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Evaluation of Chemical Composition and *in vitro* dry Matter Digestibility of Sorghum Stover Ensiled with Urea and Effective Microorganisms (EM) in West Hararghe Zone, Eastern Ethiopia

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Abstract: The effects of urea and effective microorganisms (EM) on chemical composition and *in vitro* dry matter digestibility of sorghum (*Sorghum biclor* L. Moench) stover was evaluated. The treatments include untreated sorghum stover (SS), effective microorganisms treated sorghum stover (EMSS), Urea treated sorghum stover (UTSS) and EM plus urea treated sorghum stover (EMUSS). Sensory evaluation, chemical analysis and *in vitro* DMD of sorghum stover silage were conducted. The results of sensory evaluation indicated that the color in EMSS and EMUSS of ensiled stover after twenty one days became brownish yellow with alcoholic odor and soft texture. Whereas, UTSS had dark brown color, slight alcoholic with predominant pungent smell and soft consistency. The pH values of the treated silages were 4.17, 4.30 and 4.27 for EMSS, UTSS and EMUSS, respectively. In all treated silages, there was none observed fungus. In all types of silages, treatment affected the chemical composition through decreasing OM (90.80, 91.7 and 91.6) and NDF (73.83, 72.23 and 75.00) and increasing the ash (9.17, 8.30 and 8.33) and CP (5.33, 12.97 and 8.73) for EMSS, UTSS and EMUSS, respectively as compared to the control (SS). The *in vitro* DMD values showed that all additives treated groups (EMSS, UTSS and EMUSS) had significant variation with the SS, however, UTSS showed the highest *in vitro* DMD value (54.37%). Ensiling sorghum stover with these additives generally improved the nutritive value. However, UTSS had highly increased the CP and in vitro DMD values. Therefore, we recommend urea treatment of sorghum stover for dry season feeding of cattle in the area.

Key words: Dry Matter · Effective Microorganisms · *In vitro* Digestibility · Sorghum Stover · Urea

INTRODUCTION

Natural pasture and crop residues and browse plants are the main livestock feed resources in Ethiopia with a minimum supply of improved forages and agro-industrial by-products. Currently, livestock are fed almost entirely on natural pasture and crop residues [1]. However, poor management, overgrazing and the inherent low productivity of grazing lands especially during dry season and the low nutritional value of crop residues are the main challenges of the livestock feed resource in Ethiopia [2]. Moreover, the rapid increase of human population and expansion of arable land which resulted in the incorporation of grazing lands signified the use of crop residue in livestock feeding [1].

Various crop residues are available in the highland and mid-altitudinal areas of Ethiopia. These include cereals (Teff, barley, wheat, maize, sorghum and millet); pulse crop residues (Fava beans, chickpeas, haricot beans, field peas, lentils); oil crops residues and reject vegetables are providing a considerable quantity of dry season feed supply in most farming areas of the country [1]. The amount of crop residues from cereal straws/stovers, pulse crop haulms, oil seed straws and

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vegetable wastes is 29, 155, 077, 1, 357, 621, 787, 448 and 94, 094 ton dry matter (tDM), respectively. In general, cereal crop residues have the highest contribution to the total feed supply in Ethiopia [3].

Similarly, the major livestock feed sources in West Hararghe include crop residues, natural pasture hay and commercially available industrial by products [4-6]. Among the crop residues, maize and sorghum stover are predominantly found in West Hararghe [7, 8]. However, even if these feeds are the available in the zone especially during the dry season, they are fed most of the time lacking proper form of chopping and without any chemical and biological treatments. Wastage is therefore very high and intake level low. Most of the time, the crop residue gets trampled and contaminated with urine and feces of the animals and thus either left for compost or collected for firewood. This is specially so during the dry season when the natural pasture dries out and some of the better crop residues finished. Thus, the available crop residue mostly found in the crop field is heaped sorghum stover either in the crop field or around the backyard for feeding cattle. Stover is characterized by poor palatability, low in crude protein (mostly below 6%), high in crude fiber, low digestibility, low in calcium and phosphorus and low in vitamin A content [9].

