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Silage Quality, Nutrient Content and Relative Feed Value of Urea and Molasses Added Sweet Maize [*Zea mays* (L.) *saccharata Sturt.*] Silage

Serhat Yıldız[1]

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ABSTRACT

Background: This study was carried out to determine silage quality, nutrient content, relative feed value (RFV), fermentation parameters and Fleig scores of sweet maize [*Zea mays* (L.) *saccharata Sturt*.] without the cob ensiled with urea or molasses.

Methods: Plant parts remaining from the sweet maize whose cobs were harvested were ensiled with the addition of 1% urea and 5-10% molasses. In the liquid samples collected from the silages, pH values, ammonia nitrogen (NH_3-N) and volatile fatty acid (VFA) concentrations were measured and the silage samples were subjected to crude nutrient analyses, RFV and Fleig score determination.

Result: Significant differences were found among the groups in terms of their dry matter (DM), organic matter (OM), crude ash (CA), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) values. The difference between silage groups was significant in terms of NH_3 and VFA values. In the analyses of Fleig scores, physical parameters and RFV results, the groups were found significantly different except for Fleig scores. In parallel with the increase in the concentration of urea used in the silage groups, there were reductions in Fleig scores, physical parameters and RFV values, while their CP levels increased. The molasses that was added to the silages led to a reduction in their silage pH, NH_3-N and butyric acid (BA) values and an increase in their lactic acid (LA) values. It was concluded that the additives used in this study contributed positively to the quality of the silages, all silages with additives were quality silages and they could be used as an alternative quality roughage resource in feeding ruminants.

Key words: Addition, Nutrient contents, Quality properties, Silage, Sweet maize without cob.

INTRODUCTION

Roughage constitute a large proportion of the rations of most ruminants and usually have low density. They are harvested during certain periods of the year and stored as fodder, hay or silage. Among these roughages, silage feeds are undeniably the highest quality nutritional resources for ruminants. Solving the deficit in roughage supply in the animal husbandry sector is depends on increasing the production of quality silages. Producing silages that are higher quality, more durable, contain nutrients similar to those in the initial material, have low costs and are economical will help solve this deficit. The usage of quality and water-rich silages instead of hay and fodder, which are the most frequently used roughage resources in ruminants, will reduce metabolic disease rates and feed costs by reducing the usage of concentrated feeds (Kara *et al*., 2013, Yıldız and Erdoğan, 2018; Yıldız *et al*., 2019).

Maize is usually the preferred feed crop for ensiling and the utilization rates of other products suitable for ensiling is very low. Resources that can be used as materials for silages include agricultural wastes and industrial wastes based on agricultural production, which are available in the form of large biomass. It was reported that pulps that are wastes of the sugar industry, fruit industry and alcoholic beverage industry, waste fruits and vegetables and the leaves and shoots of trees that grow in nature can be used not only as silage materials but also as silage additives (Yıldırım, 2015; Sümer *et al*., 2016).

[1]Department of Veterinary, Gevaş Vocational School, Van Yüzüncü Yıl University, Van-65700, Turkey.

Corresponding Author: Serhat Yıldız, Department of Veterinary, Gevaş Vocational School, Van Yüzüncü Yıl University, Van-65700, Turkey. Email: syildiz@yyu.edu.tr

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The main purpose of silage-making is to preserve the silage material with the minimum loss of nutrients. For this purpose, silage additives have been developed through the years to increase the nutritional value of silages and reduce some risks during the silage process. A silage additive must be safe, it must reduce DM losses, improve the hygienic quality of the silage, limit secondary fermentation, improve aerobic stability, increase the nutritional value of the silage, raise the performance of the animals, stimulate the growth of lactic acid bacteria and provide more returns to the producer than its cost. Molasses is prevalently used to provide readily available energy for lactic acid fermentation and stimulate silage fermentation. Urea that is used in the preparation of silages is in the classification of nutrients among silage additives and it is used to increase the nitrogen content in the ensiling of plants that have low nitrogen content. Additionally, urea reduces the degradability of proteins in the silage environment, improves aerobic stability of silages and prevents the growth of yeast and molds thanks to its antifungal effects (Baytok *et al*., 2005; Meeske, 2005; Canbolat *et al*., 2014; Keleş, 2017).

