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Sugarcane silage production treated with additives at different times post burning[1]

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ABSTRACT - This trial aimed to evaluate the effects of the time post-burning, and additives on fermentative characteristics, losses and chemical composition on the sugar cane silage. The sugar cane variety IAC 86-2480 was ensiled on the 1, 4, 7, 10 and 14 days after burning. The additives evaluated were: control (Cont.), *Lactobacillus buchneri* (LB), Calcium oxide micro pulverized (CO), and *Lactobacillus buchneri* (LB) plus Calcium oxide micro pulverized (LB + CO). The yeast population was determined before ensiled. After 56 days of the fermentation period the silos were opening to take samplings. The experimental design was a completely randomized design, in a factorial scheme (additive and burning time) with seven treatments and four replications. The sugar cane was recontaminated with yeast, the populations increased from 5.04 to 6.48 log cfu/g of forage. Dry matter content decreased after fermentation period in average 7.6 units, compared to the sugar cane forage before ensilage. Control and LB silage showed lowest dry matter recovery (DMR), 613 g/kg and 631 g/kg, respectively, compared to the Cal and LB + Cal, 807 g/kg and 832 g/kg. This fact probably was associated to the calcium oxide control on the yeast populations. In relation to the time post-burning, the greatest changes were observed in the gas production and DMR. Gas production were higher in the first days post-burning and decreased in response to the prolongation time post-burning. The time post-burning alters the nutritive value of the fresh sugarcane and its silage and also the size of the losses from the ensilage process.

Key Words: calcium oxide micro pulverized, ensilage, inoculants, *Lactobacillus buchneri*

Produção de silagens de cana-de-açúcar tratada com aditivos em diferentes tempos após a queima

RESUMO - Objetivou-se estudar a ação do tempo após a queima do canavial e o uso de aditivos sobre as características fermentativas, as perdas e a composição química de silagens de cana-de-açúcar. A cultivar utilizada foi a IAC 86-2480 colhida em cinco tempos (1, 4, 7, 10 e 14 dias) pós-queima. Os aditivos utilizados foram controle, sem aditivos, *Lactobacillus buchneri*, cal virgem micropulverizada e *Lactobacillus buchneri* + cal virgem micropulverizada. Antes da ensilagem em cada tempo, foram determinadas as populações de leveduras presentes na cana-de-açúcar. Decorridos 56 dias após a ensilagem, os silos experimentais foram abertos. O delineamento experimental utilizado foi o inteiramente casualizado em esquema fatorial, considerando os fatores aditivos e tempo pós-queima. Houve recontaminação da cana-de-açúcar pelas leveduras, elevando a população de 5,04 para 6,48 log ufc/g de forragem. Os teores de matéria seca (MS) após a abertura do silo reduziram em média 7,6 unidades percentuais em comparação aos observados na ensilagem. As silagens controle e com *Lactobacillus buchneri* tiveram menores recuperações da matéria seca (613 e 631 g/kg, respectivamente), em comparação às observadas nas silagens com cal e com a combinação *Lactobacillus buchneri* + cal (807 g/kg e 832 g/kg, respectivamente), fato que pode ser justificado pelo controle de levedura pela cal. Após a queima, as maiores variações foram na produção de gás e na recuperação de matéria seca: a produção de gás foi maior nos primeiros dias e diminuiu com o tempo após a queima, consequentemente, a recuperação de MS foi menor nos primeiros dias e aumentou com o tempo após a queima. O tempo após a queima altera o valor nutritivo da cana-de-açúcar fresca e das suas silagens, assim como a magnitude das perdas no processo de ensilagem.

Palavras-chave: cal micropulverizada, ensilagem, inoculante bacteriano, *Lactobacillus buchneri*

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Introduction

Pasture production decreases at a certain time of the year, so that forage resources have to be used such as hay and silage to feed ruminants. In this sense, the use of sugarcane as supplementary roughages has increased, because this crop is less demanding in terms of climatic conditions, soil fertility and topographical relief compared to crops such as corn and sorghum. Another important factor is that its harvest period that coincides with the period of forage scarcity in the pasture. However, it is a crop with a high risk of burning from accidental fire, that can prevent the use of the sugarcane crop in a direct cut system, therefore the forage could to be ensiled. However, there is little information in the literature on the time that the forage can remain in the field post burning.

