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Use of acids as additives in sugarcane silage¤

Uso de ácidos como aditivos en el ensilaje de caña de azúcar

Uso de ácidos como aditivos na silagem de cana de açúcar

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Summary

Background: sugarcane silage often becomes a problem for the producers due to its high population of yeast and its high content of soluble carbohydrates. **Objective:** to evaluate the effect of formic and phosphoric acid on the chemical composition, fermentation characteristics, and digestibility of sugarcane silages. **Methods:** sugarcane was ensiled in experimental mini-silos. Five treatments were evaluated in the ensilage process (sugarcane added with 0.5 or 1% formic acid and 0.5 or 1% phosphoric acid, and a control treatment without additives). A completely randomized design was used. **Results:** the dry matter content of silages containing phosphoric acid was lower. Lower values of NDF, ADF, and hemicellulose were observed in the control and formic acid treatments. **Conclusions:** formic and phosphoric acids promote beneficial changes in the chemical composition of sugar cane silage.

Keywords: *forages, formic acid, phosphoric acid, Saccharum officinarum.*

Resumen

Antecedentes: debido a la elevada presencia de levaduras y a la alta proporción de carbohidratos, el ensilaje de caña de azúcar presenta problemas de manejo para los productores. **Objetivo:** evaluar el efecto de la adición de ácidos fórmico y fosfórico sobre la composición química, características fermentativas y

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digestibilidad del ensilaje de caña de azúcar. **Métodos:** la caña de azúcar se ensiló en mini silos. Fueron evaluados cinco tratamientos en el proceso de ensilaje de caña de azúcar (caña de azúcar adicionada con 0,5 o 1% de ácido fórmico, o con 0,5 o 1% de ácido fosfórico, y un tratamiento control sin aditivos). Se utilizó un diseño completamente aleatorizado. **Resultados:** la proporción de materia seca de los ensilajes con ácido fosfórico fue menor. Se observaron menores proporciones de NDF, ADF y hemicelulosa en los ensilajes sin adición de ácido y en los adicionados con ácido fórmico. **Conclusiones:** el uso de ácidos fórmico y fosfórico en el ensilaje de caña de azúcar promueve modificaciones benéficas en su composición química.

Palabras clave: *ácido fórmico, ácido fosfórico, forrajes, Saccharum officinarum.*

Resumo

Antecedentes: devido à elevada presença de leveduras como também excessiva proporção de carboidratos, a silagem de cana apresenta problemas de manejo para os produtores. **Objetivo:** avaliar o efeito da adição do ácido fórmico e ácido fosfórico sobre composição química, características fermentativas e digestibilidade de silagens de cana-de-açúcar. **Métodos:** a cana-de-açúcar foi ensilada em mini silos. Foram avaliados cinco tratamentos no processo de ensilagem de cana de açúcar (cana-de-açúcar adicionada com 0,5 ou 1% de ácido fórmico ou com 0,5 ou 1% de ácido fosfórico, e um tratamento controle sem aditivos), utilizando um delineamento inteiramente casualizado. **Resultados:** os teores de matéria seca das silagens contendo ácido fosfórico foram menores. Menores valores de NDF, ADF e hemicelulose foram observados para as silagens de cana-de-açúcar in natura e adicionadas de ácido fórmico. **Conclusões:** o uso de ácido fórmico e fosfórico promove mudanças benéficas na composição química da silagem de cana de açúcar.

Palavras chave: *ácido fórmico, ácido fosfórico, forragens, Saccharum officinarum.*

Introduction

Sugarcane forage is commonly used to feed ruminants in tropical countries, especially in small farms (Bernardes and Rêgo, 2014). It is best used in the form of silage when long-term storage is necessary (Amaral *et al.*, 2009). Yeast populations along with high content of soluble carbohydrates in sugarcane silage can be an issue because the substrate is turned into alcohol, causing loss of energy (Pedroso *et al.*, 2005). Some additives could be used to minimize this problem. Besides bacterial inoculants, formic and mineral acids (added from 4 to 13 kg per ton) are additives used to reduce pH and limit protein and carbohydrates losses from silage, mainly in temperate-climate grasses. However, acid addition increases effluents and can be potentially toxic to animals (Yitbarek and Tamir, 2014). Information about the use of such additives in sugar cane silage is limited. The objective of this study was to evaluate the effect of formic or phosphoric acid addition on the chemical composition, fermentation characteristics and digestibility of sugarcane silage.

Materials and methods

The Ethics Committee of UNESP University (Protocol 005/11) approved the experimental procedures for this study. Sugarcane (IAC86-2480 variety) was chopped in 5-mm particles. Five silage treatments were evaluated: Sugarcane added with 0.5 or 1% formic acid (FA), 0.5 or 1% phosphoric acid (PA) in natural basis (1.85 or 3.7% in dry matter basis, respectively), and a control treatment without additives.

Additives were diluted in water (1:10). A completely randomized design with four replications was used. Experimental polyvinyl chloride (PVC) silos with 2.6 kg of material were used. The silos remained closed for 40 days. Samples from the silos were taken to determine the chemical composition (Silva and Queiroz, 2002), pH, and $N\text{-}NH_3$ (Campos *et al.,* 2004). The loss of total dry matter (DM) and the loss due to gas production were calculated (Andrade *et al.*, 2010). The effluent was determined by measuring the difference in the weight of the sand and silo prior and after ensiling in relation to the amount of green matter.