Sweet maize (*Zea mays L. saccharata Sturt*.) is one of the plants that can be considered among agricultural wastes, has several different areas of utilization and can be used as animal feed. Sweet maize is a variety of maize that is consumed by humans in fresh, frozen, or canned forms (Revilla *et al*., 2021; Kılınç *et al*., 2021). Byproducts that can be given to animals are produced in the production of sweet maize for human consumption. These include the stems of sweet maize that remain in the field after harvesting, sweet maize silages obtained from unharvested fields or remaining stems and processing wastes of facilities that produce canned corn (Dyk, 2009). İdikut *et al.* (2009) stated that byproducts of sweet maize can be preserved to a satisfactory extent by ensiling and they have potential nutritional value for ruminants.

The aim of this study is to identify the most suitable silage-making technique for sweet maize without the cob and determine the silage quality, nutrient content, relative feed value, fermentation parameters and Fleig scores of silages prepared with different ratios of silage additives.

MATERIALS AND METHODS

This study was carried out at Van Yüzüncü Yıl University in 2020-2021. The sweet maize [*Zea mays* (L.) *saccharata Sturt*.] without the cob (Merit F1) that was used in this study was obtained from a producer located in the Gevaş district of the province of Van in Turkey, while the urea and molasses were purchased from the market in the province.

Plant parts remaining from the sweet maize whose cobs were harvested in the milk dough period were ensiled with molasses and urea at different ratios by weight and 6 groups were created, including Control (0% urea + 0% molasses), Control + 0% urea + 5% molasses, Control+ 0% urea + 10% molasses, Control + 1% urea + 0% molasses, Control + 1% urea + 5% molasses and Control + 1% urea + 10% molasses. A total of 30 silage samples, including 6 groups with 5 replicates each, were prepared in 1-liter glass jars (Table 1). The lids of the jars were drilled, the jars were put upside down and the effluent was allowed to drain for 48 hours (Karadağoğlu and Özdüven, 2019; Yıldız *et al.* 2022a; 2022b). The drilled jar lids were sealed with duct tape at the end of 48 hours when the drainage process ended. After 70 days of incubation, the jars were opened for analysis.

After the silages were opened, the pH values of the silage liquids were measured with a digital pH meter (Polan *et al.* 1968). The distillation method was used to calculate the NH_3-N concentration of these samples (Markham, 1942). The acetic, propionic, butyric and lactic acid levels of the silages were determined by the Agilent Hi-Plex organic acid column in the HPLC device (Suzuki and Lund, 1980). All of the samples were dried at 65°C for 48 hours and ground to 1 mm in a laboratory mill. Dry matter (DM), crude protein (CP) and crude ash (CA) analyzes in silage materials were performed according to the Weende analysis system (AOAC, 2000) and ADF and NDF analyzes were performed according to the method reported by Goering and Van Soest, (1970).

Fleig scores of silages were calculated using the equation reported by Kılıç, (1984).

$$\text{Fleig Points} = 220 + (2*\%\ DM - 15) - 40*pH.$$

The relative feed value (RFV) method, which was developed in the US for quality control in the alfalfa plant, is now being used for all plants. The calculation of RFV is based on the ADF and NDF values of the roughage and the estimation of the potential consumption of the roughage by the animal and the energy it will provide. Accordingly, the RFV for alfalfa is assumed to be 100. It is accepted that the quality of the feed decreases as RFV results fall below this value (Yavuz, 2005; Kaya, 2008; Özdemir, 2019).