When conserving the forage nutritive value, only the production of lactic acid is not efficient, because yeasts can use it and the available soluble carbohydrates for ethanol production (Walker, 19898). Acetic acid, that is usually an undesirable product in conventional silages, can controls yeast action (Moon, 1983), that in the case of sugarcane ensilage, is desirable. This effect was reported by Siqueira et al. (2007), who observed reductions in dry matter losses in sugarcane silage inoculated with heterolactic microorganisms.

Bernardes et al. (2007) observed higher ethanol contents and yeast populations in silages produced with burned sugarcane. These authors attributed this fact to the presence of sugars on the external surface of the cell wall resulting from the burning that increased yeast contamination.

For better control of yeasts, that are mainly responsible for dry matter losses during fermentation and ethanol production, appropriate chemical additives or bacterial inoculants specific to the crop should be used (Siqueira et al., 2007).

The objective of this study was to evaluation the effect of time post burning on sugarcane nutritive value before and after ensilage, losses during fermentation and to determine the effect of the additives calcium oxide micro pulverized and *Lactobacillus buchneri* and their association on the ensilage.

Material and Methods

The experiment was carried out at the Alta Mogiana Regional Pole for Agribusiness Technological Development and the College of Agrarian and Veterinary Sciences – Unesp, *Campus* de Jaboticabal.

The IAC 86-2480 sugarcane cultivar was used, with 15 months of growth (the first cut) at the time of cutting. The sugarcane plantation was burnt at the end of the afternoon, on the day prior to the first cut. The stems were not separated from their link to the root until they reached the time predetermined for harvest, giving a condition of accidental fire.

On days 1, 4, 7 10 and 14 post burning, the forage was collected mechanically by a Menta Mit ensilager, ColhiFex model. After harvest, the chopped sugarcane was treated with the additives.

Five post burning times were adopted as treatments (1, 4, 7 and 10 and 14 days) in a factorial design with the additives (calcium oxide micro pulverized, *Lactobacillus buchneri* and calcium oxide micro pulverized + *Lactobacillus buchneri)* and the control group, totaling twenty treatments with three replications per treatment.

The calcium oxide micro pulverized was used at the dose of 1% in the sugarcane natural material, based on a study by Balieiro Neto et al. (2007), and the dose of the *L. buchneri* inoculant (Cepa NCIMB 40788) was 5×10^4 ufc/g silage natural material.

The experimental silos were 7 L plastic buckets closed with a plastic lid and sealed with adhesive tape. Bunsen valves were fitted in the lids for gas escape and 1.5 kg dry sand were placed at the bottom of the silo, separated from the silage forage by nylon cloth.

One sample of the forage per silo was removed before ensilage and of the silage when the silos were opened, for chemical and bromatological analyses. This sample was divided into two separate samples, one of which was prepared following the methodology described by Kung Jr. et al. (1984) to determine the pH using a potentiometer, and the other was weighed and taken to a forced air chamber at 55 °C for 72 hours. After this period, these sub samples were again weighed, ground in a knife grinder until particles were less than 1 mm and stored in plastic pots.

Before ensilage, a second sample was removed of the forage to determine the epiphyte yeast count, following the method reported by Jobim et al. (1999). The quantities of dry matter (DM), crude protein (CP) were determined following methods described by Silva & Queiroz (2002), and the neutral detergent fiber (NDF) and acid detergent fiber (ADF) by the sequential method, following techniques described by Robertson & Van Soest (1981). To determine the cellulose, 72% sulfuric acid was used (Van Soest, 1994), while the lignin contents were calculated by the difference between the ADF and the cellulose. The true *in vitro* digestibility of the dry matter (DIVMS) was assessed according to (Van Soest, 1994).

The silos were weighed after construction and stored at room temperature for 56 days. After this period, the silos were again weighed before opening to quantify gas losses, effluent losses and determine the dry matter recovery, according to Siqueira et al. (2007).

A randomized complete design was used in a 4 × 5 factorial arrangement with three replications, considering the factors additives (control, *Lactobacillus buchneri*, micropulverized calcium oxide micro pulverized, *Lactobacillus buchneri* + micropulverized calcium oxide micro pulverized,) and post-burning time (1, 4, 7 10 and 14 days), with three replications per treatment, totaling 60 experimental units. The data were analyzed by the PROC GLM of the SAS® program (SAS 1988) and the means were compared using the least squares method (LSMEANS) adopting a 5% level of significance.

