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Evaluation of the nutritive value of sugar cane tops and its silage at Wondogenet, Sidama, Ethiopia

Aman Getiso *, Diribi Mijena and Edao Shanku

Ethiopian Institute of Agricultural Research, Wondogenet Agricultural Research Center, P.O. Box 198, Shashemene, Ethiopia.

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Abstract

The study was conducted at Wondogenet Agricultural Research Center to investigate the effect of urea and urea plus molasses treatment on nutritive value of sugarcane tops and its silage. The green sugarcane top that was purchased from the surrounding farmers during the harvesting time was chopped to the favorable size for silage and ensiled with or without 1% molasses, 4% urea and 4% urea + 1% molasses in plastic silos for 21 days. Results revealed that dry matter content of the silage varied between 30.13 % and 41.86%, protein content between 5.33% and 12.49%, ash content between 2.3% and 9.03%, NDF content between 64.84% and 73.1%, ADF content between 39.09% and 41.79%, pH between 4.15 and 4.47, Fleig score between 86.46 and 111.52, digestibility of dry matter between 56.3% and 58.4%, dry matter intake between 1.6% and 1.9%, relative feed value between 74.1 and 83.4, depending on the urea and urea plus molasses treated additives. Sugarcane top ensiled with urea-based additives showed better CP content than the treatments without additive and treated with molasses. Sugarcane top silage of the current study was of bad and/or unacceptable quality in terms of the NDF ratio and good and/or medium in terms of the ADF ratio according to the roughage quality standard for farm animals. In terms of the Fleig score, it was determined that the quality of the sugarcane top silage could be classified as "very good" (Fleig score >85) and the pH value of ≤ 4.53, was within the acceptable range in quality silage. Generally, adding urea and urea plus molasses additives improved nutritional value and utilization of sugarcane top silage.

Keywords: Molasses; Nutritive value; Silage; Sugarcane tops; Urea treatment

1. Introduction

Expanding urbanization and use of arable land for housing, recreation, and industrial development is diminishing grazing lands, with an increase in human population, more and more land was devoted to crop production only fragments of marginal lands were left for feed production. As a result, ruminants feed largely on crop resides as their basal diet [1]. Crop residues also has low digestibility that leads to poor intake, particularly when fed as the sole roughage [2]. Despite their vast use as a livestock feed, crop residues are naturally of low quality and do not fulfill the nutrient requirement of animals. Feed shortage is more aggravated during dry season in both the highlands and lowlands of Ethiopia [3].

This gap in feed supply can be filled by making silage from excess forage produced during the wet season [4]. Silage is the best method for preserving fresh forage with minimal losses for dry season. Silages can be used for lamb production together with grain when the pasture quality is low. The shortage of conventional feed resources is a major constraint for increased productivity of livestock and poultry in developing countries. Sugar cane tops are by-products making up

* Corresponding author: Aman Getiso; Email: aman.getiso@yahoo.com
Ethiopian Institute of Agricultural Research, Wondogenet Agriculral Research Center, P.O. Box 198, Shashemene, Ethiopia.

18-20% of the total biomass of the plant and have been widely studied as a basal diet for fattening and milking cattle [5].

Sugar cane tops contain less nitrogen than the required concentration for optimum fermentation in the rumen. It should be possible to supplement the rumen fermentation of cane tops through the use of nitrogen rich supplements. Adding urea to cane tops improves the digestibility of organic matter. Sugar cane tops are also poor in phosphorous [6]. It is an important feed resource for ruminants. Sugar cane tops is poor in protein (5.6%) and total digestible nutrients (46.80%). It is possible to increase the rumen fermentation of cane tops through judicious use of nitrogen - rich supplements, such treatment being an effective method for improvement of nutritive value in roughages [7]. The objective of this study is to determine the nutritive values of sugarcane tops and its silage treated with different additives.