Dry matter digestibility was determined using a DAISY II fermenter (Ankom Technology Co., Fairport, NY, USA), according to Holden (1999), in which samples were incubated at 39 °C for 48 h. At the end of this period, 40 ml 6N HCl and 8 g pepsin powder were added to each fermentation vessel and incubated for another 24 h. At the end, bags with samples were oven-dried at 100 °C and weighed.

Statistical analysis

Analysis of variance was performed using SAS® statistical software (SAS Inst. Inc, Cary, NC, USA). Four orthogonal contrasts were evaluated. Significance was declared at 5%.

Results

Dry matter content in silages containing PA was lower ($p<0.01$), with the lowest value observed in silages containing 0.5% (Table 1). Mineral matter content was increased ($p<0.01$) by the addition of PA. Lower ($p<0.01$) values of NDF, ADF, cellulose, and hemicelluloses were observed in pure sugarcane silage as well as in silages with added FA. Phosphoric acid promoted an increase of the fibrous fractions content. Lignin contents were lower ($p<0.01$) in pure sugarcane silage. The addition of FA, particularly at 1%, improved ($p>0.05$) silages DM digestibility (Table 1).

The pH of silages was affected ($p<0.05$) by adding PA, and was lower when 1% acid was used. Both acids promoted a decrease in N-NH_3 values. There was no difference ($p>0.05$) among treatments for total DM loss. Dry matter losses (18.7%) were not affected by the addition of acid to silage ($p>0.05$); however, gas losses were increased (83%).

Discussion

Dry matter losses from silages containing PA can be attributed to the action of yeasts, causing substrates losses in the form of CO_2 and ethanol volatilization. Fiber fraction increases in the silage compared with the original material can be a result of loss of water, soluble constituents and effluent produced during fermentation. Freitas *et al*. (2006) reported no effluent production and the authors concluded that the changes in DM, NDF, and ADF resulted from the loss of soluble carbohydrates.

Table 1. Chemical composition, fermentation characteristics, effluent losses and "*in vitro*" DM digestibility (%) of sugarcane silage (SC) added formic (FA) and phosphoric acids (PA) at final concentrations of 0.5 and 1%.

Item	Treatments (silages)					SE	Contrast (P)			
	Pure[1]	0.5R[2]	1R[3]	0.5S[4]	1S[5]		A	B	C	D
DM	25.6	26.5	25.5	22.0	24.2	0.63	0.17	<0.01	0.30	0.03
MM	2.6	2.4	2.4	6.7	7.9	0.35	<0.01	<0.01	0.98	0.06
NDF	63.9	63.5	60.6	76.6	68.2	1.86	0.14	<0.01	0.29	0.01
ADF	42.4	42.6	41.4	50.7	46.2	1.34	0.09	<0.01	0.55	0.04
Hemicellulose	21.5	20.9	19.2	26.6	21.9	1.03	0.57	<0.01	0.26	0.01
Cellulose	34.7	31.6	32.3	37.1	31.8	1.51	0.38	0.13	0.75	0.75
Lignin	7.7	11.2	8.7	12.8	14.4	1.06	0.01	0.01	0.12	0.30
pH	3.4	3.6	3.9	2.8	2.4	0.05	<0.01	<0.01	<0.01	<0.01
N-NH_3[6]	7.3	5.6	4.4	2.6	3.1	0.95	0.01	0.04	0.40	0.72
IVDMD[7]	39.9	42.7	44.3	29.3	34.67	1.70	0.28	<0.01	0.53	0.04
Effluents, DM	6.3	7.6	7.6	7.6	7.68	8.2	<0.01	0.96	0.96	0.78

[1]Pure sugarcane; [2]Sugarcane + 0.5% formic acid; [3]Sugarcane + 1% formic acid; [4]Sugarcane + 0.5% phosphoric acid; [5]Sugarcane + 1% phosphoric acid; [6]% of total nitrogen; [7]*In vitro* dry mater digestibility. Contrasts: A = Sugarcane *vs* (sugarcane + acids); B = (Sugarcane + formic acid) *vs* (Sugarcane + phosphoric acid); C = (Sugarcane + 0.5% formic acid) *vs* (Sugarcane + 1.0% formic acid); D = (Sugarcane + 0.5% phosphoric acid) *vs* (Sugarcane + 1.0% phosphoric acid). P = probability.

The pH values observed for the PA treatments are below the ones reported by Itavo *et al.* (2010; pH = 4.07), who used acetic acid. In relation to N-NH_3, the values are considered normal.

Gas losses did not change by acid addition to sugarcane, which averaged 13.3%, a value similar to that reported (12.5%) by Schmidt *et al*. (2007) in sugarcane silages with added urea, benzoate and NaOH. The FA, particularly at 1%, increased matter digestibility, indicating that this treatment was effective in combating undesirable fermentation. The PA increased NDF and ADF contents, and decreased pH and N-NH_3 values, leading to a reduction in DM digestibility of silages. It is concluded that formic acid addition improves DM digestibility of sugarcane silages.

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Conflicts of interest

The authors declare they have no conflicts of interest with regard to the work presented in this report.

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