Research Paper

Quality properties of sunn hemp (*Crotalaria juncea* L.) and maize (*Zea mays* L.) silages

*Propiedades de calidad de ensilaje de Crotalaria (*Crotalaria juncea *L.) y maíz (*Zea mays *L.)*

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Abstract

Maize is an ideal forage crop for ensilage because of its high levels of fermentable carbohydrates, although it is low in protein. Sunn hemp is a legume with a high crude protein content with potential to be used in combination with maize to provide a silage with a higher protein content. Different percentages of sunn hemp-maize mixtures of 80-20, 60-40, 40-60 and 20-80 respectively were compared to silages of sole maize and sunn hemp. In the laboratory study, DLG classifications (color, smell, structure, total score and quality class), silage loss (%), silage pH, dry matter content, flieg score, crude protein content, crude ash content, NDF, ADF, metabolic energy (MJ kg/DM), dry matter intake, percent digestible dry matter and relative feed value were determined at the end of 60 days ensilage. The crude protein contents of silages increased as the sunn hemp ratio in the mixtures increased. In addition, pure sunn hemp silage and mixtures, especially 80% sunn hemp mixed with 20% maize, were found suitable for silage and it was concluded that sunn hemp and sunn hemp-maize silage mixtures could be used in animal husbandry.

Keywords: Ensilage, feed value, forage crop, legume mixture, protein supply.

Resumen

El maíz es un cultivo forrajero ideal para ensilaje por sus altos niveles de carbohidratos fermentables, aunque es bajo en proteínas. La crotalaria es una leguminosa con un alto contenido de proteína cruda con potencial para ser utilizada en combinación con el maíz para proporcionar un ensilaje con un mayor contenido de proteína. Se compararon diferentes porcentajes de mezclas de crotalaria-maíz de 80-20, 60-40, 40-60 y 20-80 respectivamente con ensilajes de sólo maíz y crotalaria. En el estudio de laboratorio, clasificaciones DLG (color, olor, estructura, puntaje total y clase de calidad), pérdida de ensilado (%), pH del ensilaje, contenido de materia seca, puntaje de flieg, contenido de proteína bruta, contenido de ceniza bruta, NDF, ADF, energía metabólica (MJ kg/MS), consumo de materia seca, porcentaje de materia seca digestible y el valor relativo del alimento se determinaron al final de los 60 días de ensilaje. El contenido de proteína cruda de los ensilajes aumentó a medida que aumentaba la proporción de crotalaria en las mezclas. Además, el ensilaje de crotalaria pura y las mezclas, especialmente el 80% de crotalaria mezclada con el 20% de maíz, resultaron adecuados para el ensilaje y se concluyó que la crotalaria y las mezclas de ensilaje de maíz y crotalaria se podrían utilizar en la cría de animales.

Palabras clave: Cultivo forrajero, ensilaje, mezcla de legumbres, suministro de proteínas, valor alimenticio.

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Introduction

The constant growth of the world population requires the development of productive and efficient agricultural practices to meet food demand. Turkey is very suitable for animal husbandry with the required natural resources and ecological conditions and the livestock sector is important for the general economy (Seydosoglu 2019). Roughages, one of the indispensable feed sources of livestock, are mainly obtained from meadow pasture areas and forage crop production in field agriculture (Moore et al. 2020). According to 2018 data, total hay production of these two sources in Turkey was 31 million tons, which is not sufficient for livestock needs (Acar et al. 2020).

Turkey's ecological conditions and topography allows the cultivation of many forage plants (Tan and Yolcu 2021). In addition to traditional forage crops, growing alternative forage crops will help to prevent feed shortages. Many studies reported that sunn hemp (*Crotalaria juncea* L.), which was previously not cultivated in Turkey, can be successfully grown in regions with Mediterranean climatic conditions (Demiroğlu Topçu and Özkan 2019).

Maize silage is one of the most important forage crops worldwide thanks to its high biomass yield, high energy values and the high content of non-structural carbohydrates that favor the fermentation process. Protein contribution to the ruminal system is low in maize silage (Colombini et al. 2010). Legume forage crops such as sunn hemp and soybean can be ensiled by mixing up to 50% with maize in order to increase the protein content in maize silage (Zavala et al. 2011; Sulas et al. 2012).

The aim of this study was to determine the sensory and chemical silage quality properties of silages prepared with different ratios of maize and sunn hemp under Mediterranean climate conditions.

Materials and Methods

Site description and agronomic details

This research was carried out in the experimental fields and silage laboratories of the Field Crops Department, Faculty of Agriculture, Ege University in Izmir, Turkey during the 2019 growth season. Izmir has typical Mediterranean climate conditions and a silty-clay loam soil with pH 7.8, organic matter (1.13%), salt (0.075%), total N (0.11%), available phosphorus (40 ppm) and

available potassium (400 ppm). The climate and soil properties at Izmir, Turkey are favorable for sunn hemp cultivation.