2. Material and methods

2.1 Description of the study area

The experiment was conducted at Wondogenet Agricultural Research center. Which is found in Sidama Regional state, Wondogenet woreda. It is situated about 268 km south of Addis Ababa and 14 km south east of Shashemene. Its geographical location and altitude ranges from 38° 37'13''-38° 38'20'' East and 7° 5'23''-7° 5'52'' North and 1760-1920 meters above sea level respectively [8]. The area receives mean annual rain fall of 1128 mm with minimum and maximum temperature of 11 and 26°C, respectively [9].

2.2 Silage Preparation

Sugarcane tops was purchase from Wondogenet woreda farmers during harvesting time**.** After harvest, green and healthy sugarcane tops material was chopped to 2-5 cm length and carefully pre wilted during 1-4 h in the sun so that moisture content is reduced by 40-45% depending on the moisture content. Then it was ensiled in a micro silo or available sacks which are impermeable for oxygen transmission and then it was stored in a dry area. Rumen fermentation of cane tops should be augmented through the use of nitrogen rich supplements since it contains less nitrogen than the required concentration for optimum fermentation in the rumen [10]. Hence urea and molasses were used for this experiment to provide fermentable nitrogen for microorganisms in the sugarcane tops silages and rumen of the animal and fermentable carbohydrates respectively. Accordingly, chopped sugarcane tops was ensiled with 4% urea, 1% molasses and 4% urea + 1% molasses to be used in the experiments. Urea was diluted with water at a ratio of 1:1.5 when used as sole additive. When molasses alone, or urea and molasses were mixed, the amount of water used for dilution equaled the amount of molasses used by weight [11]. The chopped materials were weighed and thoroughly mixed with the respective additive on polyethylene sheet laid on concrete floor. The tightly packed silos were immediately closed, tightly sealed and placed under shade which is allow to ferment for 21 days at room temperature. Adequate samples of the respective untreated and treated materials were taken at ensiling, put in polyethylene bags, sealed and stored in deep freezer (-20°C), waiting for laboratory analysis.

2.3 Determination of Sugarcane top and its silage pH

For pH determination, about 20 g of frozen silage sample per treatment was taken in a beaker to which 100 ml of distilled water was added [12]. The samples were blended using a glass stirrer and left for one hour before filtering using filter paper. Silage pH was measured from the extract using a conventional digital pH meter (Hanna's Benchtop pH meter), calibrated with buffer solutions (pH 4 and 7).

2.4 Experimental materials (Treatments)

The experimental materials (treatments) used were: sugarcane top without additives and three silage treatment types (4% Urea, 1% Molasses, and 4% urea + 1% molasses) and ready for fermentative quality and nutritive value analysis.

2.5 Chemical Analysis

The nutritive values of the feeds were determined at the Animal Science Nutrition laboratory in Holeta Agricultural Research Center. Sub - sample of 500g of different silage treatment were oven dried at 65ºC until constant weight was obtained to determine the dry matter. The dried samples were then ground, made to pass through 1mm screen for chemical analyses of the samples. The crude protein, ether extract and ash content of the samples were analysed according to [13]. The fibre fractions; neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined according to [14].

The IVOMD was determined according to [15] by applying a two-stage digestion process, where 0.5 g samples were first fermented in rumen fluid obtained from donor animals (three rumen-fistulated steers), followed by acid (pepsin) digestion for 48 hours.

Digestible dry matter, dry matter intake and relative feed value were calculated by using the following equations [16]:

- Digestible dry matter (DDM%) = 88.9 -(0.779 X ADF%)
- Dry matter intake (DMI%) = 120 / NDF%
- Relative feed value (RFV) = (DDM% X DMI%)/ 1.29

By using the dry matter and pH values obtained in the laboratory, Fleig scores of the sugarcane top silages were calculated with the help of the following formula [17].

