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Rumen dry matter degradability of fresh and ensiled sugarcane

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This study aimed to evaluate the chemical composition and *in situ* ruminal degradability of fresh (FSC) and ensiled (ESC) sugarcane. *In situ* dry matter degradability (DMD) was determined using the nylon bag technique with four cows equipped ruminal fistulas. Cows were fed with fresh or ensiled sugarcane and supplemented with 1 kg of commercial concentrate. Five grams of ground sample for each sugarcane treatment (FSC or ESC) were weighted in nylon bags and incubated for 8, 12, 24, 36, 48, 72 and 96 h in a completely randomized design with six replicates. The DMD (%) was higher (P<0.05) for FSC in most incubation times compared with ESC, except at 24 h of incubation. There were no differences in ruminal pH between treatments during all the incubation times. Data suggested that the sugarcane silage could be an alternative to provide forage for ruminants during the season of low growth and quality grass in Mexico.

Key words: Sugarcane, degradability, cows.

INTRODUCTION

In tropical and subtropical regions, the importance of forage species in animal production is necessary for growing demographic pressure, and it has pointed out the importance for livestock exploitation. This allows to suggest the need for a better understanding of the biology and management of forage species in the tropics, with a view to minimize the use of grains and cereals or other foods for ruminants feeding that can be consumed by man (Elias, 1983). The use of various strategies of ruminants feeding in the tropics has resulted in the use of pastures, stubble, straw and other resources such as sugarcane and its by-products, an important tropical forage resource (Espinoza et al., 2006; Aranda et al., 2010).

Conventionally, sugarcane is harvested daily, chopped and served to animals; however, the daily cut has some disadvantages, such as the demand for labor-intensive daily cuts, husked and chopped (Rocha et al., 2009). Moreover, it has a poor nutritional value because of its

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Abbreviations: FSC, Fresh sugarcane; **ESC,** ensiled sugarcane, **DMD,** dry matter degradability; **DM,** dry matter; **CP,** crude protein; **OM,** organic matter; **NDF,** neutral detergent fiber; **ADF,** acid detergent fiber.

higher fiber and low protein contents, which has a direct impact on consumption and generating a low productive efficiency (Leng, 1990).

For this reason, sugarcane forage can be an option due to its abundance, wide distribution in tropical and subtropical areas, and a high biomass production (Molina et al., 1997). Therefore, the best evaluation of feed quality is the animal response; in addition to its nutritional value of digestibility, consumption and feed efficiency (Van Soest, 1982).

Digestibility and consumption are the main parameters that define feed quality. The lack of information on chemical composition, digestibility and ruminal variables of sugarcane fresh or as silage induce this research, so that the objective of this study was to provide a useful information about ruminal digestibility of fresh or ensiled sugarcane.

MATERIALS AND METHODS

Experimental location and samples collection

The experimental work was done at the Nutrition Laboratory of the Centro Universitario del Sur de la Universidad de Guadalajara and at "Dos Pivotes" ranch located in the Municipality of Zapotlán El Grande, Jalisco, Mexico. The biomass of one hectare of sugarcane, variety CP 72-2086, with approximately 13 months old, second cut, was used in this experiment. The forage was picked manually and chopped, in a stationary chopper adjusted for theoretical cut length of 2.5 cm. The biomass of sugarcane was separated in five parts with the intention to make the same number of silages. The materials tested were: 1) whole plant fresh sugarcane, variety CP 72-2086, with 13 months of age of the second cut and 2) sugarcane silage (same variety). Ensiling was initiated simultaneously in mini silos and opened after 40 days of storage. The pH of the silage was determined as described by Tejada de Hernández (1985).

Sample analysis

Samples of FSC and ESC were dried in a circulating air oven at 60°C for 24 h and then milled in hammer mill equipped with 2 mm sieve for further analysis. Total dry matter (DM) was determined using a circulating air oven (100°C for 24 h); crude protein (CP) was determined by the Kjeldahl method; Ash content was measured after igniting samples in a muffle furnace at 550 ◦C for 4 h. Organic matter (OM) was calculated by difference, using the technique described by the AOAC (2007). Two samples for each part were collected before and after the process of silage in total of 10 samples. The determination of the fiber fractions, neutral detergent fiber (NDF) and acid detergent fiber (ADF) was performed using alpha amylase without ash correction as specified by Van Soest et al. (1991).