According to Van Dyke and Anderson (2000), for the formulae required to calculate RFV, first, the digestible dry matter (DDM) value is calculated using the ADF value.

$$\%\ DDM = 88.9 - (0.779 * \%\ ADF)$$

Using the NDF value, the dry matter yield (DMY) is determined according to the live weight of the animal.

$$\%\ DMY = 120/NDF$$

The DDM and DMY values are used in the formula to calculate RFV.

$$RFV = (\%\ DDM) * (\%\ DMY) * (0.775)$$

The analysis scheme recommended by the German Agricultural Society (DLG, 1987) that was used to analyze the physical characteristics of the silages is given in Table 2 (Canbolat, 2019).

Analysis of variance was used in the statistical evaluation of the data obtained from the study and Duncan's multiple comparison test was used to determine the difference between groups (Steel and Torrie, 1980). The significance levels of the results were considered as $P<0.05$.

RESULTS AND DISCUSSION

Nutrient contents of the silages

Nutrient contents of urea and molasses added sweet maize without the cob silages are given in Table 3. When the nutrient contents of these silages were examined, the differences between the groups were found to be significant in terms of DM, OM, CA, CP, DNF and ADF values ($P<0.05$).

One of the most important problems to be solved in the development of animal husbandry is to meet the need for quality and cheap roughage adequately. It is very important to use quality, alternative roughage, which consists of foods that are not used for human consumption and are also cheap, in ruminant feeding. Moreover, turning wastes remaining after plant production into quality feed and using them in animal rations will provide several benefits. Considering this issue, the fodder that remains after the production of fresh maize can be utilized in silage-making. In this study, the nutrient content, silage quality and relative feed value parameters of silages of the sweet maize supplemented with urea and molasses at different ratios were examined. In this trial, the cob of the sweet maize was harvested in the milk dough period and the remaining plant parts were ensiled by adding molasses and urea at different ratios by weight.

When the nutrient contents of the silages were examined (Table 3), it was determined that the additives not only increased the CP levels of the silages but also contributed to their quality positively. Canbolat *et al*., (2016) determined the DM, CA, CP, NDF and ADF sweet maize without the cob silages as 29.42-32.54%, 4.51-4.63%, 7.19-7.77%, 52.74-57.22% and 31.36-34.53%, respectively. Compared to their values, the silages in this study without additives had lower DM (26.15%), CP (6.10%) and NDF (51.03%) values, higher CA (7.93%) values and similar ADF (32.47%) values. It is believed that this difference originated from the fact that the harvest periods were different. In another study (Kaewpila *et al*., 2021), the DM, CA, CP, NDF and ADF contents of the control group among groups of sweet maize silages were found as 21.9%, 7.7%, 9.05%,

Table 1: Trial layout of the study.

Silage groups	Recurrence
1. Group: Control+ 0% urea + 0% molasses (Additive-free)	5
2. Group: Control + 0% urea + 5% molasses	5
3. Group: Control + 0% urea + 10% molasses	5
4. Group: Control + 1% urea + 0% molasses	5
5. Group: Control + 1% urea + 5% molasses	5
6. Group: Control + 1% urea + 10% molasses	5

Table 2: Analysis scheme for physical characteristics of silages.

Physical property			Score
1. Odor			
1.1. No butter (Butyric) acid odor, slightly sour, fruity and aromatic odor			14
1.2. A small amount of butter acid, strong sour odor and slight escalation			8
1.3. Moderate butter acid odor, strong escalation-musty odor			4
1.4. Strong butter acid or ammonia odor, very slight sour odor			2
1.5. Strong decomposition, ammonia or musty odor			0
2. Color			
2.1. Preserved its color at the moment it was ensiled (brown in withered silage)			2
2.2. Slightly changed color (yellow to brown)			1
2.3. Completely changed color (reseda green, light yellow, or mold formation)			0
3. Structure			
3.1. Intact leaves and stems			4
3.2. A slightly deteriorated structure of leaves			2
3.3. A deteriorated structure of leaves and stems, musty and dirty			1
3.4. Rotten leaf and stalk			0
Score	Quality class	Nutrient loss	Feed-related information
20-16	1- Very Good-Good	10-15%-15-20%	Caution for shelter and hygiene
15-10	2- Satisfactory	20-25%	To be given while milking
9-5	3- Moderate	25-50%	To be given to dairy cattle
4-0	5- Unusable, Poor	50% or above	Unusable as feed

Table 3: Nutrient contents of sweet maize without the cob silages with urea and molasses additives (DM %; Mean±SE).