Fleig Score = 220+ (2 x% Dry Matter-15) -40 x pH

3. Results and discussion

3.1 Chemical composition of untreated sugarcane tops and its silage

The results pertaining proximate composition and cell wall constituents of untreated and urea-treated sugarcane top in terms of per cent DM, Ash, CP, NDF, ADF, ADL and IVDMD contents are presented in Table 1. Higher CP (12.5%) was observed in 4% urea followed by % 4 urea + 1% molasses (10.6%) treated sugarcane top and the CP increased by 59.1% and 34.9% for 4% urea and 4%urea+1%molasses treated sugarcane top respectively. Sugarcane top ensiled with urea-based additives showed better CP content than the treatments without additive and treated with molasses. Lower CP content was observed with untreated sugarcane top (7.85%) and sugarcane top treated with 1% molasses (5.33%) which were lower than the crude protein required for maintenance for ruminants [18] and implies that sugarcane top needs to be supplemented with nitrogen rich substances to make it a better feedstuff for ruminant. In similar manner [19] and [20] reported that the CP content of sugarcane top increased from 1.25 to 6.75 and from 4.2 to 8 per cent after urea treatment respectively. This could be due to urea is a non-protein nitrogenous compound that may increase the CP as well as the ammonia nitrogen content of silage prepared in this study. Similar with the present result, [21] also reported that ensiling green maize stover with additives improved CP contents by 25.51%. Bacteria are proteins in nature and contain more than 75% of their cell mass in the form of true protein and the increased CP content in sugarcane top silage treated with additives could be attributed to the microbial growth of lactic acid bacteria during the fermentation period and hence becoming part of the medium as the pH drops to 4 [22]. This result is also in agreement with the findings of [23] and [24] resulted in higher CP content than the control due to the addition of molasses on grass before ensiling and EM inoculation on coffee husks, respectively. The CP content of the current study treated with 4%urea (12.49%) and treated with 4% urea+1%molasses (10.59%) is higher than [25] reported 6.91% CP content of sugarcane top treated with 5% urea and 10% molasses for 21 days but higher than 5.33% CP content sugarcane top silage treated with 1% molasses of the current study.

The DM ratio has great importance in the full realization of chemical events during silage formation and it is the most important quality criterion used in the determination of silage quality [26]. The difference in the silage DM ratio between the sugarcane tops silages were also affected by the difference in DM losses, caused by chemical events in the fermentation process, according to different additives used. [27] and [28] reported that the DM contents of the material to be used for good quality silage (successful fermentation) should be between 28-42% and 25-40%, respectively. Hence the dry matter content of the current study is between 30.13-41.89, hence, in view of these values reported by the researchers, it was observed that all sugarcane top silage treated with different additives contained quite sufficient DM.

The NDF and ADF contents of the sugarcane top silages ranged from 64.84 to 73.1% and 39.09 to 41.79 % respectively. Sugarcane top silage of the current study was of bad and/or unacceptable quality in terms of the NDF ratio and good and/or medium in terms of the ADF ratio according to the roughage quality standard for farm animals reported by Rohweder et al. (1978) (<31%= top quality, 31-35%= very good, 36-40%= good, 41-42%= medium, 43-45%= bad and >45%= unacceptable for ADF; <40%= top quality, 40-46%= very good, 47-53%= good, 54-60%= medium, 61-65%= bad and >65%= unacceptable for NDF). The NDF and ADF of the sugarcane top silage of the current study fell in the range of the switchgrass cultivars silage studied for different purposes reported by [29; 30; 31; 32] ADF and NDF ratios varied between 21.3%-66.9% and 57.6%-86.5%, respectively. The NDF content of the current study treated with 1% molasses (73.1%) is higher than [25] reported 68.43% NDF content of sugarcane top treated with 5% urea and 10% molasses for 21 days but higher than 64.84% NDF content sugarcane top silage treated with 4%urea+1% molasses and similar with NDF content of sugarcane top silage treated with 4% urea (67.76%) of the current study. Low ADF and NDF contents

are usually desired for forage crops since these materials complicate digestion and consequently decrease the quality [33]. ADF and NDF contents determined in the sugarcane top silages of current study were similar to finding of [34] who reported NDF 66.20-77.80 and ADF 38.80-46.00 for green sugarcane top silage treated with urea and urea plus molasses. The NDF contents in sugarcane top silages with the addition of urea and urea plus molasses increases while ADF showed slight decrease. This decrease takes place because of the lower ADF content of the additives [35]. Generally, adding urea and urea plus molasses additives improved nutritional value and utilization of sugarcane top silage.

