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Nutritional and fermentative quality of maralfalfa (*Pennisetum* sp.) silages at different cutting ages and ground corn levels

Calidad fermentativa y nutricional de ensilados de maralfalfa (*Pennisetum* sp.) a diferentes edades de corte y niveles de maíz molido

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Abstract

Effect of cutting age and level of ground corn grain inclusion were determined on nutritional and fermentative quality of maralfalfa silages (*Pennisetum sp*). Two cutting ages 48 and 60 (Days After Regrowth) and five levels of ground corn (0, 5, 10, 15 and 20%) were evaluated on pH, ammoniacal nitrogen ($N\text{-}NH_3$), dry matter (DM), ash, crude protein (CP), ether extract (EE), hemicellulose, and cellulose; as well as *in vitro* dry matter digestibility (IVDMD). The data obtained were analyzed under a completely randomized design with factorial arrangement (2x5, two cutting ages anda five corn levels). In maralfalfa silage 48 DAR and 5% ground corn was obtained highest content of crude protein (12.2%; $P \leq 0.05$), and was decreased the level ammoniacal nitrogen (0.06%; $P \leq 0.05$), also was observed in maralfalfa silages 60 DAR that addition ground corn increased digestibility and decreased cellulose content. The addition of ground corn to silages improved nutritional and fermentative characteristics and reduced pH, and ammoniacal nitrogen in maralfalfa silages, which improved the conservation, quality and digestibility. Results indicate that the production of maralfalfa silage more the addition of ground corn can improve protein content and digestibility, becoming in an option to incorporate into feeding of livestock.

Keywords
Maralfalfa • silage • crude protein • digestibility

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Resumen

Se determinó el efecto de la edad de corte y el nivel de maíz molido en la calidad fermentativa y nutricional de ensilados de maralfalfa (*Pennisetum sp*). Dos edades de corte, 48 y 60 días después del rebrote (DDR) y cinco niveles de maíz molido (0, 5, 10, 15 y 20%) fueron evaluados en pH, nitrógeno amoniacal ($N\text{-}NH_3$), materia seca (MS), cenizas, proteína cruda (PC), extracto etéreo (EE), hemicelulosa y celulosa; como también digestibilidad *in vitro* de la materia seca (DIVMS). Los datos obtenidos fueron analizados bajo un diseño completamente al azar con arreglo factorial (2x5, dos edades de corte y 5 niveles de maíz). En el ensilado de maralfalfa a 48 DDR y 5 % de maíz molido se obtuvo el más alto contenido de proteína cruda (12.2 %; $P \leq 0.05$) y se disminuyó el nivel de nitrógeno amoniacal (0.06 %; $P \leq 0.05$), mientras que el ensilado de maralfalfa 60 DDR and 0 % de maíz molido tuvo más alto contenido de cenizas (18.3 %; $P \leq 0.05$), también se observó en los ensilados de maralfalfa a 60 DDR que la adición de maíz molido incrementó la digestibilidad y disminuyó el contenido de celulosa. La adición de maíz molido a los ensilados mejoró las características fermentativas y nutricionales y redujo el pH y nitrógeno amonical en ensilados de maralfalfa, lo cual mejoró la conservación, calidad y digestibilidad. Los resultados indican que la producción de ensilado de maralfalfa más la adición de maíz molido pueden incrementar el contenido de proteína y digestibilidad, convirtiéndose en una opción para incorporar dentro de la alimentación del ganado.

Palabras clave
Maralfalfa • ensilado • proteína cruda • digestibilidad

Introduction

Livestock in the north of Mexico is one of the most important economic activities due to livestock inventory and economic spill-over that it generates, the main species exploited in extensive systems are ruminants (24).

The most practical and economical way to feed cattle herds during all the year is grazing of native pastureland (3, 21). However, the quality and quantity of forage available depends on environmental conditions and management, therefore, cattle generally have an adecuate diet for short periods of time (4). This has resulted in a decline in livestock productivity (11).

An alternative for ruminant feeding when there is shortages of forage due to the dry season, may be the use of silage. Maralfalfa (*Pennisetum sp.*) is a grass that is usually supplied fresh (11), which has a high biomass production and an acceptable protein content (5). It has been shown that maralfalfa is an option for forage production in the semiarid region of Mexico, provided that there is availability of irrigation (14).