The Tillage Sun cultivar of sunn hemp and C-955 cultivar of silage maize were used for the study. The plants were grown separately in the field on approximately 0.004 ha each. The plants were simultaneously sown at the beginning of July 2019 under second crop planting conditions. The sunn hemp was seeded in rows with 40 cm row spacing (50 kg/ha) and maize was sown in rows with 70 cm row spacing (95.238 plants/ha). Conventional agriculture practices were carried out during the growing season. Since there were no significant problems of pests, diseases or weeds in the study site, no chemical was applied.

Plant harvesting and ensiling process

Sunn hemp was harvested at the beginning of flowering and maize was harvested at the dough stage simultaneously from the middle rows of the plots. Plants were harvested by hand by cutting at soil level. Plants were chopped to about 2-3 cm in size and the chopped materials were thoroughly mixed to attain homogeneity. Different mixture ratios (sunn hemp %-maize %; 100-0, 80-20, 60-40, 40-60, 20-80, 0-100; on the basis of fresh weight) were used for preparing the silage in four replications with a randomized design (6 treatments x 4 replications = 24 silage samples).

Samples of 500±20 g of each silage mixture were placed in separate vacuum bags (thickness 110 microns or more), and after 99.9% of the air was removed by vacuum, bags were glued and closed (Johnson et al. 2005). The bagged silage samples were stored in a dark and cool environment at 24±4°C for 60 days.

Assessment of silage samples

Physical quality analysis for DLG classifications (DLG 1987) and chemical properties were examined after 60 days of fermentation. The silage loss was calculated according to Danley et al. (1973). The pH of the silage juice was measured by the HANNA HI 2211 pH/ORP pH meter (Hanna Instruments Ltd., USA). The silage samples were dried in an oven at 65°C for 48 hours, ground and passed through a 2 mm sieve to prepare for chemical analysis. Nitrogen content was determined by the Kjeldahl method and multiplied by the coefficient of 6.25 to obtain crude protein concentrations (AOAC 1990). Crude ash content was determined at 550ºC (Bulgurlu

and Ergul 1978). The neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentrations were analysed by the sequential detergent analysis method (Van Soest et al. 1991). Flieg score, metabolizable energy (ME), estimated dry matter intake (DMI), digestible dry matter (DDM) and relative feed value (RFV) were determined by using the following commonly used formulas (Kirchgessner and Kellner 1977; Van Dyke and Anderson 2000; Morrison 2003).

Flieg score = 220 + (2 x % Dry Matter - 15) - 40 x pH
Dry Matter Intake (% of BW) = 120 / (% NDF)
Digestible Dry Matter (%) = 88.9 - (0.779 x % ADF)
Relative Feed Value = (DMI x DDM) / 1.29
Metabolizable Energy, MJ kg/DM = 14.70 - 0.150 x ADF

Statistical analysis

Statistical analyses were conducted using ANOVA, Statistical Analysis System version 7.0 (SAS Institute 1998) for a completely randomized design. The treatment means were compared by the LSD test described by Steel and Torrie (1980).

Results

Physical observation values (color, smell, structure) and

DLG classifications of the silage samples are given in Table 1. The total DLG score obtained by summing the color, smell and structure scores is an indicator of the quality class of silage (20-18:very good, 17-14:good, 13-10:medium, 9-5:low, 4-0:deteriorated) (DLG 1987). In terms of sensory properties, all silage alternatives (sole crop and mixtures) were classed as high quality.

There were significant differences (P<0.05) in silage losses of fresh matter and silage pH among pure and mixed silages (Table 2). Silage pH values increased as the ratio of sunn hemp in the silage was increased. Significant differences (P<0.05) were found among silage types for dry matter content and Flieg score (Table 2). Dry matter content and Flieg score values of silages decreased as the ratio of sunn hemp increased. Crude protein and crude ash values were found to be significantly different (P<0.05) among the sunn hemp and maize silages (Table 2).

The silage NDF, ADF and metabolizable energy values were found to be statistically significantly (P<0.05) different in sole crop and different ratios of sunn hemp and maize mixtures (Table 3).

Significant differences (P<0.05) in dry matter intake, digestible dry matter content and relative feed value were observed among the silage mixtures (Table 3). The relative feed value of the silage decreased as the ratio of maize in the mixture decreased.

Table 1. Physical observation values and DLG classification of sunn hemp-maize silage.

Mixtures	Color (point)	Smell (point)	Structure (point)	DLG (point)	Quality Class
100% S	2.00	12.75	4.00	18.75	Very Good
100% M	2.00	14.00	4.00	20.00	Very Good
80% S + 20% M	2.00	13.25	4.00	19.25	Very Good
60% S + 40% M	2.00	13.75	4.00	19.75	Very Good
40% S + 60% M	2.00	14.00	4.00	20.00	Very Good
20% S + 80% M	2.00	14.00	4.00	20.00	Very Good

S=sunn hemp, M=maize

Table 2. Silage loss, pH, dry matter, flieg score, crude protein and crude ash contents of sunn hemp-maize silage