In situ degradability

In situ degradability was determined using four 4-year old Holstein cows (625 ± 63 kg) equipped with permanent rumen cannula of 10 cm core diameter (Bar Diamond Lane, Parma, ID, USA). Cows were distributed at random in an experimental design. The experiment lasted 30 days, divided into two periods of 15 days each (10 for adaptation and 5 for samples). The diets consisted of: fresh sugarcane (FSC) and ensiled sugarcane (ECS) *ad libitum* plus 1.0 kg of commercial dairy concentrate (APILECHE ULTRA®, México, México) split into two feeding times (AM - PM) to ensure greater cellulolytic activity of the microflora of the rumen. Fresh clean water was available *ad libitum*.

For *in situ* digestibility of DM, the procedure proposed by Vanzant et al. (1998) was followed. Nylon bags were used (10 x 15 cm, pore size 40 to 60 µm) with 5 g of sample. Each sample of the proposed treatments (FSC and ESC) were incubated in rumen for 8, 12, 24, 36, 48, 72 and 96 h in triplicate, in addition at each time blanks secured with nylon thread to a piece of string (30 cm long, weight 150 g) were added and left suspended in the rumen. Subsequently, the bags were removed from the rumen according to the incubation times along with the zero hour, and then bags were washed with running water at low pressure, until the water came out just as clear as it had entered. Subsequently, the bags of waste were dried in a circulating air oven (48 h at 60°C). Ruminal fluid samples were taken from the ruminal cannula at 2 h intervals; one was taken 1 h before daytime feeding and the other 12 h later. Ruminal pH was measured using a portable potentiometer (Model PC18, México) immediately after rumen fluid was collected.

The *in situ* DM degradability for samples at each incubation time was calculated by the weight loss of samples in bags during ruminal incubation, applying the model described by Ørskov and McDonald (1979), modified by McDonald (1981):

$$P = a + b\,(1 - e^{-c*t})$$

Where, a, Washing loss or soluble (%); b,is the insoluble, but potentially digestible fraction (%); P = degradation of DM (%); a + b = potential degradability (%); c = fractional degradation rate (h^{-1}); t = time (h).

Ruminal turnover constants (k) at 1, 5, and 10% h^{-1} were used to model effective degradation (ED; Ørskov and McDonald, 1979):

$$ED = a + (b*c)/(c+k).$$

Statistical analysis

Data from *in situ* digestibility of DM and chemical composition was analyzed using PROC GLM (SAS, 1999) and ruminal pH was measured, with PROC MIXED SAS (1999).

RESULTS AND DISCUSSION

In Table 1, the chemical analysis of FSC and ESC showed significant changes ($P<0.05$) in DM, ADF, NDF and ash. The DM content of FSC was 31.36% higher than the values found by different authors. Rocha et al. (2009) reported an increased by 30.5% of DM with the RB72454 variety at 12 months old, while Alli and Baker (1982) and Ferreira et al. (2007) reported an increase of 28.2% in DM of different varieties of sugarcane harvested at seven months old. However, the DM content of sugarcane in the present study was less than the reported by Peláez et al. (2008) who found an increase of 35.4% DM in sugarcane at 12 months old. The DM in ESC was 36.0%, and this value was higher than the reported by Rocha et al. (2009) and Ferreira et al. (2007), 28.6 and 21.58%, respectively. Peláez et al. (2008), reported a value of 38.0%, which was higher than what was found in our

Table 1. Chemical composition (%) of fresh and ensiled sugarcane (n = 10).

	Fresh	Ensiled
Dry matter	31.4[b]	36.0[a]
Organic matter	25.3	25.7
Crude protein	4.4	5.0
Neutral detergent fibre	49.5[b]	54.4[a]
Acid detergent fibre	20. 9[b]	27.1[a]
Ash	6.1[b]	10.2[a]
pH	6.9[a]	3.6[b]

[a,b]Different superscripts following means in the same row indicate differences at P<0.05.

Table 2. *In situ* DM digestibility and ruminal degradability parameters (%) of fresh and ensiled sugarcane.

	Fresh	Ensiled	SEM
Incubation time (h)			
96	61.9[a]	56.6[b]	1.15
72	60.8[a]	52.3[b]	0.89
48	56.8[a]	51.5[b]	1.08
36	47.2[a]	44.1[b]	0.66
24	44.1	43.6	0.86
12	38.6[a]	34.3[b]	0.92
8	39.9[a]	32.1[b]	0.82
0	4.0	4.1	0.10
DM degradability parameters			
Soluble (*a*)	4.2	4.1	0.10
Potentially digestible (*b*)	53.0	48.1	1.20
Potential degradability (*a*+*b*)	57.2	52.2	1.06
Constant of degradation (*c*)	0.084	0.081	0.0051
Effective degradability modeled at different fractional passage rates (h^{-1})			
0.01	51.9[a]	47.0[b]	1.02
0.05	38.6[a]	34.4[b]	0.89
0.10	30.1[a]	26.5[b]	0.98

[a,b]Different superscripts following means in the same row indicate differences at P<0.05. SEM, Standard error of the mean.

study. In the present study, the CP of ESC was 14.6% higher than the FSC. This increase occurred as a result of the use of soluble carbohydrates during silage fermentation that increased the CP concentration. According to Rotz and Muck (1994), the CP content can increase from 1 to 2 percentages with this process.