Silage is a method for preserving fodder for feeding of ruminant mainly during periods of shortage during the year (11). Through this process the silage material preserves its nutrients, maintaining a good palatability to livestock (20). Production of maralfalfa silage increases the availability of livestock feed, reducing the deficit observed in the dry season, as well as production costs of herds. An important

variable to consider in the ensiling process is the moisture content to be carried out a favorable fermentation (13).

Nowadays, conservation methods are required that affect in the least nutritional and organoleptic properties and even improve them. Previous studies have shown that the inclusion of the additives to maralfalfa silage improved nutritional properties silage (15, 26, 27). A limited number of studies have been performed with respect to the effect of additives and cutting age on the nutritional composition of maralfalfa silage.

Therefore, the objective of this study was to determine the effect of cutting age and the addition of different levels of corn on nutritional and fermentative quality of maralfalfa silage.

Materials and Methods

The experiment was performed at the Facultad de Medicina Veterinaria de la Universidad Juárez del Estado de Durango, located at 11.5 Km of the Durango-Mezquital highway, Durango, México. The site is located at coordinates 23°57' N latitude and 104°34' W longitude, altitude 1876 meters.

The climate of the region is temperate semi-arid with rainfall in summer, strong temperature variation [BS1 kw (w) (e)], an average annual temperature of 17.4°C (9) and the annual rainfall reaches 450 mm (16).

Experimental field where was planted maralfalfa in June 2014, covers an area of 5,499 m^2. In 2015 the crop (July 31) was fertilized with urea (46-00-00) at the rate of 60 kg ha^{-1} and then irrigation to incorporate the fertilizer. On August 13, 2015 a cut was made to standardize the phenology of maralfalfa plants before starting the study of forage production. Seven days after cutting (regrowth) was performed a nitrogen fertilization with urea at a dose of 80 kg ha^{-1} and fertilizer was incorporated by irrigation. Subsequently, irrigations were applied every 15 days until the end of the experiment, in order to keep the soil above the 80% moisture and thereby avoid water stress in plants. Maralfalfa plants were cut at 48 and 60 days after regrowth (DAR), forage was allowed to dry in the sun for 48 h and then was chopped into small pieces.

The chopped forage was mixed with different proportions of ground corn grain (white, commercially obtained) for following treatments: T1 (maralfalfa 48 days + 0% ground corn), T2 (maralfalfa 48 days + 5% ground corn), T3 (maralfalfa 48 days + 10% ground corn), T4 (maralfalfa 48 days + 15% ground corn), T5 (maralfalfa 48 days + 20% ground corn), T6 (maralfalfa 60 days + 0% ground corn), T7 (maralfalfa 60 days + 5% ground corn), T8 (maralfalfa 60 days + 10% ground corn), T9 (maralfalfa 60 days + 15% ground corn) and T10 (maralfalfa 60 days + 20% ground corn). The experimental unit was a minisilo, with three replicates for each treatment included in the study.

The minisilo consisted of a rigid polyethylene container with 19 L capacity and covered inside with black polyethylene bag. In each container, forage was compacted manually, the bags were closed with an elastic band and the container capped.

Silages were stored at room temperature for a period of 36 days. Silos were opened to obtain samples of each treatment. The samples obtained were dried in a forced air oven at 55°C for 48 h, ground through 1mm screen, stored inside white polyethylene bottles; they were identified and stored at room temperature until analysis. The samples were analyzed for crude protein (CP), ether extract (EE), ash, and dry matter (DM), according to the methods described by the AOAC (2).

Proportions of neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin (L) were estimated by the method of Van Soest *et al.* (1991) and from them were determined by difference cellulose (Cellulose = ADF - L) and hemicellulose (Hemicellulose = NDF - ADF) (21). The pH was measured according to the method described by Mier-Quiroz (2009) and the ammoniacal nitrogen (NH_3-N) evaluated by the method of Galyean (1980). In vitro dry matter digestibility (IVDMD) it was determined according to ANKOM method, including the use of equipment Daisy II Incubator (1).

