treated sorghum stover; SEM = Standard error of the mean; Significance level***=P<0.001; **=P<0.01; *=P<0.05; NS=Non-significant.

The current result is comparable with the general trend of increase in degradable fraction values of sorghum stover treated with rabaa ash alkali [53, 54]. In general, compared to the control, the higher soluble fraction (a) of the treated sorghum stover explain the effectiveness of urea treatment in increasing in CP and decreasing NDF values. The insoluble but potentially soluble (b) fraction for urea treated stover is higher than the other treatments.

The higher potential degradability (PD) values of urea (69.69%) followed by EM plus urea (65.63%) treated sorghum stover might explain the higher washing losses and lower NDF values as compared to the untreated one. [16] reported increased potential degradability (b) value increased from to for untreated (50.4) and 4% urea treated (58.0%) sorghum stover, respectively. [55] reported 91.2, 81.2, 79.9 and 73.3% of PD for oat hay, barely straw, maize stover and wheat straw, respectively after treating with urea. [10] reported the maximum rate of degradation (P value) for ammoniated barley reached 77.1 from 52.1 percent in untreated straw.

Ruminal Disappearance Rate of DM: The DM degradation increased with increasing the incubation time across all treatments and reached maximum at 96 hours in all types of treated sorghum stover in this study (Table 4). The increased DM degradability with time was a good indication of improvement in nutritive value by biological (EM) and chemical (Urea) treatment of sorghum stover [10, 18]. The ruminal disappearance rate of untreated sorghum stover for the different incubation hours is lower than all the treated sorghum silages. Generally the rate degradation decreased in the order of T3> T4 > T2 > T1. The variation in disappearance rate of DM in different treatments at different hours of incubation is an attributes to the difference in the level of CP and cell wall content after treatment of sorghum stover.

Disappearance rate of sorghum stover increased slowly from 12 to 24 and from 72 to 96 hours but there was a higher change of values between 6 to 12 and 24 to 48 hours of incubation across in all the four treatments indicating the treatment had improved the degradation of stover as was reported by earlier studies [53]. Assefa [16] reported comparable trend of slow increase between 12 to 24 and 72 to 96 hours but higher increase from 6 to 12 and 24 to 48 hours of disappearance rate for sorghum stover treated with 4% urea. In addition, Zhishan and Qiaojuan [10] reported comparable trend of higher and lower DM degradability rate between 24 to 48 and 72 to 96 hours, respectively for untreated and ammonia treated wheat straw. In contrast to the current report, Selma and Amir [56] reported slow DM disappearance rate between 24 to 48 but higher increase between 72 to 96 hours of incubation. The difference could be attributed to the variation in laboratory which is mainly associated with sample preparation and processing and in the bags used for incubation [57] and dosage of urea applied [48]. The ruminal disappearance rate in this study was the highest (68.70%) in T3 and lowest (51.37%) in T1 at 96 hours of incubation and this may be due to the higher level of crude protein and lower NDF fraction. This was similar to the report of Zhishan and Qiaojuan [10] for ammoniated wheat straw (70.1%) and untreated straw (50.8%).

Among the three types of treatments, urea treated sorghum stover (T3) showed higher values of DM degradability rate at every hours of rumen incubation starting from six hours. This might be related to the increase in CP and decrease in NDF values in urea treated sorghum stover. A similar general trend of increase in ruminal disappearance result was obtained in previous studies [10, 35,43, 53]. With regard to roughage degradation, Lawrence [58] indicated that the bleaching effect by urea results in the breakage of the ligno-cellulose bonds effecting an unlocking of the once unavailable N to the rumen microbes resulting in their proliferation and increased dry matter digestibility (DMD). Smith [18] also indicated urea breaks down the ligno-cellulose bonds of the residue, increasing rate and extent of rumen microbial digestion and as well, it improves the nitrogen status of the residue.