Mixtures	Silage Loss (%)	Silage pH	Dry Matter (g/kg)	Flieg Score (score)	Crude Protein (g/kg DM)	Crude Ash (g/kg DM)
100% S	3.06 a	4.44 a	273.4 e	81.95 d	163.8 a	70.7 a
100% M	2.47 d	3.93 d	339.0 a	115.59 a	82.2 f	62.1 d
80% S + 20% M	2.83 b	4.30 b	288.3 d	90.53 c	148.8 b	69.4 a
60% S + 40% M	2.60 c	4.13 c	306.4 c	101.09 b	130.1 c	66.9 b
40% S + 60% M	2.62 c	4.10 c	313.2 c	103.51 b	115.8 d	65.1 c
20% S + 80% M	2.52 cd	3.98 d	325.8 b	111.09 a	100.2 e	63.1 d
Mean	2.68	4.15	307.7	100.63	123.5	66.2
CV (%)	2.97	1.43	2.24	3.02	2.47	1.75
LSD (0.05)	0.12	0.09	10.4	4.58	4.6	1.7

S=sunn hemp, M=maize. Means followed by different letters are significantly different (P<0.05).

Table 3. Silage quality features of sunn hemp-maize silage.

Mixtures	NDF (g/kg DM)	ADF (g/kg DM)	ME (MJ kg⁻¹ DM)	DMI (% of BW)	DDM (%)	RFV
100% S	603.8 a	422.7 a	8.36 f	1.99 d	55.97 d	86.23 e
100% M	520.8 d	318.7 f	9.92 a	2.30 a	64.08 a	114.46 a
80% S + 20% M	578.1 b	402.7 b	8.66 e	2.08 c	57.53 c	92.58 d
60% S + 40% M	572.6 b	387.6 c	8.89 d	2.10 bc	58.71 c	95.38 d
40% S + 60% M	555.3 c	356.6 d	9.35 c	2.16 b	61.12 b	102.44 c
20% S + 80% M	529.7 d	340.2 e	9.60 b	2.27 a	62.40 b	109.59 b
Mean	560.1	371.4	9.13	2.15	59.97	100.11
CV (%)	1.72	1.94	1.27	2.04	1.56	3.04
LSD (0.05)	14.5	1.08	0.17	0.07	1.41	4.58

S=sunn hemp, M=maize, DMI=Dry Matter Intake, DDM=Digestable Dry Matter, RFV=Relative Feed Value. Means followed by different letters are significantly different (P<0.05).

Discussion

The highest quality silage was determined as the mixture of 80% sunn hemp with 20% maize. The findings of this study are similar with other studies on different legumes with maize (Budakli Carpici 2016; Titterton and Maasdorp 1997). Loss of silage dry matter and decrease in the feed value of silage of 3-5% could occur due to respiration or fermentation (Buxton et al. 2003). Wang et al. (2009) reported that pure sunn hemp silage has a high pH value. The results of our study were in accordance with the previous research and pH values increased as the ratio of sunn hemp increased (Zavala et al. 2011).

The fermentation of silages may be adversely affected by dry matter. Panyasak and Tumwasorn (2015) reported that the dry matter content of well fermented silage should be between 25-40%. The high dry matter values obtained indicate that the soluble carbohydrate content per unit dry matter of silage was high and the lactic acid fermentation was also successful.

The Flieg score value provides a practical assessment of the chemical properties of silage. All ratios of sunn hemp with maize in this study were included in the "very good" quality class and Flieg scores were inversely proportional to silage pH as expected (Woolford 1984). Crude protein contents increased as the ratio of sunn hemp was increased. Budakli Carpici (2016) found that crude protein contents of mixtures of different silages varied between 7.08–17.43% and Martínez-García (2015) reported increased crude protein content as a result of increases in legume ratio in silage mixtures similar to that reported in this study. The NDF content is lower than found by Titterton and Maasdorp (1997) who reported a NDF value of 675 g kg/DM for sunn hemp silage. The results of the study indicated that as the sunn hemp ratio is increased in the mixtures, the NDF and ADF ratios decreased. The dry matter intake ratio of silage is negatively correlated with NDF and the digestible dry matter of silage is inversely related with ADF (Yucel et al. 2018). The metabolizable energy values of all silage samples examined in the study were at an acceptable level (Boguhn et al. 2003) and similar to the 8.2 MJ kg/DM reported for sunn hemp silage (Titterton and Maasdorp 1997). Relative feed value has been used to compare the quality of legume and legume/grass hays or silages (Jeranyama and Garcia 2004) and was positively correlated with dry matter intake and digestible dry matter contents of silage (Yucel et al. 2018). According to the quality classification of Rohweder et al. (1978), the sole sunn hemp and mixtures of sunn hemp-maize silage studied were of acceptable quality for use as feed.

Conclusions

Maize silage is used extensively in Turkish dairy rations to address the inadequacy of quality feed supply. The results of this study showed that sunn hemp could make good silage and improve the nutritive value of maize silage. Sole sunn hemp silage and the mixture of 80% sunn hemp and 20% maize were found suitable for making good quality silage and it was concluded that they could be used in animal husbandry.

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(Note of the editors: All hyperlinks were verified 6 September 2021).

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