The data obtained were subjected to an analysis of variance under an experimental design completely randomized with factorial arrangement (2 x 5), in which was worked with two cutting ages (48 and 60 DAR) and five levels of ground corn (0, 5, 10, 15 and 20%). For means comparison was employed Tukey test (P ≥ 0.05) using the statistical package SAS View 9.0 (23).

Results and Discussion

CP content in maralfalfa silage was different (P ≤ 0.05) between cutting ages and levels of corn (table 1). T2 had the highest value of CP (12.2%), which corresponds to maralfalfa forage at 48 days and 5% ground corn in contrast to T6 and T7 showed the lowest values (6.7%).

The highest average of protein was recorded in the first cutting age (8.5%), while the lowest value was presented at the second cutting age (6.9%), this behavior can be explained to progress in phenology of forage (6). Similar results are reported, where the protein content in maralfalfa silage to the cutting age of 70 days, gave a value of 6.2% (11). This process allowed the production of a food that can be used as ruminants feedstuff (17).

Table 1. Nutritional content of maralfalfa silages elaborated with forage obtained at two cutting ages and different levels of ground corn grain.

Tabla 1. Contenido nutricional de ensilados de maralfalfa elaborados con forraje obtenido a dos edades de corte y diferentes niveles de grano de maíz molido.

[1]Trat	CP (%)	EE (%)	DM%	Ash (%)	Hcellulose (%)	Cellulose (%)
T1	7.3 ± 0.37[2] c	1.5 ± 0.26 e	20.4 ± 1.11 e	17.3 ± 0.15 b	27.6 ± 0.64 b	33.9 ± 0.09 a
T2	12.2 ± 0.23 a	2.9 ± 0.06 b	25.5 ± 1.75 bcde	13.1 ± 0.13 e	23.6 ± 0.73 c	26.7 ± 1.29 b
T3	8.5 ± 0.35 b	3.5 ± 0.02 a	30.2 ± 1.20 abc	9.7 ± 0.14 hg	22.8 ± 0.70 c	18.4 ± 1.68 c
T4	7.3 ± 0.35 c	2.8 ± 0.01 bc	32.1 ± 3.28 ab	10.2 ± 0.56 fg	28.7 ± 2.40 b	19.6 ± 0.16 c
T5	7.3 ± 0.29 c	2.4 ± 0.16 cd	36.1 ± 3.73 a	11.0 ± 0.14 f	34.9 ± 2.23 a	19.9 ± 0.46 c
	8.5	2.6	28.9	12.3	27.5	23.7
T6	6.7 ± 0.40 c	1.2 ± 0.03 e	21.5 ± 1.26 de	18.3 ± 0.28 a	27.3 ± 0.22 b	35.3 ± 0.45 a
T7	6.7 ± 0.31 c	1.5 ± 0.07 e	24.2 ± 0.87 cde	15.3 ± 0.45 c	29.3 ± 0.55 b	29.8 ± 0.17 b
T8	7.2 ± 0.15 c	2.1 ± 0.15 d	27.0 ± 1.54 bcd	14.2 ± 0.03 d	30.7 ± 0.59 b	29.0 ± 0.11 b
T9	6.9 ± 0.26 c	2.5 ± 0.02 c	34.2 ± 3.50 a	9.0 ± 0.50 h	36.2 ± 0.87 a	22.4 ± 0.95 c
T10	7.2 ± 0.10 c	2.7 ± 0.14 bc	26.6 ± 2.20 bcde	7.0 ± 0.06 i	28.6 ± 0.15 b	12.5 ± 0.06 d
	6.9	2.0	26.7	12.8	30.4	25.8

[1]Trat = treatment, CP = crude protein, EE = ether extract, DM = dry matter, Hcellulose = hemicellulose; [2]standard error of the mean. [a-h]Different letters within a column indicate significant differences (P ≤ 0.05).

[1]Trat = tratamiento, PC = proteína cruda, EE = extracto etéreo, MS = materia seca, Hcelulosa = hemicelulosa; [2]Error estándar de la media. [a-h]Letras diferentes dentro de una columna indican diferencias significativas (P ≤ 0, 05).

