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Evaluation of Wheat Straw's Physical Characteristics and Chemical Composition of Treated Ensiled with Urea-Molasses, Urea-Lime and Effective Microorganisms

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Abstract: This study was conducted to determine the effects of treatment on the sensory evaluation, chemical composition and *in vitro* dry matter digestibility of wheat straw. The treatment options were untreated wheat straw (T1), urea-molasses-treated wheat straw (T2), urea-lime treated wheat straw (T3) and effective microorganism-treated wheat straw (T4). A completely randomized design with five replications was employed to evaluate the chemical composition of the experimental diet and physical observation was performed to determine the sensory silage quality. The sensory evaluation of urea-molasses treated wheat straw (T2) after twenty-one days became brownish yellow with a predominant pungent smell and soft texture. In comparison, (T3) contains a minor pungent odor and a soft consistency with a pale-yellow color. There was no mold growth observed on T2 and T3. Effective microorganism-treated wheat straw (T4) contained a sweet yogurt odor and a soft consistency with a light-yellow color and showed some fungus on the top of the silage. The highest CP% was recorded by T2 (6.31%), followed by T3 (4.88%). *In vitro* DMD values revealed that all treated groups (T2, T3 and T4) were significantly different from the control group. The treatment cost was higher for the urea-molasses and effective microorganism-treated groups, followed by the straw treated with urea-lime and untreated straw. As a result, treating wheat straw with these additives improved the nutritional value. This study showed that urea-lime (T3) treatment of wheat straw was cost-effective for dry season feeding of cattle in the study area compared to the other treatments.

Key words: Effective Microorganisms · Urea Lime · Wheat Straw · Treatment and Molasses

INTRODUCTION

One of the core bases for livestock production systems is nutrition and correct nutrition is essential for ensuring sustained livestock productivity [1]. The main constraint of livestock production in Ethiopia is the variation in the quality and quantity of animal feed. The major reason for this constraint is the rapid conversion of natural grazing areas for crop production. As a result, crop residues are becoming increasingly important animal feed resources [2]. According to [3], grazing is the most common source of feed for livestock (54.54%), followed by crop residues (31.13%). To ensure proper utilization of feed resources, appropriate technological interventions need to be developed and transferred to the user community [4]. In addition to supplementation, many physical, biological and chemical treatment options have been studied globally to improve the nutritional quality of crop residues [5]. The goal of improving crop residue quality using potential treatment methods is to improve the nutritional value, palatability, intake and digestibility of feeds in poor and middle-income countries [6]. Wheat (*Triticum spp*.) straw is one of the dominantly available crop residues in Ethiopia. Treatment of such poor-quality roughage with urea and ammonium bicarbonate increased its CP from 3.2 (untreated) to 8.7% and 9.5%, respectively [7]. It was also reported that urea-lime treatment increased CP and OM and improved DMI and OMI compared to untreated wheat straw [8]. Similarly, wheat straw treated with 4% urea increased CP% from 3.2% to 6% and NDF was reduced from 80.7% to 74.3% compared to untreated wheat straw [9]. According to [10], treating wheat straw with urea (2%) plus lime (3%) resulted in significant improvements in

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nutritional content, intake and digestibility. However, there is very limited information on the sensory quality and chemical composition of wheat straw silage fermented with various treatment options in Ethiopia. Therefore, this study was initiated to determine the sensory quality, chemical composition, *in vitro* dry matter digestibility and treatment cost of wheat straw treated with urea-molasses, urea-lime and effective microorganisms.

MATERIALS AND METHODS

Description of the Study Area: The study was conducted at the Holetta Agricultural Research Center dairy farm. The center is located 29 km west of Addis Ababa at a latitude of 9°00’ N and 38°30’ E. The study area has an altitude of 2400 meters above sea level and receives a mean annual rainfall of approximately 1144 mm. The mean minimum and maximum temperatures are 6°C and 22°C, respectively. The soil types in the area are nitisol and vertosols. The major crops grown are teff, wheat, barley, oats, potatoes, oil crops and pulses. The experimental feed along with additives required for 100 kg of sun-dried straw are presented in Table 1.