Tadesse *et al.* [6] also reported that most common feed resource in East and West Hararghe was crop residue therefore, suggested the introduction of potential forage production, improvement of the feed resource through different techniques and/or supplementing the animal to optimize cattle production in response to the prevalent feed scarcity in the area. From the 277, 460 ha land covered by annual crop in the West Hararghe zone, sorghum covers 98, 965.28 ha (35.67%) and this gave a potential stover yield of 544, 309.04 tons [3, 10].

With regard to upgrading the nutritive value of crop residues through chemical and biological treatment, many studies were conducted in Ethiopia. Specifically, a number of studies were done on urea treatment of maize stover [11-13] wheat straw [14-16] rice straw [17] and sesame straw [18]. However, few studies were done on effective microorganism treatment of sorghum stover [19] and effective microorganism treatment of wheat, barley and oats [20]. This study inquires the efficient utilization of sorghum stover in the areas through treatment of urea and EM as additives. Therefore, the objective of this study is to investigate the nutritional value of EM, Urea and EM plus urea treated and ensiled sorghum stover on chemical composition and in vitro dry matter digestibility in the study area.

MATERIALS AND METHODS

Physical Description of the Study Districts: Among the 14 districts in the Western Hararghe Zone, 11 districts are areas of mixed crop livestock production system and 3 are pastoral weredas. Four weredas from mixed crop livestock production areas namely; Chiro, Tullo, Gemechis and Habro were identified and selected for this study based on potential and abundance cattle fattening practices and utilization of crop residues in consultation with West Harerghe Zone Livestock Development and Health Office. The physical description of the districts is summarized in Table 1.

In West Hararghe, along with the crop production farmers give more emphasis for livestock feed. They sow 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, 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 is a common practice both in the wet and dry season of the year. Feed shortage is critical during the dry season (March to June). Thus, the dry season feeding is mainly dependent on maize and sorghum stover. Most often fattening cattle are tied up and fed near the crop land or at backyard [8, 10].

The feed quality of treated and ensiled sorghum stover was evaluated for visual appraisal, smell, texture and pH value. This was conducted in Chiro town private farm. Chiro town is located in West Hararghe zone, Oromia National Regional State, Ethiopia. It is located in the geographical coordinate of 40° 35’ 49’’-41° 5’40’’ E longitude and 8° 56’ 21’’ – 9° 13’ 21’’ N latitude. It has an altitude ranging between 1500 and 2800 masl. The annual temperature ranges from 27-38.5°C [10].

Sample Collection and Preparation: The sorghum stover was collected from the four weredas of West Hararghe zone, Oromia Regional State, Ethiopia. The local varietal name for the sorghum crop (*Sorghum bicolor*) include Chefere, Wegere, Dasle, Harka bas, Goronjo, Muyra, Gebabe and Zengada. Composite sample of the stover was chopped manually at approximately 3 cm and exposed for sunlight on a plastic sheet for 5 days and manually turned timely to keep uniformity in drying.

Adequate quantities of an inert form of EM (EM-1) packed in plastic bottles and Molasses was purchased from Weljijie PLC, the sole distributor at Bishoftu town.

Table 1: Physical description of study districts (Weredas) in West Hararghe zone, Oromia, Ethiopia.

Study Districts/ Weredas	Geographical Co-ordinate	Annual Temp. (°C)	Alt. (m.asl)	Annual Rain Fall (mm.)	No. of Kebel-es (PAs)	Cattle popul-ation	Total land Area (ha)	Cultivated land (ha)	Land covered by sorghum (ha)	Amount of sorghum stover (ton) produced
Chiro	34° 18'43'' – 43° 04' 33'' E longitude and 10° 09' 24''- 30° 18'43'' S latitude	27-38.5	1500-2800	900-1800	39	91, 274	70, 962.834	26, 807.274	10, 599 (39%)	58, 294.5
Gemechis	40° 49' 46'- 41° 11' 26'' E longitude and 8° 40' 25''- 9° 3' 42'' N latitude.	15-30	1300-2400	850	36	89, 251	77, 785	29, 812	11, 585 (39%)	63, 717.5
Habro	7°55'–9°33'N latitude and 40°01' and 41°39'E longitude	20-22.5	1200-2590	650-1050	32	77, 440	72, 270	10, 132.9	2, 424 (23.9%)	13, 332
Tullo	9° 1' 45''- 9° 18' 48'' N and 40° 58' 24'' 41° 16' 49'' E longitude.	23-32	1500-2797	800	30	125, 915	58, 950	13, 280	4, 141 (31.2%)	22, 775