The structural components of cell wall, NDF and ADF, did not differ between treatments (P>0.05), and it was 9.76 and 29.9% for ADF and NDF, respectively. Similar results were reported by several authors (Bravo-Martins et al., 2006; Ferreira et al., 2007; Pelaez et al., 2008; Rocha et al., 2009). The increase in the proportion of fiber components of silage in relation to original material was due to the loss of water-soluble constituents, together with the tributaries produced during fermentation and loss of gas (Kung Jr and Stanley, 1982; Bolsen, 1995).

The ash content in the sugarcane was generally low. Ash concentration in our study was considered high compared to values obtained by Rocha et al. (2009). These differences may be related to the varieties, plant age and fertilization. Pedroso et al. (2005) noted that the ash content in sugarcane silages increased with the fermentation, due to loss of nutrients in the form of gas and effluent during the ensiling. The pH value of the ESC was within the limits reported for sugarcane silages (Pedroso et al., 2007). No differences (P>0.05) were observed in the digestibility between treatments (i.e., FSC and ESC) after 24 h of incubation of sugarcane samples, but in other periods of incubation were higher (P<0.05) in FSC (Table 2). The highest values of digestibility were reached from

Table 3. Ruminal pH over time (h) of fresh and ensiled sugarcane.

	Fresh	Ensiled	SE
-1(before feeding)	7.30	7.20	0.140
0 (at feeding)	6.93	7.03	0.140
2	6.90	7.27↑	0.140
4	7.46↑	7.62	0.140
6	7.19	7.57	0.140
8	7.19	7.04↓	0.140
10	6.72	6.64	0.140
12	6.68	6.60	0.140

[a,b]Different superscripts following means in the same row indicate differences at P<0.05. Values preceded by ↓ or ↑ presented an increase or decrease significantly (P≤ 0.05) compared with previous measurements in the same treatment. SE, Standard error.

8 to 96 h of incubation (39.9 to 61.9%, respectively). Other authors (Aranda et al., 2004; Lopez et al., 2003; Peláez et al., 2008) reported similar results at 72 h of incubation (higher than 60%) exploring different varieties of sugarcane.

Molina et al. (1999) in a study of 74 sugarcane varieties found digestibility values between 54.1 to 81.0% of the total DM and pointed out that sugarcane varieties used forage have at least 50% of DM digestibility. The decreased of DM degradability in ESC is reflected by the concentration of DM, NDF and ADF during the fermentation process. Pedroso (2003) observed a significant decreased in *in vitro* DM of silage of sugarcane.

There were no differences (P>0.05) in ruminal pH between treatments; the mean ruminal pH for treatments (FSC and ESC) was 6.98 and 7.12, respectively (Table 3). Similar results were found by Garcia et al. (2008) with average values of 6.62 and 7.20. Gürtler (1975) suggests that the rumen pH is an indicator that may change the cellulosis and mention that the optimum value for cellulosis in a range of 6.7 to 7.0. At low and high ruminal turnover, effective degradability was lower in ESC than FSC (P<0.05). Under these conditions, the process of silage influenced the effective ruminal degradability of forage.

Values of ruminal degradability parameters were similar for both treatments, and higher than 30% of the fraction *b*, and potential degradability of DM, as reported by Fernandes et al. (2003) and Schmidt et al. (2007). Sampaio (1988) concluded that the constant of ruminal degradation below 2% h^{-1}, were in low quality feeds because they require much time to be degraded and digested in the rumen. This may be explained by the low soluble fraction and constant of degradation of DM in this study.

The animals fed with sugarcane, obtain energy from sugar soluble fraction, however, the fibrous fraction had low ruminal digestibility and reflected low ruminal turn over. These can decrease the efficiency of microbial synthesis in the rumen, and could explain the reason of offered sugarcane to animals in terms of DM content, structural and nonstructural carbohydrates.

Conclusion

Ensiling of sugarcane could be a good alternative for ruminant feeding, because it preserve the nutrient content in the season when cutting fodder reach low nutrient levels. Moreover, the advantage of FSC was increased in the DM, CP and improving rumen pH conditions.

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