Experimental Feed Collection and Preparation: The wheat straw of variety *Danda’a* used in this experiment was collected in January 2021 after crop harvest from the Holetta Agricultural Research Center on station plots. The straw was chopped to 5-10 cm before being subjected to the treatment options. The wheat straw was chopped into 5-10 cm lengths for the first treatment (control). Urea-molasses treatment T2 was prepared according to the procedure outlined by [11]. The solution was prepared using 5% urea and 10% molasses and allowed to dissolve fully in 80 liters of water. The solution was uniformly sprayed over 100 kg of air-dried wheat straw at a rate of 800 ml kg^{-1} straw mass. To prepare urea lime-treated wheat straw T3, the solution was prepared from a mixture of 2.5% urea and 2.5% quicklime and allowed to completely dissolve in 80 liters of water [12]. The solution was gradually sprayed on the straw at a rate of 800 ml kg^{-1} dry straw mass to achieve appropriate moisture contents in the final treated straws as recommended by [13]. In the last treatment T4, wheat straw was subjected to treatment prepared from a solution containing a blended mix of essential microbes called effective microorganisms. Adequate quantities of activated effective microbial solution, also called EM-2, were purchased from Weljijie private limited company located at Bishoftu. According to the procedure, one liter of EM-2 was dissolved in 18 liters of fresh water in the presence of 1 kg of molasses to make up a total volume of 20 litters of extended EM solution. The extended EM was sprayed directly on the wheat straw sample in a batch at a rate of 500 ml kg^{-1} straw [14]. The extended EM was prepared from the activated EM following the procedure. Three aboveground cement pits/silos with equal dimensions of 1.5x1x 0.8 m (length, width and height) were prepared per treatment for T2, T3 and T4. The walls of the pits were covered with polyethylene sheet, followed by placing, trampling and compacting batch by batch until filled to the pit’s capacity. Finally, the pits were sealed with plastic sheets and loaded on top by heavy stones to make them airtight. For all treatment options, wheat straw was left to ferment in the silo for twenty-one days as per the respective recommendations made for each case above.

Data Collection Procedures: The silage quality of treated straw was evaluated for visual appraisal, smell and texture. Evaluation was done subjectively with the participation of five people. Sample collection was performed carefully by grabbing the treated straw by hand and as much as possible minimizing the entrance of air into the silage container and placing the sample in plastic bags. The pH values of the treated wheat straw samples were determined by soaking 20 g in 100 ml of distilled water overnight and using the extract's benchtop digital pH meter [15].

The color, smell and texture parameters were checked and the result of each test was recorded. For the laboratory analysis, five representative samples from different sides were taken from the three respective silos to determine major response variations in feed proximate, detergent and *in vitro* dry matter digestibility fractions. Representative samples were dried in an oven at 65°C for

Table 1: Experimental feed with additives required to treat 100 kg of straw

Treatment	Silage material	Amount of Straw (kg)	Additives	Amount of additive	Amount of water (lt)
T1	Wheat straw	100	-	-	-
T2	Wheat straw	100	Urea + molasses	5kg +10 l	80
T3	Wheat straw	100	Urea +lime	2.5+2.5kg	80
T4	Wheat straw	100	EM	0.5l/kg	50

T1 = untreated wheat straw, T2 = Urea-molasses treated wheat straw, T3 = urea- lime treated wheat straw, T4 = Effective micro-organism treated wheat straw

72 hours. The dried materials were ground to pass through a 1 mm sieve for *in vitro* dry matter digestibility. DM, total ash and crude protein (CP) were analyzed using the procedure of [16]. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and permanganate lignin were determined following laboratory procedures of [17]. *In vitro* dry matter digestibility (IVDMD) was analyzed according to procedures of [18]. Calculation of feed cost analysis under each dietary treatment was based on comparison of straw treatment cost incurred per kilogram straw mass for the three dietary treatments and the cost incurred per kilogram of untreated straw mass. Treatment cost (chemicals, labor for chopping and ensiling the straw) for the three dietary treatments.

Statistical Data Analysis: Data were analyzed using the ANOVA procedures of R software version 4.1.0. Mean separations for all the parameters were subjected to the LSD test at P = 0.05.

The statistical model for the lab-based trial was $Yji = \mu + Ti + \varepsilon ji$, where Yji = response variable; μ = overall mean; Ti = treatment effect; and εij = random error.

