CHEMICAL COMPOSITION AND *IN SITU* EVALUATION OF FRESH AND ENSILED SUGARCANE (*Saccharum officinarum*)

[COMPOSICION QUIMICA Y EVALUACION *IN SITU* DE CAÑA DE AZUCAR FRESCA Y ENSILADA (*Saccharum officinarum*)]

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SUMMARY

This study evaluated chemical composition and *in situ* degradability of dry matter (DM), organic matter (OM) and ruminal pH of fresh (FSC) and ensiled (SCS) sugarcane (*Saccharum officinarum*) forage diets. *In situ* digestibility was determined using the nylon bag technique with four cows fitted with a rumen cannula. Cows were fed with fresh or ensiled sugar cane and supplemented with 1 kg of commercial dairy concentrate (18% CP). Ground sample (5g) for each sugar cane (FSC, and SCS) were incubated in rumen for 0, 8, 12, 24, 36, 48, 72 and 96 h. Treatments were distributed in a completely randomized design with six replicates. ESC showed significant changes (P<0.05) in DM, ADF, NDF and ash. *In situ* digestibility of dry matter (ISDDM, %) was higher (P<0.05) for FCS in most incubation periods with respect to SCS, except at 24 h of incubation in which no difference (P>0.05) was noted. *In situ* digestibility of organic matter (ISDOM, %) was higher (P<0.05) for FCS at incubation periods of 8, 36, 48 and 96 h; however at 24 h of incubation was higher (P<0.05) in SCS. The ISDOM was similar (P>0.05) at 12 and 76 h of incubation. The ruminal pH showed no differences (P>0.05) between treatments. It is concluded that the silage of sugar cane is an alternative to provide forage in the season of low growth and quality of the grass.

Key words: Sugarcane silage; digestibility; forage; rumen; chemical composition; *in situ*.

RESUMEN

El objetivo fue evaluar la composición química y la degradabilidad ruminal *in situ* de la materia seca (MS), materia orgánica (MO) y pH ruminal de dietas de caña de azúcar (*Saccharum officinarum*), en rumiantes: A) Caña de azúcar fresca (CAF) y B) Ensilado de caña de azúcar (ECA). La digestibilidad *in situ* fue determinada utilizando la técnica de la bolsa de nylon, con cuatro vacas fistuladas en rumen, que fueron alimentadas únicamente con cada uno de los ingredientes en estudio y suplementadas con 1 kg de concentrado comercial (18% PC). Se incubaron 5 g de muestra (CAF y ECA) en periodos de 0, 8, 12, 24, 36, 48, 72 y 96 h. Los tratamientos se distribuyeron en un diseño completamente al azar con seis repeticiones por tratamiento. Se encontró que la digestibilidad *in situ* de la materia seca (DISMS, %) fue superior (P< 0.05) para CAF en la mayoría de los periodos de incubación con respecto al ECA, excepto a las 24 h de incubación en el cual no hubo diferencia significativa (P>0.05). Respecto a la MO, el tratamiento CAF mostro mejores resultados (P<0.05) en los periodos de 8, 36, 48 y 96 h; siendo a las 24 h el mejor (P<0.05) para ECA, no hubo diferencia (P>0.05) en los periodos de 12 y 76 h. El pH ruminal no mostro diferencias significativas (P>0.05) entre tratamientos. El uso de ensilado de caña de azúcar es una buena alternativa de uso de forraje en épocas de baja calidad y crecimiento de pastos.

Palabras clave: Caña de azúcar; ensilado; digestibilidad; forraje; rumen; composición química; *in situ.*

INTRODUCTION

In the world, the ruminants that contribute to food security for humans are estimated at two billion. These animals provide 70% of the total animal protein consumed, 80% of the milk consumed and 10% of the natural fiber used by humans. In the next 25 years, it will be necessary to double the production

of animal protein derived from ruminants to ensure the protein intake of a growing world population (Barahona and Sánchez, 2005). Forage resources play a fundamental role in ruminant nutrition and provide over 90% of the energy consumed by them worldwide (Fitzhugh *et al.*, 1978; Wilkins, 2000).