Crop residue production is estimated by multiplying crop production data with established conversion factors for each crop. Accordingly, the conversion factor for sorghum stover is 2.5 [3].

Table 2: Experimental treatments

Treatments	Silage material	Amount of Sorghum stover (kg)	Additives	Amount of additives (Liters)
SS	Sorghum Stover	5	-	-
EMSS	Sorghum Stover	5	EM	4.5
UTSS	Sorghum Stover	5	Urea	5
EMUSS	Sorghum Stover	5	EM + Urea	4.75

SS=Sorghum stover; EMSS=Effective micro-organisms treated sorghum stover; UTSS= Ureatreated sorghum stover; EMUSS= Effective micro-organism plus urea treated sorghum stover

Higa [21] indicated that EM was developed from three major microorganisms; namely photosynthetic bacteria, lactic acid bacteria and yeast. Molasses was added and mixed with EM at equal proportion in order to initiate the microbial (EM) multiplication and metabolism. Cane molasses has brix (degree brix), dry suspended particles (>100µ), total sugars as invert, calcium as Calcium oxide, reducing sugars, nitrogen content, sulphated ash and unfermentable sugars % w/w 86, 13.27, 41.6, 1832.64, 12.5, 0.90, 17.12 and 5.55, respectively [22].

The molasses serves for further activation and multiplication and the water as a carrier to uniformly distribute the microorganisms. Fertilizer grade urea (46% N) was purchased from the district agricultural and rural development office. The treatments for EM and Urea treated silage making were prepared following the procedures of Kassu *et al*. [23] and Girma and Goetsch [24] respectively.

Accordingly, one liter of EM solution was mixed with one kg of molasses and 18 liters of chlorine free water in the ratio of 1:1:18. To make this effective, the chlorinated /tap/ water was left for overnight before mixing with EM and molasses. Chlorine free water is needed because the microorganisms are very sensitive to chlorine and it could kill them before they commence their activities. To prepare urea-water mix a ratio of 20:1:20 (Water: urea: stover) was needed. Table 2 summarizes experimental treatments.

Ensiling Procedure: The treated sorghum stover was separately put in a transparent plastic bag and pressed by hand layer by layer so as to avoid air space [25]. Individual containers were knotted at the top by a rope and sealed to block entrance of oxygen and finally the bag was inserted into another plastic bag or to assure anaerobic fermentation and protection. The same weight of untreated stover (SS) in three replications was simply put in plastic bag. All the bags are kept in a clean room at a room temperature that could facilitate the anaerobic fermentation. Each of the three types of the treatments: effective microorganisms treated sorghum stover (EMSS), urea treated sorghum stover (UTSS) and effective microorganisms plus urea (EMUSS) treated sorghum stover and untreated sorghum stover (SS) was replicated three times. All the silages were kept for 21 days which is commonly recommended in Ethiopia [24]. Thirty degree centigrade is an ideal temperature for urea treatment of lingo-cellulosic residues [26]. Chiro town has an average temperature ranging from 24 to 30 °C, which is good temperature for efficient ensiling. Moreover, Smith [27] also suggested that the best period for incubation for the tropics is from 14 to 42 days.