Groups	N	DM %	OM %	CA %	CP %	NDF %	ADF %
Control	5	26.15±0.18^{c}	92.07±0.53^{a}	7.93±0.53^{b}	6.10±0.11^{e}	51.03±0.52^{c}	32.47±0.39^{bc}
Control + 0% urea + 5% molasses	5	26.40±0.35^{bc}	92.86±0.12^{a}	7.14±0.12^{b}	6.53±0.14^{de}	49.23±0.60^{d}	30.91±0.31^{c}
Control + 0% urea + 10% molasses	5	27.99±0.44^{a}	92.62±0.06^{a}	7.38±0.06^{b}	6.71±0.04^{d}	48.50±0.66^{d}	29.12±0.40^{d}
Control + 1% urea + 0% molasses	5	27.18±0.36^{ab}	93.13±0.14^{a}	6.87±0.15^{b}	8.75±0.20^{c}	52.03±0.58^{c}	33.92±0.62^{b}
Control + 1% urea + 5% molasses	5	27.42±0.14^{a}	90.91±0.12^{b}	9.09±0.12^{a}	11.54±0.10^{b}	65.04±0.33^{a}	39.83±0.31^{a}
Control + 1% urea + 10% molasses	5	27.97±0.33^{a}	90.07±0.62^{b}	9.93±0.63^{a}	12.14±0.31^{a}	62.96±0.66^{b}	39.73±1.01^{a}
P-value		0.001	0.000	0.000	0.000	0.000	0.000

DM: Dry matter, OM: Organic matter, CA: Crude ash, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber. a,b,c,d,e: Differences between means with different superscripts in the same column are significant (P<0.05).

68.7% and 41.6%, respectively. When these values are compared with the values obtained in our study; It is thought that the DM (26.15%) value is low, the CP (6.10%), NDF (51.03%) and ADF (32.47%) values are high and the CA (7.93%) values are similar and these differences are thought to be due to the varietal difference. In a similar study conducted with sweet maize stem silages by Ahmad *et al*., (2018), the same parameters in the group created with the addition of 6% molasses and 0.9% urea were determined respectively as 23.50%, 10.15%, 9.20%, 71.39% and 45.62%. When these values are compared with the values obtained in this study, the DM (26.40%) values in our study were higher, the CA (7.14%), CP (6.53%), NDF (49.23%) and ADF (30.91%) values in our study were lower and the differences between these two studies may be associated with differences in materials used and harvesting periods.

Fermentation quality of the silages

Silage fermentation parameters are some of the significant criteria in the determination of silage quality and the parameter values that were found in this study are given in Table 4. The pH value of the silage is an important parameter that determines the fermentation levels inside the silo. The optimum pH value for a quality corn silage is between 3.7 and 4.2 (Kung and Shaver, 2001). In this study, pH values of silages were determined in the range of 4.28-4.42. These values were close to the optimum values and the lowest pH values were found in the 0% urea + 5% molasses group. The highest NH_3 value was in the 1% urea + 0% molasses silage (123.28 mg.dl-1), the lowest NH_3 value was in the 1% urea + 10% molasses silage (37.07 mg.dl-1) and silage groups for NH_3 value It was determined that the difference between (P<0.05). The highest LA and the lowest BA values were found in the 0% urea + 10% molasses group, the highest AA value was in the control group, the highest BA value was in the 1% urea + 10% molasses group and the difference between the groups in terms of silage VFA was significant (P<0.05).