Table 1 Chemical composition (% DM) of fresh sugarcane tops and its silage

Parameters	USCT	SCT treated with 4% urea	SCT treated with 1% molasses	SCT treated with 4% urea + 1% molasses
DM	41.86	30.13	33.86	34.49
Ash	9.03	4.04	2.3	5.87
CP	7.85	12.49	5.33	10.59
NDF	65.54	67.76	73.1	64.84
ADF	41.79	39.09	39.41	39.5
ADL	4.76	5.17	5.22	5.34
IVDMD	54.85	57.26	58.02	58.83

USCT= Untreated green sugarcane tops, SCT = Sugarcane tops; DM = Dry Matter; CP = Crude Protein; NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; ADL = Acid Detergent Lignin; IVOMD = *in vitro* organic matter digestibility

3.2 Silage physical properties and Relative feed values of Sugarcane top silage

Table 2 pH value, Fleig scores, Digestible dry matter, dry matter intake and the relative feed value of sugarcane top silages from different feed additives

Parameters	Treatments			
	USCT	SCT treated with 4% urea	SCT treated with 1% molasses	SCT treated with 4% urea + 1% molasses
pH	4.43	4.15	4.47	4.2
DDM%	56.3	58.4	58.2	58.1
DMI%	1.8	1.8	1.6	1.9
RFV	80.0	80.2	74.1	83.4
Fleig Score	111.52	86.46	106.72	105.98

USCT = Untreated sugarcane top; SCT = Sugarcane top; DDM = Digestible Dry Matter; DMI = Dry Matter Intake; RFV = Relative Feed Value

pH value, Fleig scores, Digestible dry matter, dry matter intake and the relative feed value of sugarcane top silages as affected by different additives are presented in Table 2. pH formed during silage fermentation is one of the most important parameters determining the quality of fermentation [29] and it is reported that the optimum pH range is between 3.8-4.2 for the development of acidic milk bacteria in acidic environment [36]. The pH of the silages ranged from 4.15 – 4.47. High pH value is also observed in sugarcane top without additive which may be due to low concentration of fermentable carbohydrates [34]. According to [23] and [37] this result is not within the acceptance range for good silage in the tropics since all silage mixtures had pH scores values fell above 4 but in line with [38] stated that all silages that had a pH value of ≤ 4.53, was within the acceptable range in quality silage. According to the [39] and [40] description of the scale used as indices of silage quality assessment classification (pH>5.0 rated as bad, pH = 4.4-5.0 rated as moderate, pH = 4.1-4.3 rated as moderate, pH = 4.1-4.3 rated as good and pH≤4.0 rated as excellent); all silage mixtures of this study had good pH scores since pH values fell within 4.0-4.5. NPN always acts as a buffer during fermentation, requiring extra lactic acid to be produced to lower the pH enough for preservation, thus increasing DM loss [41].