Sensory Evaluation: The feed quality of treated stovers was evaluated for visual appraisal, smell, texture and pH value. Sensory evaluation was done subjectively with the

participation of two people. The pH value of the treated sorghum stover samples was determined by digital pH meter of the extract [28]. Sample taking was done cautiously grabbing the silage material by hand and as much as possible minimizing entrance of air in the main plastic bag and putting the sample in plastic cups. The pH of the treated feeds was determined by soaking 20 g of the materials overnight in 100 ml of distilled water. Then the soaked sample was thoroughly mixed and stirred up properly to get the juice and finally filtered with a normal sieve. This was then divided into three equal portions, filtered and pH determined using a pH meter. The mean pH for each treatment was calculated using a procedure of Otieno *et al*. [29]. The color, smell and texture parameters were checked and the result of each test was recorded [23].

Accordingly, 300 g of silage sample from each replicated treatment was taken by measuring with a suspended balance calibrated at 0. This was done as much as possible by taking representative samples from the top, middle and bottom part of each plastic bag. These samples were put in small plastic bags and sealed immediately and put in ice box to arrest further fermentation process and finally the sample was submitted to Bishoftu NVI laboratory and there it was sub-sampled, weighed, put in petri-dishes covered with white paper, coded for identification and was put in Partial drying oven at 55°C for 72 h for partial DM determination. Consequently, from each of the 12 samples, the DM, Ash, CP and EE parameters were determined.

Chemical Analysis: The chemical analysis was done at National Veterinary Institute (NVI) laboratory, Bishoftu. Accordingly, the samples untreated and additive treated sorghum stover silage were analyzed for dry matter (DM), crude protein (CP), Ash and ether extract (EE) according to AOAC [30]. The detergent analysis was conducted at Holeta Agricultural Research Center (HARC). Neutral detergent fiber (NDF), Acid detergent fiber (ADF) and Acid detergent lignin (ADL) was analyzed using detergent extraction method, Van Soest and Robertson [31]. The dry matter content of the treated and untreated samples was determined by 105 °C oven drying for 24 hours. Whereas, the OM was determined by subtracting the Ash value from 100%. The crude protein (CP) content was determined by titrating the sample with standard NaOH till pink color comes and recording the volume of NaOH used for titration. By igniting the crucible containing dry sample at 600°C for 2 hours till no black particle remains in it and weighing it in a desiccator, ash content was determined. The ether extract was determined by heating the dry sample with petroleum ether for 8 hours and preserve the extracted material (Sample) for crude fiber estimation.

In vitro DM Digestibility Procedure: *In vitro* dry matter digestibility (IVDMD) was analyzed according to procedures of Tilley and Terry [32]. Representative samples from untreated and treated sorghum silage were dried in an oven at 65 °C for 72 hours. The dried materials were grounded to pass through 1 mm sieve for *in vitro* dry matter digestibility. About 0.5 g of the samples was incubated in 125 ml flasks containing rumen fluid-medium mixture for 48 hours in a water bath maintained at 39°C. This was followed by a 24 hour acid-pepsin digestion phase at 39°C, under anaerobic conditions. The rumen fluid was obtained from rumen fistulated animals kept at the Holeta Agricultural Research Center, Holeta. The steers were offered grass hay, water and mineral block ad libitum and concentrates. The DMD can be calculated according to Galyean [33] as follows:

IVDMD % = 100 x [(Initial dry sample wt - (Residue - blank))/initial dry sample wt]

Statistical Analysis: All data obtained from chemical analysis of the experimental feeds including *in vitro* dry matter digestibility was analyzed using analysis of variance (ANOVA) following the general linear model (GLM) procedure of the statistical analysis system (SAS) [34]. Least Significant Difference (LSD) procedures was followed to separate the means when the F value shows significant differences. The model useful for analysis of the chemical composition and *in vitro* dry matter digestibility data is:

$Y_{ij} = \mu + T_i + \beta_j + e_{ij}$ where;
Y_{ij} = response variable
μ = overall mean
T_i = treatment (additives) effect
β_j = replication effect
e_{ij} = the random error

RESULTS AND DISCUSSION

Sensory Evaluation of Silage: The effect of treatment on pH, sensory appraisals and fungus prevalence of untreated and treated sorghum stover is summarized in Table 3. In this study, the pH values of all the treated

Table 3: Effect of treatment on pH, sensory appraisals and fungus prevalence of untreated and treated sorghum stover