Table 4: Ruminal disappearance rate of DM (%) from sorghum stover treated with different additives

	0	6	12	24	48	72	96
T1	19.53[c]	30.56[d]	36.70[d]	38.56[d]	47.05[d]	49.83[d]	51.37[d]
T2	23.54[b]	32.15[c]	39.68[c]	43.28[c]	52.67[c]	55.42[c]	57.40[c]
T3	29.10[a]	36.91[a]	45.68[a]	51.27[a]	62.16[a]	66.57[a]	68.70[a]
T4	28.08[a]	36.23[b]	44.19[b]	48.69[b]	59.23[b]	62.91[b]	65.00[b]
SEM	1.16	0.81	1.08	1.48	1.77	1.96	2.03
Significance level	*	*	*	*	*	*	*

abcd means in a column with different letters are significantly different (P<0.05); T1= Untreated sorghum stover; T2=Effective Micro-organism treated sorghum stover T3=Ureatreated sorghum stover; Effective Micro-organism + Ureatreated sorghum stover; SEM = Standard error of the mean; Significance level *=P<0.001

The lower ruminal disappearance rate (36.6 to 39.6) between 48 and 72 hours of incubation of EM inoculated maize stover reported by Syomiti *et al.* [35] is comparable to the (52.7 to 33.4%) in the current study. The mean values of ruminal disappearance of DM of the EM and EM plus urea treated sorghum stover at 72 hours in this study is lower than the value reported by [58] in that the rumen degradability of 8 (89.93 ± 4.16) and10 (95.61 ± 4.22 %) day yeast treated maize stover were significantly (P<0.05) higher than the control (43.18 ± 4.78 % for maize stover) at 72 hours for maize stover. The EM used to treat the stover in this study has beneficial micro-organisms which secret enzymes that can degrade the fiber and at the same time enhance the number of microbes which can add up to the CP value of the residue. Similarly, Maqbool *et al.* [37] indicated that the mico-organisms in the EM are responsible to the DM degradability of lingo-cellulosic contents improving the nutritional value of the rice straw and affect the weight gain of animal. Mahesh and Madhu [36] suggested that biologically treated roughages have higher digestibility for most of the nutrients (Both cell walls and cell solubles) with an increase in crude protein content as compared to untreated material, besides ensuring more fermentable substrates in the rumen.

CONCLUSION

The chemical and biological additive treatments used in the present study improved CP and degradation parameters of the sorghum stover. Nevertheless, treatment of sorghum stover with urea resulted in higher CP and *in sacco* DM degradability and ruminal disappearance rate. Therefore, we recommend use of the additives for improving nutritive value of low quality feeds based on their availability, cost and environment friendly.

ACKNOWLEDGEMENTS

The author would like to acknowledge Addis Ababa University for granting the scholarship and Haramaya University for financial assistance. National veterinary Institute (NVI) and Holeta Agricultural Research Center (HARC) for conducting the laboratory analysis. Last but not least I extend my gratitude for many individuals who directly or indirectly gave hand for the work.

REFERENCES

1. Tolera, A., 2007. Feed Resources for Producing Export Quality Meat and Livestock in Ethiopia. Ethiopia Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program. Texas Agricultural Experiment station (TAES)/Texas A & M University system, Addis Ababa, Ethiopia.
2. Etafa, A., K. Kasim, Y. Esmael and M. Debela, 2013. Cattle Production in West Hararghe: An Opportunity and Constraints Assessments in Darolabu, Odabultum, Gemechis and ChiroWeredas, Oromia Regional State, Ethiopia. International Journal of Livestock Production Research, 1(1): 01-15.
3. Fekadu, T. and M. Urge, 2011. Assessment of traditional cattle fattening practices and feedlot performance of Hararghe highland Bulls. In Haramaya University 28th Annual Research and Extension Review Proceedings, pp: 179-189.
4. Tsegaye, D. and T. Lemma, 2008. Livestock production systems in Darolabu, Habro and Boke districts of Western Harerghe. Commercialization of Livestock Agriculture in Ethiopia. In Proceedings of the 16th annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, pp: 179-186.
5. Gebreyohanes, G. and G. Hailemariam, 2011. Challenges, Opportunities and available good practices related to zero grazing in Tigray and Hararghe, Ethiopia. The Drylands Coordination Group, Report, No. 66.
6. WHZLDHO, (West Hararghe Zone Livestock Development and Health Office) Unpublished, 2015. Annual report. West Hararghe Zone Livestock Development and Health Office, Oromia, Ethiopia.