As seen in Table 4, the molasses that was added as an easily digestible additive to the silages led to reductions in silage pH (Control + 0% urea + 5% molasses group), NH_3-N (Control + 1% urea + 10% molasses group) and BA (Control + 0% urea + 10% molasses group) values and an increase in LA (Control + 0% urea + 10% molasses group) values. İdikut *et al*., (2009), who investigated fermentation criteria in sweet maize stem silages, determined the LA, AA, BA, NH_3-N and pH values of the silages respectively as 61.34, 15.19, 0.37, 145 (g/kg DM) and 3.76. The values reported by İdikut *et al*., (2009) were higher compared to ours in terms of LA (1.42%) and AA (0.85%) and lower compared to ours in terms of BA (0.72%), NH_3-N (58.90%) and pH (4.30). In another study (İptaş and Avcıoğlu, 1993), the authors reported pH and LA parameter values of 4.25 and 1.49% for sweet maize silages were found to be similar to the values determined in this study. In their study on sweet maize stem silage, Kaewpila *et al*., (2021) reported the LA, AA, BA, NH_3-N and pH values of the control group to be 91.80, 25.20, 1.20, 1.41 (g/kg DM) and 3.87 respectively. Compared to their results, the results of our study were higher for LA (1.42%) and AA (0.85%) and lower for BA (0.72%), NH_3-N (58.90%) and pH (4.30). The reason for these differences may be the different growing conditions of sweet maize and the different materials used in these studies. In a study that was carried out on silages that were obtained by adding urea and molasses to Italian ryegrass at different ratios, the ranges of pH, LA, AA, BA and NH_3 concentrations as fermentation parameters were reported respectively as 4.64-7.24, 0.02-3.54, 0.16-0.75, 0.16-1.35 and 0.34-2.16. Among these values, pH values were higher, LA, AA and BA values were similar and NH_3-N values were lower compared to those obtained in this study. These differences may have originated from the differences in the silage materials that were used and the differences in the ratios of molasses addition (Gürsoy *et al*., 2022). In a study that was performed by Demirel and Yıldız, (2001) on barley silages, silages with 5% and 10% molasses addition and 1% urea addition were made. The lowest pH and BA values obtained in the study conducted by these researchers were determined in the groups containing 5% molasses and 10% molasses, respectively, similar to the values obtained in this study. The highest LA concentrations in the study conducted by Demirel and Yıldız, (2001) were found in the group of silages containing 10% molasses and 1% urea, while the highest concentrations in our study were found in the group of silages containing only 10% molasses. In both studies, the addition of molasses to silage materials had a positive effect on silage fermentation.

Table 4: Fermentation quality of sweet maize without the cob silages with urea and molasses additives (Mean±SE).

Groups	N	pH	NH_3-N mg.dL^{-1}	LA %	AA %	BA %
Control	5	4.30±0.01	58.90±0.56^{c}	1.42±0.21^{a}	0.85±0.06^{a}	0.72±0.06^{bc}
Control + 0% urea + 5% molasses	5	4.28±0.09	64.28±1.93^{bc}	1.45±0.18^{a}	0.37±0.13^{b}	0.45±0.13^{bc}
Control + 0% urea + 10% molasses	5	4.33±0.11	65.92±3.65^{b}	1.82±0.13^{a}	0.41±0.13^{b}	0.38±0.20^{c}
Control + 1% urea + 0% molasses	5	4.38±0.03	123.28±1.68^{a}	1.65±0.08^{a}	0.61±0.14^{ab}	0.51±0.12^{bc}
Control + 1% urea + 5% molasses	5	4.35±0.01	44.62±1.09^{d}	0.62±0.12^{b}	0.39±0.06^{b}	0.92±0.20^{b}
Control + 1% urea + 10% molasses	5	4.42±0.01	37.07±1.66^{e}	0.40±0.02^{b}	0.36±0.05^{b}	1.45±0.18^{a}
P-value		0.128	0.000	0.000	0.027	0.001

NH_3-N: Ammonia nitrogen, LA: Lactic acid, AA: Acetic acid, BA: Butyric acid, pH: Scale of acidity. a, b, c, d, e: Differences between means with different superscripts in the same column are significant (P<0.05).