	Type of silage			
Parameters	Untreated sorghum stover (SS)	EM treated sorghum stover (EMSS)	Urea treated sorghum stover (UTSS)	EM + Urea treated sorghum stover (EMUSS)
pH	-	4.17	4.30	4.27
Color	Straw	Brownish yellow	Dark brown	Brownish yellow
Smell	Natural	Highly Alcoholic odor	Slight Alcoholic with pungent smell	Moderately Alcoholic odor
Texture	Hard	Soft	Soft	Soft
Fungus	-	-	-	-

- = no mold; + = Slightly moldy; ++ = Heavily moldy

silages were 4.17, 4.30 and 4.27 for EMSS, UTSS and EMUSS, respectively. The current pH values are comparable to Syomiti [35] who reported pH levels within the range 3.9-5.4 after evaluating the feed value of maize stover treated by EM which is acceptable for high DM silages. The current pH values represent characteristics of a good silage. Liu and Guo [36] classified silages based on their pH values as excellent, good, average and bad for values below 4, 4.1 and 4.3, 4.4 and 5.0 and above 5, respectively. Thus, the present findings can be categorized under good quality silage (4.17 to 4.30). This might be due to the effect of treating the sorghum stover with fermentation enhancer additives such as EM, urea and EM and urea mix in water solution. Otieno *et al.* [29] obtained a pH of 4.20 and 4.13 with and without molasses, respectively for sorghum silages ensiled for two months. Keskin *et al.* [37] reported a pH value of 4.23, 5.54 and 4.84 for control, urea and urea plus Molasses, respectively treated silages with different sorghum varieties harvested at the milk stage. However, Keskin *et al.* [37] reported higher (5.54 and 4.84) pH values than the result obtained in the current study.

The results of the visual appraisal, color and smell in this study were an indication of good quality and obviously shows EM as a biological inoculant and urea as a chemical additive could enable facilitate the fermentation process. This finding agree with that of Yirga *et al*. [13], Abera [20], Kassu et al. [23] and Demeke [38]. In this work, sorghum stover (UTSS) treated with urea showed dark brown color, having pungent smell, absence of mold and soft texture. Moreover, Ali [39] reported similar results after treating sorghum stover with 2 and 4% urea. However, Otieno *et al.* [29] reported that silage of sorghum stover with and without molasses showed moderate appearance and smell which is a little bit lower than brownish color and typical silage without any foul smell which is a good silage characteristics. Proper chopping, uniform sprinkling of the additive solutions, rubbing to wet the stover by the solution and pressing to avoid air space and proper packing of the chopped stover in this study might have ensured good result of anaerobic fermentation.

Chemical Composition and *In vitro* Dry Matter Digestibility (IVDMD) of Silage: There is no significant ($P > 0.05$) variation in the DM of SS and treated silages in the current study (Table 4). Silage DM slightly increased with the addition of EM and molasses (EMSS). This might be due to the increase in the ash content of treated stover because molasses has high content of minerals [22, 23]. Similarly, Keskin *et al.* [37] reported that there is a non-significant variation in the mean values of the DM of urea (29.46%) and urea plus molasses (32.35%) treated silage over the control (30%) of sorghum harvested at the milk stage. Asma and Mohamed [42] also reported a non -significant variation in DM content of untreated with 3 and 5% Rabaa ash alkali treated sorghum stover. Dante *et al*. [43] observed no difference between treatments for DM, OM and lignin of maize stover either treated or untreated with a fungus strain- *Pleurotus djamor.*

However, Samsudin *et al.* [44] reported significant variation in DM between untreated and biologically treated rice stover. Keskin *et al.* [37] indicated that silage DM content generally increased with the addition of urea plus molasses. But in the current study, urea did not significantly ($P>0.05$) affect DM content compared to the control. However, there is a decrease in the OM content of additives treated sorghum stover to the control in this study. This might be due to an increase in soluble carbohydrates during ensiling in the additives treated groups. Assefa *et al.* [19], Abera [20] and Keskin *et al.* [37] reported similar findings. Fiber fractions for the control (SS) in the current study were recorded 77.77, 54.97 and 9.63%for NDF, ADF and ADL, respectively. These values are comparable to the range of values 59.9 to 79.3%, 46.4 to 70.0% and 9.2 to 13.5% for NDF, ADF and Lignin in four local sorghum varieties in Sudan [42]. However, Reddy *et al*. [45] reported NDF value of 70.2% for sorghum stover.