7. Funte, S., T Negesse and G. Legesse, 2010. Feed, Food and Resources and Their Management Systems in Ethiopian Highlands: The Case of Umbulo Wacho Watershed in Southern Ethiopia. Tropical and Subtropical Agro Ecosystems, 12: 47-56.
8. Hanafi, E.M., H.H. El. Khadrawy, W.M. Ahmed and M.M. Zaabal, 2012. Some observations on rice straw with emphasis on updates of its management." World Applied Sciences Journal, 16(3): 354-361, Giza, Egypt.
9. Elnazeir, M.D.M. and B.A. Suaad, 2013. Improvement of Hay and Crops Straw Using chemical Additives and Testing of Cassia Fistula Tree Pods as Animal Feed." Greener Journal of Agricultural Sciences, 3(9): 687-692.
10. Zhishan, Z. and Y. Qiaojuan , 2002. Ammoniation of crop residues'', pp: 47-72. In: T. Guo, D.S. Manuel and P.Y. Guo (eds). "Animal Production Based on Crop Residues: Chinese Experiences. FAO, Rome, Italy.
11. Yirga, H., S. Melaku and M. Urge, 2011. Effect of Concentrate Mix Supplementation to Urea-Treated and Ensiled Maize Stover on Feed Intake, Digestibility and Nitrogen Balance of Hararghe Highland Sheep." East African Journal of Sciences, 5(1): 51-57.
12. Assefa, F., M. Urge and G. Animut, 2015. Growth performance of Adilo sheep fed urea treated wheat straw supplemented with enset (Ensete ventricosum), atella and their mixtures. African Journal of Research, 10(24): 2444-2452.
13. Dejene, M., S. Bediye, G. Kitaw and A. Kehaliw, 2009. On-farm evaluation of lactating local (Bosindicus) dairy cows fed urea-treated wheat (Triticumaestivum) straw supplemented with soluble protein source-based concentrate mixture during the dry season in crop-livestock production system of south west shoa, Ethiopia. In Proceedings of the 17th Annual conference of the Ethiopian Society of Animal Production (ESAP) held in Addis Ababa, Ethiopia, pp: 239-252.
14. Mesfin, R. and I. Ledin, 2004. Assessment of the treatment and the use of urea treated straw for cattle feeding in Selale, central Ethiopia. Ethiopian Journal of Animal, 4(1): 23-32.
15. Gashu, M., B. Tamir and M. Urge, 2014. Effect of Supplementation with Non-Conventional Feeds on Feed Intake and Body Weight Change of Washera Sheep Fed Urea Treated Finger Millet Straw." Greener Journal of Agricultural Sciences, 4(2): 067-074.
16. Assefa, F., 2014. Chemical composition, *in-vitro* digestibility and in-sacco degradability of urea treated sorghum stover, dried leaves of erythrina burana, casimiroa edulis, concentrate mix and their mixtures. In feeding potential and nutritional value of erythrina burana and casimiro aedulis. PhD dissertation, Haramaya University, Ethiopia, pp: 134.
17. Abera, M., 2015. Evaluation of effective microbes (EM) treatment on chemical composition of crop residues and performance of crossbred dairy cows." M.Sc. Thesis, Haramaya University, Ethiopia.
18. Smith, T., 2000. On-farm treatment of straws and stovers with urea" University of Reading, Reading, United Kingdom, pp: 15-22. http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/33/032/33032968.pdf.
19. Higa, T. and G.N. Wididana, 2007. The Concept and theory of Effective Microorganism. http://infrc.or.jp/english/KNF_Data_Base_Web/PDF%20KNF%20Conf%20Data/C1-5-015.pdf, 2007.
20. Kassu, Y., S. Demeke, T. Tolemariam and Y. Getachew, 2014. Effect of Effective Microorganism (EM) on the nutritive quality of coffee husk silage. International Journal of Scientific and Technology Research, 3(7).
21. Girma, A. and A.L. Goetsch, 2008. Urea-Ammonia Treatment of Low Quality Roughages. Technical bu1lletin No. 2. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP), Ethiopia, pp: 345.
22. Seiichi, C., C. Hisao and Y. Masuo, 2005. A Guide for Silage Making and Utilization in the Tropical Regions." Japan Livestock Technology Association.
23. AOAC (Association of Analytical Chemists), 1990. Association of Official Analytical Chemists. Official methods of analysis." Washington. DC., USA.
24. Van Soest, P.J. and J.B. Robertson, 1985. Analysis of forage and fibrous foods. A laboratory manual for Animal Science 613." Cornell University, USA.
25. Osuji, P.O., I.V. Nsahlai and H. Khalili, 1993. Feed evaluation. In: ILCA Manual 5." ILCA, Addis Ababa, Ethiopia, pp: 40.
26. Ørskov, E.R. and Mc Donald, 1979. The estimation of protein degradability in the rumen of incubation measurement weighted according to rate of passage. Journal of Agricultural Sciences (Camb.), 92: 499-503.
27. SAS (Statistical Analysis System), 2010. Statistical Analysis Systems Institute Inc. User's Guide, Version 9.3, SAS Institute Inc. Cary, NC, USA, 2010.