EE content in maralfalfa silage had significant differences (P ≤ 0.05) between cutting ages and levels of addition of ground corn. The highest average value of EE was observed in the first cut (2.6%) and on this cut excelled the T3 that included cut forage at 48 DAR with 10% ground corn (3.5%) (table 1, page 348). The EE increased as increased corn content in silages which were elaborated with the forage obtained 60 DAR. Maza *et al.* (2011) reported a lower content of EE in silage at 100% maralfalfa and 60 DAR (2.2%), they also noted that increasing the proportion of cassava in the maralfalfa silage decreased values of EE. Guerra *et al.* (2015) also worked with maralfalfa silage at 100% and 70 DAR, and reported a value of 2.0% of EE, which is within the values observed in the present study with forage obtained 48 and 60 DAR. Corn grain increased the proportion of EE in maralfalfa silage and was observed a constant increase with forage obtained at 60 DAR. This increase is due to the ground corn grain provides EE content (3.5%) higher than maralfalfa at 60 DAR (1.7%).

DM content showed significant differences (P ≤ 0.05) between the cutting ages and addition level of ground corn grain (table 1, page 348). Highest values of DM in silages were observed in treatments T5 (36.1%) and T9 (34.2%). In silages of both cuts DM content increased (P ≤ 0.05) when increased the proportion of ground corn, except in the treatment T10 (26.6% of DM).

The increase in DM was possibly caused by the low moisture content of the corn, reducing the moisture content of silage, favoring optimum fermentation of forage. Maza *et al.* (2011) referred that the high moisture content of the forage, greater than 70%, causes pollution problems and loss of quality of the silage due to microbial activity (*Clostridium* sp.), and showed that the increase in the proportion of the additive had a positive influence in the proportion of DM, which favored the elaboration of higher quality silages.

Ash showed significant differences (P ≤ 0.05) between cutting ages and levels of addition of corn (table 1, page 348), which obtained the highest value, in T6 (18.3%). It was observed to decrease when increased the amount of ground corn grain, which was related with the mineral content of maralfalfa. A slight increase was also observed in the ash content when increased the number of days after the regrowth, possibly because of the phenological stage of the crop. These results coincide with those reported by Ramirez and Pérez (2006) with maralfalfa, in which were observed an increase in the ash between cutting ages, with values of 9.4% for 45 DAR and 11.8% for 60 DAR.

In the case of hemicellulose and cellulose, significant differences (P ≤ 0.05) were observed between cuts and levels of ground corn (table 1, page 348). The highest values of hemicellulose were observed in silages with forage at 60 DAR, which showed a constant increase of this compound in maralfalfa due to increase cell wall during its development (6).

The T5 and T9 treatments showed the highest values of hemicellulose (34.9 and 36.2%, respectively). Early cutting dates in combination with low concentrations of corn had the lowest content of hemicellulose. The results presented by Vargas *et al*. (2014) were similar to observed in the present study. Higher average value of cellulose was presented at the second cut (25.8%). The increase in the proportion of corn in silage reduced levels of cellulose, which was more patent in the forage of second cut (60 DAR) where values decreased from 35.3% (T6 = 100% maralfalfa) until to reach 12.5% in the T10 treatment (80 % maralfalfa + 20% ground corn grain).

In both cuts the cellulose content decreased according to the increase of level of ground corn grain, for what was shown that the additive has a dilution effect of this compound.

The fermentation quality variables showed significant differences ($P \leq 0.05$) between cutting ages and levels of ground corn grain (table 2). The lowest average pH was presented at the first cutting age (4.4); while the second cut increased slightly (4.5) due to progress in the growth and development of the maralfalfa.

The addition of corn grain favored reducing the pH, especially in the forage harvested at 60 DAR. This was related to the contribution of soluble carbohydrates of corn favored a rapid lactic fermentation and reduced pH to safe levels (4 to 4.5) (28). So this decreased probability of microbial growth (*Clostridium spp*.) and protein degradation, as in the case of legumes silages that have high moisture content (28). In the present study was observed that the low pH values favored forage preservation (15) because of the samples no were observed putrescence or unpleasant odor in any of the silages. The level of ammoniacal nitrogen (NH_3-N) was lower in silages made with forage at 48 DAR (0.08%, average value) than those obtained 60 DAR (0.21%, average value). The results showed that the addition of corn to the maralfalfa silage reduced the formation of ammoniacal nitrogen, because the soluble carbohydrates in corn grain accelerated fermentation and prevented the degradation of the protein (28). The results are consistent with the work done by Vargas *et al.* (2014), in which was obtained values between 1.2 and 0.70% and was demonstrated that addition sugar cane vinasse reduced levels of ammoniacal nitrogen. It has been established that silage with ammoniacal nitrogen percentages below 7.0% can be considered excellent quality (7), because is avoided the proteolysis and undesirable fermentations (12).