Table 4: Chemical composition and in vitro dry matter digestibility (%) of sorghum stover treatment silages

		% DM							
Treatments	DM Mean±SEM	Ash Mean±SEM	OM Mean±SEM	CP Mean±SEM	EE Mean±SEM	NDF Mean±SEM	ADF Mean±SEM	ADL Mean±SEM	IVDMD Mean±SEM
SS	96.23±0.03^{a}	7.20±0.18^{c}	92.80±0.18^{a}	2.93±0.35^{d}	1.17±0.03	77.77±0.28^{a}	54.97±0.86^{b}	9.63±0.26^{bc}	49.83±0.01^{c}
EMSS	96.43±0.28^{a}	9.17±0.10^{a}	90.83±0.10^{c}	5.33±0.49^{c}	1.23±0.26	73.83±0.34^{b}	51.20±0.37^{c}	8.50±0.49^{c}	51.07±0.21^{bc}
UTSS	95.20±0.22^{b}	8.30±0.40^{b}	91.70±0.40^{b}	12.97±0.68^{a}	1.33±0.07	72.23±0.31^{c}	56.60±1.48^{ab}	11.10±0.19^{a}	54.37±0.35^{a}
EMUSS	95.87±0.44^{ab}	8.33±0.17^{b}	91.67±0.17^{b}	8.73±0.52^{b}	1.27±0.06	75.00±0.49^{b}	58.33±0.74^{a}	10.10±0.52^{ab}	51.80±0.66^{b}
P-value	ns	0.01	0.01	0.001	ns	0.001	0.01	0.05	0.001

$^{a-d}$ Means with different superscript letters in a column within a category differ at 5% level of significance; ns = non-significant ; SEM = Standard error of the mean

Silages inoculated with EM and treated with urea plus EM had resulted in increased level of mineral matter (ash) as compared to the control. This might be attributed to the nature of molasses in EM treated silage because it has naturally high level of minerals. Abdalla [40] and Assefa *et al.* [41] reported molasses had 12.4 and 18.4 % ash, respectively. Similarly, Kassu [23] reported that the total ash contents increased because of dilution of coffee husk with different levels of chopped grass hay and due to the effect of EM since molasses naturally has high level of minerals.

UTSS in this study also showed the same trend of increase in the ash content. However, Abdalla [40] reported a decrease in the ash content of sorghum husk (*Butab*) when treated with urea. Similarly, Elkholy*et al.* [46] also reported a decrease in the ash content of urea and yeast with molasses treated corn silage.

The OM content of the sorghum stover has decreased in the order of EMSS<UTSS and EMUSS<SS and this might be attributed to the molasses added as a starting additive for EM activation and proliferation of the number of microbes and these eventually degrade the OM and ammonia released from urea modifying the lingo-cellulose bonds eventually increasing the nutritional value [26, 47].

The NDF and ADF values in UTSS were lower than the SS. The decline in the values of fiber fractions possibly due to the increase with the action of alkali in the feed that disturbed the cell wall components resulting in increasing the soluble fraction [48]. However, there is a significant increase in IVDMD value in EMSS. Maurya [49] explained that microbial populations (Yeasts and bacterial species) which are present in the EM had positive effects in feed degradability. More importantly, yeasts have an important role in utilizing feeds with high structural components. Similarly, Abera [20] reported a decrease in the values of OM, NDF and ADF fractions of EM treated barely, wheat and oat straw but an increase in the values of percent IVOMD values for the three straws. Samsudin *et al*. [44] also found lower values of NDF, ADF and ADL in fungal and fungal plus EM-treated rice straw than the untreated one.