Relative feed values of the sugarcane tops of the current study varied between 74.1 and 83.4. While the highest value was obtained from the sugarcane top silage treated with 4%urea+1% molasses, the lowest one was obtained from the sugarcane top silage treated with 1% molasses. The relative feed value of the current study is not in agreement and lower than the result by [33] reported that relative feed values varied between 88.55 and 110.90 on determination of silage characteristics and nutritional values of some Triticale Genotypes. One of the most important criteria used in the determination of the quality of silage feed is the FS, which is calculated based on the regression equation between DM and pH of the silage [42]. In this study the Fleig scores of the sugarcane top silages were ranging from 86.46-111.52 (Table 2.). In our study, it was observed that the Fleig scores of all sugarcane top silages except sugarcane top treated with 4% urea (86.46) was above 100 which indicated that desired pH and DM ratio is ensured [29]. But according to [17], all sugarcane silages were of very good quality (FP>85). Similar result was reported by [29] Fleig scores of all switchgrass cultivars other than the Shawnee cultivar (88.6) was above 100.

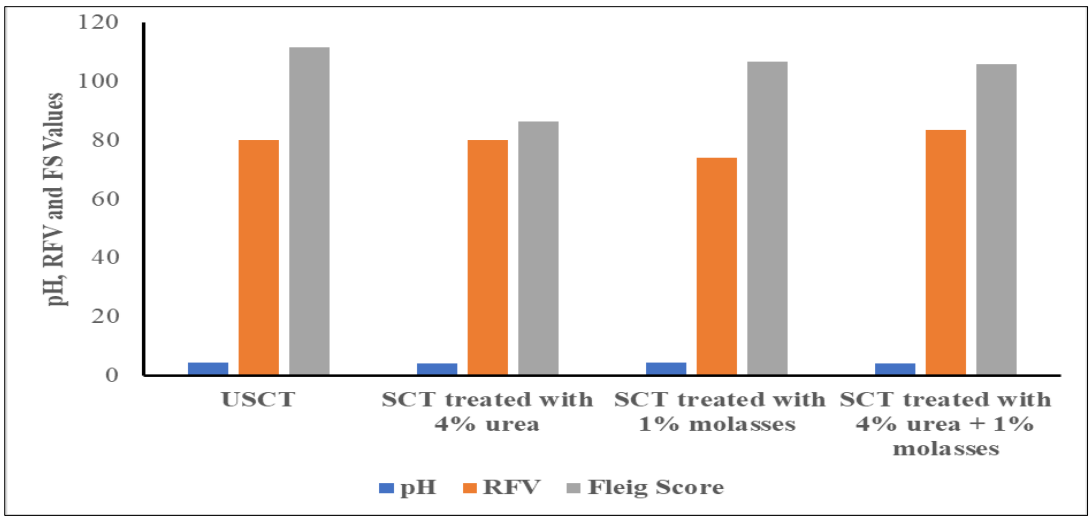

Figure 1 pH, Relative Feed Value and Fleig Score

4. Conclusion

Results of the current study revealed that sugarcane top ensiled with urea-based additives showed better CP content than the treatments without additive and treated with molasses. Sugarcane top silage of the current study was of bad and/or unacceptable quality in terms of the NDF ratio and good and/or medium in terms of the ADF ratio according to the roughage quality standard for farm animals. In terms of the Fleig score, it was determined that the quality of the sugarcane top silage could be classified as “very good” (Fleig score >85) and the pH value of ≤ 4.53, was within the acceptable range in quality silage. Generally, adding urea and urea plus molasses additives improved nutritional value and utilization of sugarcane top silage.

In this study carried out with sugarcane top silage treated with urea and urea plus molasses it was concluded that promising results were achieved in terms of silage quality and it could be an alternative source of roughage for livestock productions besides sugarcane top is copiously available and by reducing the major constraints limiting its utilization, more fodder will be made available during dry season. Hence, Sugarcane top was found to be suitable as an alternative silage crop with regard to both their chemical compositions and silage characteristics.

Demonstration and training farmers on proper feeding, processing and preservation of sugarcane top are important to improve utilization and reduce feed cost. Further studies on evaluating the sugarcane top and its silage with different ensiling periods, different silage additives, evaluating as a basal feed on performances ruminants. Feeding packages based on sugarcane top for small holder farmers for ruminants should be developed.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest regarding the publication of this paper.

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