IVDMD showed significant differences ($P \leq 0.05$) between cutting ages and levels of addition of corn (table 3, page 351). The highest average value was obtained in the first cutting age (78.5%) due to lower degree of lignification of maralfalfa stems at that age, also combined with the addition of ground corn (which provided soluble carbohydrates), favored forage digestibility (6).

[1]Trat	pH	NH_3-N/ total N %
T1	4.5 ± 0.05[2] bcd	0.08 ± 0.009 d**
T2	4.4 ± 0.03 bc	0.06 ± 0.002 d
T3	4.3 ± 0.02 bcd	0.08 ± 0.004 d
T4	4.3 ± 0.02 cd	0.08 ± 0.011 d
T5	4.5 ± 0.09 bc	0.09 ± 0.011 d
	4.4	0.08
T6	4.7 ± 0.01 a	0.34 ± 0.03 a
T7	4.4 ± 0.05 bcd	0.19 ± 0.020 bc
T8	4.6 ± 0.03 ab	0.18 ± 0.009 c
T9	4.3 ± 0.04 cd	0.09 ± 0.011 d
T10	4.3 ± 0.05 d	0.23 ± 0.009 b
	4.5	0.21

Table 2. Fermentative parameters of maralfalfa silages at different cutting ages and levels of ground corn grain.

Tabla 2. Parámetros fermentativos de ensilados de maralfalfa a diferentes edades de corte y niveles de grano de maíz molido.

[1]Trat = treatment; [2]standard error of the mean. [a-d]Different letters within a column indicate significant differences ($P \leq 0.05$).

[1]Trat = tratamiento; [2]Error estándar de la media. [a-d]Letras diferentes dentro de una columna indican diferencias significativas (P ≤ 0, 05).

[1]Treat	IVDMD (%)
T1	70.8 ± 0.11[2] ef
T2	75.4 ± 1.36 cde
T3	80.0 ± 0.08 abc
T4	84.7 ± 2.23 a
T5	81.5 ± 4.91 ab
	78.5
T6	69.9 ± 0.09 f
T7	73.1 ± 1.26 def
T8	74.8 ± 0.11 def
T9	77.4 ± 0.35 bcd
T10	84.3 ± 0.10 a
	75.9

Table 3. *In vitro* dry matter digestibility of Maralfalfa silages to different cutting ages and level of ground corn grain.

Tabla 3. Digestibilidad *in vitro* de materia seca de ensilados de maralfalfa a diferentes edades de corte y niveles de grano de maíz molido.

[1]Trat = treatment, IVDMD = *in vitro* dry matter digestibility; [2]standard error of the mean. [a-f]Different letters within a column indicate significant differences ($P \leq 0.05$).

[1]Trat = tratamiento, DIVMS = Digestibilidad *in vitro* de materia seca; [2]Error estándar de la media. [a-f]Letras diferentes dentro de una columna indica diferencias significativas ($P \leq 0.05$).

The highest values of digestibility were observed in silages with higher amount corn grain as T4 (84.7%), T10 (84.3%), T5 (81.5%) and T3 (80.0%) treatments. This showed that the addition of corn increased the digestibility of silages from both cuts. Romney and Gill (2000) mention that forage with digestibility of 65% has good nutritional value.

Conclusion

The cutting age influences in the nutritional and fermentative characteristics of *Penissetum* sp. The results obtained in this study indicate that the cut to 48 days after the regrowth had the highest protein content and digestibility, and lower content of ammoniacal nitrogen and pH. Which are indicators of suitable fermentation and therefore conservation of forage.

The addition of ground corn to the maralfalfa silage improved its nutritional and fermentative characteristics and reduced the pH and ammoniacal nitrogen allowing a better forage conservation. The results indicate that silages of maralfalfa with the addition of ground corn are acceptable in protein content and digestibility, becoming in an option to feedcattle herds in Northern Mexico.

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