Ruminants have the ability to convert low-quality feed into high quality protein, and use feed produced on land unsuitable for growing crops for human consumption (Varga and Kolver, 1997). This is possible because the rumen microorganisms synthesize and secrete an enzyme complex of β-1-4 cellulases that allow the hydrolysis of forage cell walls. Sugarcane is found amongst these important resources (Espinoza *et al.,* 2006; Aranda *et al*., 2010). Conventionally, it is harvested every day, chopped and served to the animals; however, the daily cut has some disadvantages, such as the demand for labor-intensive daily cuts, husked and chopped (Rocha *et al.*, 2009). In this scenario, cane of sugar as silage can be an option due to its persistence, wide distribution in tropical and subtropical areas, and a high biomass production (Molina *et al.,* 1997).

The appropriate supplementation with sugarcane is necessary to improve its use (Martin, 1997). Therefore, the best evaluation of feed quality is the animal response, in addition, nutritional value of feed is the combined effect of digestibility, consumption and feed efficiency (Van Soest, 1982). Digestibility and intake are the main parameters that define feed quality; however these are not routinely measured because of high costs and strong demand for labor and time required for *in vivo* experiments (Rodriguez *et al.,* 2007). The lack of information on chemical composition, digestibility and ruminal variables of sugar cane fresh or as silage induce this research, so that the objective of this study was to provide useful information about ruminal digestibility and chemical composition of fresh or ensiled sugarcane.

MATERIALS AND METHODS

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 materials tested were: 1) fresh sugar cane, variety CP 72-2086, with 13 months of age of second cut and 2) sugar cane silage (same variety). Samples of ingredients were dried in a circulating air oven at 60 ˚C for 24 hours and then milled in hammer mill with 2 mm sieve for further analysis. Total dry matter (DM) was estimated a circulating air oven (100 ˚C for 24); crude protein (CP) was determined by the Kjeldahl method; ash (A) and organic matter (OM) was calculated by difference, using the technique described by the AOAC (2007). The pH of the silage was determined as described by Tejada de Hernández (1985).

The determination of the fiber fractions (NDF and ADF) was performed using alpha amylase without ash correction as specified by Van Soest *et al.* (1991). Digestibility was determined *in situ* using four Holstein cows (625 ± 63 kg) of 4-years old, and fitted with permanent rumen cannula of 10 cm core diameter (Bar Diamond Lane, Parma, ID, USA). Cows were distributed at random in an experimental design in simple sequences of treatments. The experiment lasted 30 days, divided into two periods of 15 days each (10 for adaptation and 5 for collecting samples). The diets consisted of: the ingredient under study (FSC, and SCS) *ad libitum* plus 1.0 kg of commercial dairy concentrate (APILECHE ULTRA®, 18% PC, México) divided into two meals (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 and OM 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 SCS) were incubated in rumen for 0, 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 circulating 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). Fluid ruminal samples were taken from the ruminal cannula at two hour intervals; one was taken 1 h before daytime feeding and the other 12 hours later. Ruminal pH of the fluid in the rumen was measured using a portable potentiometer (Model PC18) immediately after rumen fluid was collected.

Statistical analysis

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

RESULTS AND DISCUSSION

The chemical analysis of the FSC and SCS (Table 1) showed changes in DM, CP, ADF, NDF and ash, due to fermentation. The OM value was similar between fresh or ensiled sugarcane. The DM content in FSC was 31.36%; this value was higher than the results found by different authors. Rocha *et al.* (2009)

reported 30.5% of DM with the RB72454 variety at 12 months old; Alli and Baker (1982) and Ferreira *et al.* (2007) reported 28.2% of DM in different varieties of sugarcane and harvested at seven months old. However, the DM content of sugarcane in present research was less than the reported by Peláez *et al.* (2008), they found 35.4% DM in sugar cane for 12 months old.

The DM in SCS was 36.0%, 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), found a value of 38.0%, which was higher than what was found in this study. In present study, the CP for SCS 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 percentage of CP. According to Rötz and Muck (1994), the CP content can increase from 1 to 2 percentage units in the DM with this process.

Table 1. Chemical composition (%) of fresh or ensiled sugarcane (DB)

	FSC	SCS
Components	%	
Dry Matter	31.36b	36.00a
Organic Matter	25.25	25.76
Crude Protein	4.37	5.01
ADF	20.89b	27.14[a]
NDF	49.54b	54.38[a]
Ash	6.11b	10.24[a]
pH	6.90a	3.58b

[a,b] Different superscripts following means in the same row indicate differences at P<0.05;
FSC = Fresh sugarcane; SCS= sugarcane silage.