28. Bediye, S., Z. Sileshi and D. Fekadu, 2007. Chemical composition and nutritive values of Ethiopian feeds." Research report 73. Ethiopian Institute of Agricultural Research (EIAR), Addis Ababa, Ethiopia.
29. Akinfemi, A., O.A. Adu and F. Doherty, 2010. Conversion of sorghum stover into animal feed with white-rot fungi: Pleurotus ostreatus and Pleurotus pulmonarius." African Journal of Biotechnology, Vol. 9(11): 1706-1712.
30. ElObied, G.H. and J.A. Ali, 2013. Optimum concentrate supplement to sorghum straw to reduce live weight loss in calves during summer season in Sudan. International Journal of Agricultural Sciences, 3(9): 016-021.
31. Gemiyo, D., 2015. Evaluation of major feed resources in crop-livestock mixed farming systems, southern Ethiopia: Indigenous knowledge versus laboratory analysis results. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 116: 157-166.
32. Kassu, Y., 2010. Chemical composition and in vitro digestibility of coffee pulp and coffee husk ensiled with Grass (HyperchenniaHirta) hay and effective microorganism. M.Sc. Thesis, Jimma University, Jimma, Ethiopia.
33. Batool, N., I.Q. Ahmad, I. Hussain and M.U.K. Fateh, 2013. Mixing Less Palatable Grasses with Urea, Molasses and Effective Microorganisms and its Effect on Chemical Composition and Digestibility in Goats. Pakistan J. Agric. Res., 26(3).
34. Samsudin, A.A., M.F. Masori and A. Ibrahim, 2013. The Effects of Effective Microorganisms (EM) on the Nutritive Values of Fungal-Treated Rice Straw. Mal. J. Anim. Sci., 16(1): 97-105.
35. Syomiti, M., M. Wanyoike, R.G. Wahome and J.K.N. Kuria, 2010. In saccoprobiotic properties of effective microorganisms (EM) in forage degradability, Livestock Research for Rural Development, 22(1).
36. Mahesh, M.S. and M. Madhu, 2013. Biological treatment of crop residues for ruminant feeding" African Journal of Biotechnology, 12(27): 4221-4231.
37. Maqbool, A., M.K. Shafiq, I.A. Khan and F. Mahmood, 1997. Prevalence, aetiology, chemotherapy and control of DegNala disease in buffaloes and cattle." Ind. J. Dairy Sci., 50: 1-5.
38. Mehari, F. and G. Asghedom, 2010. Effect of supplementing Urea-treated Sorghum stover with Sesame cake or Fishmeal on the body weight of sheep and cattle." Sustainable improvement of Animal production and health. FAO and IAEA, Rome, Italy.
39. Bareeba, F.B. and K.E. McClure, 1996. Effect of ensiling maize stover with alfalfa or urea on intake, digestibility and nitrogen balance by growing lambs. In: Ndikumana, J. and de Leeuw (eds.). Sustainable Feed Production and Utilization for Smallholder Livestock Enterprise in Sub-Saharan Africa. In Proceedings of AFRNET Workshop, Harare, Zimbabwe, pp: 22-24.
40. Fernandes, E.F.P., G. Rasmo, J.V.P. Aureliano, G.P. Odilon, G.P.C. Gleidson and S.O. Cellyneude, 2009. Sorghum silage with added urea in two periods storage. Brazilian Journal of Animal Science.
41. Ngele, M.B., T.A. Adegbola, S.E.S. Bogoro, M. Abubakar and D.J.U. Kalla, 2009. Rumen degradability and kinetic properties of urea and poultry litter treated rice straw." Emir. J. Food Agric., 21(1): 32-39.
42. Fonseca, A.J.M., A.A Dias-da-Silva and E.R. Ørskov, 1998. In sacco degradation characteristics as predictors of digestibility and voluntary intake of roughages by mature ewes." Animal Feed Science and Technology, 72: 205-219.
43. Ali, S.B., 2007. Effect of urea treatment of sorghum stover on the chemical composition and in rumen degradability. M.Sc. Thesis, University of Khartoum, Sudan.
44. Wambui, C.C., S.A. Abdulrazak and Q. Noordin, 2006. The effect of supplementing urea treated maize Stover with Tithonia, Calliandra and Sesbania to growing goats. Livestock Research for Rural Development, 18(5).
45. Nguyen, Y.T., M. Magne and D. Guxuan, 2001. Effects of treatments of rice straw with lime and/or urea on its chemical composition, in vitro gas production and in sacco degradation characteristics. Livestock Research for Rural Development, 13(4).
46. Chenost, M., 1987. Optimizing the use of poor quality roughages through treatments and supplementation in warm climate countries with particular emphasis on urea treatment. Tropical Feeds and Feeding System, pp: 71-92. http://www.fao.org/livestock/agap/frg/ECONF95/PDF/Chenost.