Table 5: Fleig scores, physical analysis results and RFV results of sweet maize without the cob silages with urea and molasses additives (Mean±SE).

Groups	N	Fleig scores	Qualifications class	Physical analyzes	Quality class	RFV
Control	5	85.30±0.97	Excellent	20.00±0.00[a]	Excellent	115.99±1.72[b]
Control + 0% urea + 5% Molasses	5	86.67±3.95	Excellent	19.80±0.02[a]	Excellent	122.54±4.06[a]
Control + 0% urea + 10% molasses	5	87.85±1.02	Excellent	20.00±0.00[a]	Excellent	127.10±5.00[a]
Control + 1% urea + 0% molasses	5	84.00±1.16	Excellent	20.00±0.00[a]	Excellent	111.78±2.13[b]
Control + 1% urea + 5% molasses	5	85.93±0.50	Excellent	19.00±0.00[b]	Excellent	82.76±1.49[c]
Control + 1% urea + 10% molasses	5	84.14±0.61	Excellent	17.60±0.04[c]	Good	85.65±3.94[c]
P-value		0.641		0.000		0.000

RFV: Relative feed value. a,b,c: Differences between means with different superscripts in the same column are significant ($P<0.05$).

Fleig scores, physical analysis results and RFV results of silages

The Fleig scores, physical parameters and RFV results of the sweet maize without the cob silages with urea and molasses additives are presented in Table 5 and there were significant differences among the groups in terms of all these parameters, except for Fleig scores ($P<0.05$). For all silages that were tested in this trial, the quality classes based on Fleig scores were “very good”, the quality classes based on physical parameters were “very good” for all groups except for the 1% urea + 10% molasses group and the highest RFV results were found in the 0% urea + 10% molasses group.

As seen in Table 5, there were decreases in Fleig scores, physical parameters and RFV results in parallel with the increase in urea added to silages. The addition of molasses to the silages gave higher Fleig scores and RFV results compared with the control group. İptaþ and Avcıoğlu, (1993) determined the Fleig score and physical assessment score of sweet maize silages as 100 and 20, respectively. Their Fleig score was higher compared with the scores found in our study, whereas the physical assessment results of the two studies were similar. Geren *et al*. (2014) reported the feed value results of Napier grass (*Pennisetum hybridum*), Chinese silver grass (*Miscanthus sinensis*), sugarcane (*Saccharum officinarum*), dent maize (*Zea mays* L. *indendata*), hybrid sorghum-sudangrass (*Sorghum bicolor* × *Sorghum sudanense*) and sorghum (*Sorghum bicolor*) silages for the 2nd year of their trial as 73.8, 70.3, 121.7, 193, 122.2 and 128.6, respectively. Compared with those found in our study, the values of dent maize were higher, the values of Napier grass and Chinese silver grass were lower and the values of sugarcane, hybrid sorghum-sudangrass and sorghum were similar.

CONCLUSION

When the results obtained from this study were evaluated, quality silages were obtained by ensiling the sweet maize without the cob adding 1% urea or 5-10% molasses. In parallel with the increase in the concentration of urea used in the silage groups, there were reductions in Fleig scores, physical parameters and RFV values, while their CP levels increased. The molasses which was added as an easily digestible additive to the silages led to reductions in silage pH, NH_3-N and BA values and an increase in LA values. It was concluded that the additives used in this study contributed positively to the quality of the silages, all silages with additives were quality silages and they could be used as an alternative quality roughage resource in feeding ruminants.

Ethical statement

For this study, it was decided that there is no need to obtain “Study and Research Final Results Approval Certificates” in accordance with the relevant article of the regulation, dated 23/02/2023-2023/04-02 of Van Yüzüncü Yıl University, Animal Experiments Local Ethics Committee.

Conflict of interest

Authors have declared no conflict of interest.

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