The structural components of cell wall, NDF and ADF (Table 1), the values were different between treatments; similar results were reported by several authors (Alli and Baker, 1982; Kung Jr. and Stanley, 1982; Pedroso *et al.,* 2006; 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 in silage in relation to original material is 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 is generally low. The concentrations of ash obtained in this study are considered high compared to values obtained by Rocha *et al.* (2009). These differences may be related to the varieties, plant age and fertilization. In the silages, the variations in the levels of ash can be used to estimate the losses in DM during fermentation, which does not change during the fermentation process. Pedroso *et al.* (2005) noted that the ash content in sugar cane 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 SCS (3.58) is within the limits reported for sugarcane silages (Pedroso *et al.,* 2007). Regarding the ISDDM, Table 2 shows that at 24 h of incubation there were no differences between treatments (P>0.05), but in other periods of incubation were higher (P <0.05) in FSC. From 8 to 96 h of incubation reached the highest values of digestibility (39.92 to 61.93%, respectively). Other authors (Aranda *et al.,* 2004; Lopez *et al.,* 2003; Peláez *et al.,* 2008) reported similar results as the ones in this study at 72 h of incubation (above 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, pointed out that sugar cane varieties for forage use must have at least 50% of DM digestibility. The reduction coefficient of ISDDM in SCS is reflected by the concentration of DM, NDF and ADF during the fermentation process. Pedroso (2003) observed a significant reduction in IVDDM of silage from sugarcane in relation to forage (47.1% vs 62.9%).

Table 2. Percentage of *in situ* digestibility of fresh and ensiled sugarcane.

Fraction	Incubation time (h)	FSC	SCS	SEM
DM	96	61.93a	56.60b	1.15
	72	60.75a	52.29b	0.89
	48	56.80a	51.45b	1.08
	36	47.21a	44.08b	0.66
	24	44.11	43.6	0.86
	12	38.61a	34.29b	0.92
	8	39.92a	32.06b	0.82
OM	96	57.88a	47.43b	2.35
	72	56.66	56.66	0.90
	48	50.70a	45.87b	1.50
	36	52.29a	47.50b	1.06
	24	50.13b	56.30a	0.85
	12	46.01	44.12	1.45
	8	54.20[a]	45.70b	2.96

[a,b] Different superscripts following means in the same row indicate differences at P<0.05;
FSC = Fresh sugarcane; SCS= sugarcane silage; SEM= Standard error of the mean.

The *in situ* digestibility values of OM (Table 2) showed significance (P <0.05) between treatments in

most incubation times. The FSC treatment had the highest values except at 24 h of incubation, which was favorable (P <0.05) for the SCS. At 12 and 72 h of incubation no difference (P <0.05) between treatments was observed. In this sense, the decline in overall OM digestibility observed in this study is similar to other reports, and it is attributable to the increase in the proportion of cell walls (López *et al.*, 2000). There were no differences (P> 0.05) in ruminal pH between treatments, mean rumen pH for treatments (FSC, SCS) of 7.04 and 7.12 respectively (Table 3). Similar results to this study were found by Garcia *et al.* (2008) with average values of 6.62 and 7.20. Görtler (1975) who suggests that the rumen pH is an indicator that may change the celullosis, and mention that the optimum value for celullosis is in a range of 6.70 to 7.00, that was found in this study.

Table 3. Effect of FSC and SCS on ruminal pH over time.

	TREATMENTS[1]		
Time	FSC	SCS	SEM[2]
-1	7.30	7.20	0.14
0	6.93	7.03	0.14
2	6.90	7.27	0.14
4	7.46	7.62	0.14
6	7.19	7.57	0.14
8	7.19	7.04	0.14
10	6.72	6.64	0.14
12	6.68	6.60	0.14
Average	7.04	7.12	0.14
SET[3]	0.21	0.21	

1 Treatments: FSC= fresh sugar cane, SCS= sugarcane silage;
2 SEM = standard error of the mean.
3 SET = standard error of the treatments.

CONCLUSION

It is concluded that the conservation technique (silage) of sugarcane is a good alternative, because it preserve the nutrient content in the season when cutting fodder reach low nutrient levels. Moreover, the advantage of the FSC is by increases in the percentages of DM, CP and improving rumen pH conditions.

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