Results and Discussion

In the assessment of the post-burning time, the DM contents (Table 1) differed only on the seventh day of exposure (304 g/kg) possibly because of the rain (14 mm) in the night prior to the fourth day post-burning. A reduction in the DM content was expected in the sugarcane on the fourth day of assessment. However, this cut was made before the time necessary for the sugarcane to absorb the water and forage handling so that the excess water was eliminated from the forage surface. Consequently, the reduction in the DM content was observed only on the seventh day.

The DM content in the fresh forage was different among the additives, but this difference could be considered small, 0.9 percentage points, between the smallest and greatest DM content. The DM contents in the fresh sugarcane were greater than those observed by Bernardes et al. (2007), of 276 g/kg DM in burnt sugarcane, and lower than that reported by Siqueira et al (2009), of 341g/kg DM in burnt sugarcane.

At opening, the DM contents of the control silos and the silos with *Lactobacillus buchneri* treated forage performed similarly, presenting the lowest DM contents during the period compared to the silages treated with calcium oxide micro pulverized and calcium oxide micro pulverized + *Lactobacillus buchneri*. The DM contents of the control and *Lactobacillus buchneri* silages at opening were close to the value of 201g/kg DM observed by Bernardes et al. (2007) in burnt sugarcane silages. Higher values were detected by Siqueira et al. (2009), who reported DM contents in burnt sugarcane silage and silage treated with *Lactobacillus buchneri* of 334 g/kg DM or with NaOH (1%), of 327 g/kg DM.

In the silages produced on the seventh day post burning, the DM contents at the assessment made at opening were the lowest and significantly similar to those of the first day, because when the sugarcane was ensilaged, they already presented a lower DM content.

The yeast population increased in response to time post burning (Figure 1), indicating that the potential for recontamination of the sugarcane plantation prevails for a long period.

The increase in the yeast population post burning resulted in great alcohol production in the silage. Thus, Bernardes et al. (2007) observed that silage where the sugarcane had been burnt presented higher ethanol contents (79 g/kg de DM) compared to *in nature* sugarcane (69 g/kg de DM). The authors reported that the high temperatures during burning may have destroyed the wax layer that covers the cell wall of this plant species, a fact the causes the stems to crack and the exudation of cell content (sugars), increasing the microbial contamination and with this, there is greater alcohol fermentation in burnt sugarcane silages.

The control forage and the forage treated with *Lactobacillus buchneri* performed similarly for pH value at ensilage (Table 2), but the pH decreased over time post burning. The pH values in the forage of the first day, of the control forage and the forage treated with *Lactobacillus buchneri* were close to that observed by Siqueira et al. (2010), of 5.7 in the control forage and 5.6 in that treated with *Lactobacillus buchneri*.

Until the tenth day post burning, the pH values differed statistically among the forage treated with calcium oxide micro pulverized associated or not to *Lactobacillus buchneri*, but tended to decrease with the days post burning. The pH values found were high, that was expected, because calcium oxide micro pulverized is an alkaline product responsible for raising pH. Siqueira et al. (2010) reported 11.7 pH in sugarcane treated with 1% NaOH.

On the 14th day there was significant difference among the forages treated with calcium oxide micro pulverized and with calcium oxide micro pulverized and *Lactobacillus buchneri*, but these forages continued with the highest pH values compared to the others.

At silo opening, regardless of the time post burning, all the silages treated with calcium oxide micro pulverized or calcium oxide micro pulverized and *Lactobacillus buchneri* had pH greater than the control silage or those treated with *Lactobacillus buchneri*, because, when calcium oxide micro pulverized was added at the time of ensilaging the sugarcane, the pH values increased. A similar fact occurred in the study by Siqueira et al. (2010),

Table 1 - Chemical composition of fresh sugarcane and silage at different days after burning and treated with additives