47. Derso, T.A., 2009. On-farm evaluation of urea treated rice straw and rice bran supplementation on feed intake, milk yield and composition of Fogera cows, North Western Ethiopia. MSc thesis. Bahir Dar University, Bahir Dar, Ethiopia, pp: 89.
48. Cañeque, V., S. Velasco and J.L. Sancha, 1998. Nutrional value and use of lingo-cellulosc feed treated with urea in the ruminant diet. In: Anton Giovan N. I. M. (ed.). Exploitation of Mediterranean roughage and by-products. Zaragoza, CIHEAM, pp: 17-32.
49. Keskin, B., I.H. Yimaz, A.M. Karsu and H. Nursoy, 2005. Effects of Urea or Urea plus Molasses Supplementation to Silages with Different Sorghum Varieties Harvested at the Milk Stage on the Quality and In Vitro Dry Matter Digestibility of Silages. Turk Journal of Veterinary Animal Science, 29: 1143-1147.
50. Elkholy, M.E.L.H., E.L.I. Hassanein, M.H. Soliman, Wafaa Eleraky, M.F.A. Elgamel and I. Dohaa, 2009. Efficacy of Feeding Ensiled Corn Crop Residues to Sheep" Pakistan Journal of Nutrition, , Zagazig University, Egypt, 8(12): 1858-1867.
51. Hassoun, P., F. Geoffroy, G. Saminadin, P. Prior and M. Beramis, 1990. Studies on the ammoniation of sugar-cane bagasse by urea. Effect of moisture, urea levels, urease source and treatment periods on composition, in vitro dry matter digestibility and evolution of ureolytic bacteria." Anim. Feed Sci. Technol., 29(1): 13-1 29.
52. Ikhimioya, O.A., Isah U.J. Ikhatua and M.A. Bamikole, 2005. Rumen degradability of dry matter and crude protein in Tree leaves and crop residues of humid Nigeria. Pakistan Journal of Nutrition, 4(5): 313-320.
53. Asma, H.M.H. and E.E. Mohamed, 2008. "Degradation of sorghum stover treated with Rabaa ash alkali in the rumen of Nubian goats." Gezira Journal of Agricultural Science., Sudan, 6(2).
54. Niemat, I.N.E.I., 2006. In-Sacco Degradability, Chemical and Morphological Composition of Five Varieties of Sorghum Stover." M.Sc. Thesis, Sudan University for Science and Technology, Sudan.
55. Tesfayohannes, S.T., I.V. Nsahlai and K. Bengaly, 2013. Effect of Urea Treatment and Concentrate Proportions on Dry Matter Degradation of Different Roughages in the Rumen of Jersey Cows. Global Journal of Science Frontier Research Agriculture and Veterinary, 13(8) Version 1. University of KwaZulu-Natal, South Africa.
56. Selma, A.B.A. and M.S. Amir, 2012. The Effect of Urea Treatment on the Chemical Composition and Rumen Degradability of Sorghum Stover. Journal of Agricultural Science and Technology, 2: 489-494.
57. Wilson, J.R., 1994. Cell wall characteristics in relation to forage digestion." Journal of Agricultural Science, Cambridge, 122: 173-182.
58. Lawrence, A.O., 2010. Effect of in-vitro yeast treatment on the in-sacco degradability of some tropical crop residues in rumen fistulated West African dwarf sheep. Animal research international, University of Nigeria, Nsukka, Nigeria, 7(2): 1176- 1183.