The CP value obtained in the current study for SS is very low and it is comparable with the 3.1% Bediye*et al.* [50] but this value is higher than the value in Akinfemi *et al.* [51] who reported that the crude protein content of 2.54 % sorghum stover. Ali [39] and ElObied [52] reported CP value of 4.3% for sorghum straw used as basal roughage for feeding calves. However, Tolera [3], Assefa [19] and Gemiyo [53] reported 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, respectively. Varietal difference, agronomic practices and stage of harvest might attribute to the difference in CP. Owen [54] indicated that cereals crop residues are low in nutritive value because of their relatively low digestibility, low crude protein content and low content of available minerals and vitamins.

Generally a considerable change in the CP values of the treated sorghum stover was observed in this study. The CP content of EMSS increased by 81.9% that is from 2.93 (Untreated) to 5.33%. Comparable to the current values, Akinfemi *et al.* [51] reported that the crude protein content of fungal treated sorghum stover increased from 2.54 for the control to 4.5% for *Pleurotus ostreatus* and 4.59% for *Pleurotus Pulmonarius* treated substrates, respectively. Batool *et al*. [55] 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*. [44] reported that fungal-treated rice straw was inoculated with EM, there was a significant increment in CP content (5.96 %) of the rice straw compared with control (5%). 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% [23]. EM treated dry maize stovers ensiled with spent brewers' grains has shown good silage stability and increased in CP content [35]. The increase in CP content of EM treated sorghum stover in this study might be attributed to the microbial growth and proliferation during the ensiling process. But the difference in CP value in different works could be due to the type and stage at harvest of crop residue, the

dose of EM and molasses used and the management of silage. Maqbool *et al.* [56] reported that by degrading the lingo-cellulosic contents of rice straw, more nutrients are made available for ruminal micro flora, which in turn will sustain the longevity of the microbes. Mahesh and Madhu [57] 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.

The increase in the CP value of UTSS is comparable to the report of Mehari and Asghedom [58] who stated urea treatment sorghum stover was effective in upgrading the CP content by 79.7% (From 6.25% to 11.12%). The CP value in this work is higher than the value reported by Assefa *et al*. [19] who found a change in the value of CP from 4.7 to 10.3% when sorghum stover was treated with 4% urea. Fernandes *et al.*[59] reported CP values of 7.9, 15.9, 23.8 and 31.8% when urea was applied during sorghum ensilage for urea doses of 0, 2.5, 5.0 and 7.5%, respectively. Ngele *et al*. [60] reported that urea treatment of rice straw had remarkably enhanced the CP value from 4.44 to 12.35%. Fonseca *et al*. [61] also reported that urea-treated rye and wheat straw had CP value of 10.4 and 11.5%, respectively. However, Ali [39] obtained a CP value of 6.06 and 7.35% after treating sorghum stover with 2 and 4% urea, respectively. Similarly, Wambui *et al.* [62] reported that the urea treatment improved the CP content of maize stover from 5.1 to 8.3%. Batool *et al*. [55] also reported a range of CP values of 7.61 – 9.24% in urea treated different species of matured grasses which were initially having a range of 5.70 – 8.51% CP. These CP values are lower than the value recorded in the current study. The significant increment of CP value for urea treated sorghum stover in the current study shows the effectiveness of urea treatment in low quality roughages such as sorghum stover. Nguyen *et al*. [63] indicated that ammoniation of low quality feed with urea or ammonia solution increases levels in protein content. Chenost [64] reported that treatment with urea enriches the nitrogen content of the feed, multiplying it by two or three times its initial value at the average urea 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 [17] and Cañeque *et al.* [26]. Additionally, sorghum variety and stage of maturity are other factors which affect silage quality [37].

Similarly EMUSS in this study had increased the CP value of from 2.93 to 8.73%. The nitrogen in urea and the multiplying microorganisms in EM might contribute to the increase in CP content. Treatment with urea enriches the nitrogen content of the feed [64] and similarly, Syomiti *et al.* [35] reported treatment of crop residue with EM increased the CP content in the crop residue. Batool *et al*. [55] reported that treatment of four different species matured grasses with EM, molasses and urea had increased the CP value from range of initial 5.70 to 8.57 to that of 10.45 to 12.42%.