RESULTS

Sensory Evaluation and pH: The effect of treatments on sensory appraisals, pH and fungus prevalence of untreated and treated wheat straws are summarized in Table 2. Sensory evaluation of urea-molasses-treated wheat straw (T2) silage revealed that it became brownish yellow with a pungent smell and soft texture. In comparison, (T3) contains a minor pungent odor and a soft consistency with a pale-yellow color. There was no fungal growth observed in T2 and T3. However, effective microorganism-treated wheat straw (T4), which contains a sweet and yogurt-like odor and a soft consistency with a light-yellow color, showed some fungus on the top of the silage. The pH values were 8.63, 8.30 and 4.27 for T2, T3 and T4, respectively.

Chemical Composition of Test Diets: The chemical composition of the dietary treatments is shown in Table 3. T1 had a significantly (P<0.001) higher dry matter content than T3, T4 and T2 because of the moisture content included during the treatment process to facilitate fermentation. The total ash contents for T2, T3 and T4 were highly comparable (P<0.001) and higher than those of the untreated wheat straw samples (P<0.001). The crude protein values were significantly different (P<0.001), T2>T3>T1>T4, in that order of importance. In T1 and T3, NDF and ADF constituents were significantly higher (P<0.001) than in T2 and T4. The IVDMD values were comparable for T2 and T4 but significantly (P<0.001) lower for T3 than for T1.

Straw Treatment Cost: The straw cost and treatment cost are presented in Table 4. The treatment cost is high for urea-molasses and effective microorganism-treated groups, followed by the straw treated with urea-lime and the cost of untreated straw. The total cost of treated straw was also higher for urea-molasses and effective microorganism-treated straw. The current market price and cost involved in treating a kg of straw on a DM basis are as indicated below. Wheat straw cost = 5.6 Birr/kg. Treatment cost (chemicals, labor for chopping and ensiling the straw) for the three dietary treatments: - 3.13, 2.75 and 2.95 Birr/kg straw mass of wheat straw treated using urea-molasses, urea-lime and effective microorganism solution, respectively. Costs that did not vary over the treatments (fixed costs) were not generally considered in the calculations.

Table 2: Sensory evaluation of of and pH of treated wheat straw

Treatments	Silage color	Silage textures	Silage smell	Mold stratus	pH
T1	Straw	Hard	-	-	-
T2	Dark yellow	Soft	Pungent	none	8.63
T3	Pale-yellow	Soft	Moderate pungent	none	8.3
T4	Light yellow	Soft	Sweet and yogurt	Few on top	4.27

T1=Untreated wheat straw, T2=Wheat straw treated with urea-molasses, T3=wheat straw treated with urea-lime, T3= Effective Microorganisms treated wheat straw

Table 3: Chemical composition and IVDMD of Experimental diet

Parameters	DM%	CP	Ash	NDF	ADF	ADL	IVDMD%
T1	93.1^{a}	2.94^{c}	10.5^{b}	76.48^{a}	53.39^{a}	6.31^{a}	47.90^{c}
T2	69.8^{d}	6.31^{a}	11.8^{a}	74.98^{b}	51.39^{b}	6.18^{a}	52.35^{a}
T3	75.2^{b}	4.88^{b}	11.5^{a}	76.14^{a}	52.86^{a}	5.75^{b}	50.90^{b}
T4	71.4^{c}	2.76^{d}	11.3^{ab}	53.43^{c}	51.12^{b}	5.64^{b}	53.30^{a}
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

$^{a-d}$ Means with different superscript letters in the column shows significantly different (P<0.05), T1=Untreated wheat straw, T2=Wheat straw treated with urea-molasses, T3=wheat straw treated with urea-lime, T3= Effective Microorganisms treated wheat straw, NDF= neutral detergent fiber, ADF =Acid detergent fiber, ADL= Acid detergent lignin, IVDMD=In vitro dry matter digestibility

Table 4: Experimental feed cost and treatment cost

S.no	Parameters	T1	T2	T3	T4
1	Wheat straw cost (birr/kg)	5.6	5.6	5.6	5.6
2	Treatment cost (birr/kg)	-	3.13	2.75	2.95
3	Total cost (birr/kg)	5.6	8.73	8.35	8.55

T1=Untreated wheat straw, T2=Urea-molasses treated wheat, T3=Urea-lime treated wheat straw, T4= Effective Microorganisms treated wheat straw