The EMSS showed lower values NDF, ADF and ADL than the SS. In consistent with these results, Abera [20] also obtained lower values for NDF, ADF and ADL in the EM treated barley, wheat and oat straws, respectively than the untreated straw. Similarly, Akinfemi *et al.* [51] reported lower values of NDF, ADF and ADL in sorghum stover treated with white-rot fungi than the control. These authors further discussed that the decrease in the fiber fractions may be the result of cellulase enzyme secreted by cellulolytic fungi. Samsudin *et al*. [44] reported among the rice straw groups treated with fungi and fungi and EM, there was reduction in the mean values of NDF and ADF when compared to the untreated rice straw and moreover, Elkholy *et al*. [46] reported the same trend of decrease in crude fiber fractions in corn silage.

The UTSS showed lower NDF value however, the ADF and ADL values for t he same treatment are higher than the SS. This result is in agreement with Dejene *et al.* [12] who reported lower NDF value (75.9%) for urea treated than untreated (77.2%) wheat straw but ADF and ADL values were higher (54.6 and 9.9%) for the urea treated wheat straw than the untreated straw value (48.2 and 7.9%), respectively. Cañeque [26] indicated the drop in neutral detergent fiber (NDF) of straws treated with urea, in comparison with the control 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*. [65] indicated the acid detergent fiber (ADF) content of the straw generally increases with the urea treatment which is still favored by a high moisture level. The same trend of lower NDF but higher ADF and ADL values were found in urea and EM treated sorghum stover (EMUSS) in the present study. However, in contrast to the current study, Assefa *et al.* [19] reported a decrease in ADF and ADL values of 4% urea treated when compared with the untreated sorghums stover. Keskin *et al*. [37] reported NDF and ADF values of urea and urea plus molasses treated sorghum stalk were lower than that of the control. Similarly, Elkholy *et al*. [46] reported a decrease in the crude fiber content of corn silage treated with urea and yeast with molasses.

In this study, there was an increase in IVDMD values of all the treated sorghum stover over the untreated one. There was an increase in IVDMD values of EM, Urea and EM plus Urea treated sorghum stover 51.07, 54.37and 51.80 %, respectively than the untreated (49.83). Regarding the *in vitro* DMD of untreated sorghum stover, Tolera [3] and Reddy *et al*. [45] reported an IVDMD value of 50.5 and 59.5%, respectively. However, Madebela *et al*. [66] reported that *in vitro* dry matter digestibility of twelve local sweet sorghum landraces harvested at dough stage showed an average 78%. The highest IVDMD value was recorded for UTSS could mainly be attributed to higher CP content and the effect of urea. Cañeque *et al*. [26] stated that the ammonia released from urea modifies the ligno-cellulosic bonds, which in turn increases its nutritional value.

Girma and Goetsch [24] stated that the urea treated low quality roughage will be higher in digestibility and crude protein than the untreated material. The value of IVDMD of UTSS in this study is comparable to Assefa *et al.* [19] who reported a value of 54.6% using 4% urea treatment of sorghum stover. Elnazeir and Suaad [67] also reported IVDMD value of 52% after 15 days fermentation of sorghum straw (94% DM) treated with 5% urea. Similarly, Dejene *et al.*[12] reported there was an increase in IVOMD by 19.6 % (From 45.5 to 54.4%) when wheat straw was treated with urea. Aregawi *et al*. [18] reported that *in vitro* OM digestibility of the sesame straw increased by 33% (from 32.8 to 43.5) in response to treating it with a 4% urea solution.

CONCLUSSION

The chemical and biological additives used is in this study suggested that there were improvement in CP and *in vitro* DM digestibility by treating and ensiling sorghum stover under favorable condition and enhancing the nutritional value of this crop residue in the area. Treatment of sorghum stover with urea had resulted in higher CP and *in vitro* DM digestibility. Therefore, we recommend this treatment for cattle production performed in the area.

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