DISCUSSION

Sensory Evaluation and pH: The visual appraisal, color, smell and pH results in this study were an indication of good quality and showed EM as a biological inoculant and urea-lime and urea-molasses as chemical additives. Proper chopping, a uniform sprinkling of the additive solutions, rubbing to wet the straw with the solution and pressing to avoid air space might have contributed to good results of anaerobic fermentation. The wheat straw treated with urea molasses had a dark yellow color, a pungent smell and a soft texture, which agrees with the findings of [19], who found that the dark brown appearance and color of coffee husk silage is an indicator of silage that has good quality. The silage pH observed in the current study (urea-molasses and urea-lime) treatments was consistent with the results of [20], who reported a pH of 8.65 and 9.44 for urea-treated triticale straw at rates of 3 and 4.5%, respectively. The increase in pH could be due to the addition of ammonia in the form of urea. This result is in line with the results of [21], who concluded that adding ammonia increases the pH of silage to 8 or 9. With this high pH and ammonia effect on silage, the growth of mold and yeast populations is inhibited, which consequently increases the aerobic stability of the silage materials [22]. The silage color, aroma and pH observed in the effective microorganism-treated wheat straw agreed with the results of [14] who reported the results of teff straw treated with different levels of effective microorganisms. Moreover, the pH observed in the effective microorganism-treated wheat straw in the current study is comparable to the results of [23] who reported a pH of 4.27 in sorghum straw treated with effective microorganisms.

Chemical Composition of Test Diets: The observed improvement in the CP, NDF, ADF and ADL in urea-molasses treated wheat straw agrees with the finding reported for maize Stover and rice straw treated by urea-molasses [24, 25]. Moreover, improvement in the nutritional value by urea-lime treated wheat straw compared to untreated wheat straw in the current study can fairly be compared to previous findings conducted on urea-lime treated sesame straw in Ethiopia by [26] and to the results reported elsewhere by [27, 28]. The ash content was significantly affected by treatment, which could be justified by the higher mineral concentration in the molasses and quick lime (CaO) used to make up the solution for the respective treatment options. Lime and/or urea-lime inclusions in the treatment of wheat straw have also been reported to have improved CP, reduced cell wall composition and enhanced rumen degradation [29, 8, 12]. According to [30], using 2.2% urea+2.2% calcium hydroxide-treated rice straw for straw treatment could be an alternate treatment to 5.5% urea treatment in terms of effectiveness and treatment cost for lactating dairy cows. The IVDMD of wheat straw in the present study was significantly improved by all the treatment options used compared to the untreated straw. In support of the present study, [31] observed incremental changes in the IVDMD of sorghum Stover treated by EM and urea solutions. Similarly, the observed IVDMD in the current study is in line with that reported by [32, 33, 35], who found that treatment with EM of cereal straw resulted in a substantial reduction in the straw cell wall constituents (NDF, ADF and ADL).

However, the reduction in CP content observed in the EM-treated wheat straw compared to the untreated straw in the present study can be speculated to be due to the biochemical change that occurs in the soluble carbohydrates and protein during fermentation [36]. In agreement with the current study, [19] and [35] reported minor reductions in CP content. [14] also described that the nutritional contents of EM-treated teff straw decreased as the ensiling period advanced due to the solubility of the material. In contrast to the current finding, [32] and [37] observed significant improvements in the CP contents of EM-treated cereal residues. Any difference with previous but related studies' findings could be attributed to straw and variety types, the level of chemicals/microbial inoculants used in the respective cases and the environmental factors under which the trials were conducted. In general, all treatment options used in the current study resulted in significant changes in the proximate, detergent and IVDMD fractions when compared to untreated straw, implying an even broader scope of utilization of the various crop residue treatment options under the country's current socioeconomic and farming systems.

Straw Treatment Cost: Straw treatment cost indicated that each kg of wheat straw treated with urea-molasses, urea-lime and effective microorganisms was relatively cost-effective compared to the control diet. The costs of each kg of straw treated with T2, T3 and T4 were 3.13, 2.75 and 2.95 ETB, respectively. This result agreed with the report by [38], who showed that maize stover treated with urea was relatively cost-effective when compared to untreated maize Stover-based diets. Similarly, [39] reported that the prices of wheat straw and maize stover increased from 0.06 yuan/kg to 0.12 yuan/kg because of the treatment cost.

It is concluded that treating wheat straw with 2.5% urea + 2.5% quicklime could be an alternative treatment option to the 5% urea and 10% molasses treatment in terms of crop residue improvement. The findings of this study provide new and practical information on the use of low-quality roughage, such as wheat straw, with effective chemical treatment at a lower cost, as well as its adaptability for use in practical farming conditions.

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