Additive	Days post-burning					Mean
	1	4	7	10	14	
			Dry matter of fresh sugarcane (g/kg DM)			
Control	326	337	310	327	314	323A
L. buchneri	319	328	300	321	323	318AB
Calcium	330	326	298	322	332	322AB
L. buchneri+calcium	317	313	308	312	319	314B
Mean	323a	326a	304b	321a	322a	319
CV%						2.67
			Dry matter of silage (g/kg DM)			
Control	193Cc	226Bab	201Cc	221Bb	235Ca	215
L. buchneri	213Bbc	228Ba	205Cc	219Ba	221Dab	217
Calcium	278Aa	279Aa	234Bb	276Aa	286Aa	271
L. buchneri+calcium	276Aa	277Aa	251Ab	278Aa	271Ba	271
Mean	240	252	223	249	253	243
CV%						3.07
			Neutral detergent fiber of fresh sugarcane (g/kg DM)			
Control	378Bc	464Aa	412Ab	433Aab	438Aab	425
L. buchneri	433Aa	447Aa	402Aba	430Aa	447Aa	432
Calcium	398ABab	428Aa	372ABb	403Aab	416Aa	404
L. buchneri+calcium	385Bb	436Aa	368Bb	427Aa	429Aa	409
Mean	399	444	388	423	433	417
CV%						3.38
			Neutral detergent fiber of silage (g/kg DM)			
Control	707Aab	739Aa	688Ab	682Abc	636Ac	690
L. buchneri	697Aab	734Aa	692Aab	672Abc	646Ac	688
Calcium	472Ba	487Ba	465Ba	461Ba	473Ba	472
L. buchneri+calcium	433Bb	511Ba	477Bab	435Bb	449Bb	461
Mean	577	618	580	562	551	578
CV%						3.15
			Acid detergent fiber of fresh sugarcane (g/kg DM)			
Control	352Bab	373Aa	290Ac	287Bc	300Abc	320
L. buchneri	405Aa	323Bbc	305Ac	377Aab	319Abc	346
Calcium	350Ba	338ABab	329Aab	294Bb	322Aab	327
L. buchneri+calcium	310Bb	348ABab	323Ab	394Aa	297Ab	334
Mean	354	345	312	338	309	332
CV%						6.30
			Acid detergent fiber of silage (g/kg DM)			
Control	564Ba	553Ba	547Aa	536Aa	510Aa	542
L. buchneri	638Aa	591Aab	500Ac	538Abc	504Ac	554
Calcium	350Cb	448Ca	343Bb	331Bb	426Ba	380
L. buchneri+calcium	306Db	396Dab	344Bab	348Bab	410Ba	361
Mean	465	497	434	438	463	459
CV%						6.16
			Lignin of fresh sugarcane (g/kg DM)			
Control	60Bb	100Aa	52Cb	53Bb	61Ab	65
L. buchneri	71ABbc	70Bbc	76Aab	83Aa	63Ac	73
Calcium	78Aa	64Ba	65Ba	59ABa	69Aa	67
L. buchneri+calcium	65ABa	76Ba	81Aa	76ABa	63Aa	72
Mean	69	77	68	68	64	69
CV%						9.22
			Lignin of silage (g/kg DM)			
Control	149Aa	128Aa	130Aa	152Aa	146Aa	1409
L. buchneri	164Aa	145Aa	137Aa	151Aa	153Aa	1499
Calcium	75Bbc	95Bab	68Bc	68Bc	103Ba	818
L. buchneri+calcium	71Bb	104Ba	69Bb	63Bb	99Ba	813
Mean	115	118	101	109	125	1135
CV%						13.84

Means followed by the same uppercase and lowercase in the column on the line do not differ (P>0.05) by LSMEANS.
Calcium: calcium oxide micro pulverized; CV% = coefficient of variation.

who observed pH of 11.7 in silage treated with NaOH (1%) at ensilage and 4.86 at silo opening. The values obtained post burning differed from those determined at opening, but the difference was small.

Gas losses (Table 3) were high in the silos without additives (control) because there was probably a high yeast population and these microorganisms produced ethanol and carbon dioxide during fermentation, producing gas and consequently DM losses. Gas production in the control silage was very high compared to that observed by Pedroso et al. (2007), of 103 g/kg DM *in nature* sugarcane silage.

L. buchneri application did not decrease gas production in the silages produced on days 1, 4, 7, and 10 post burning compared to the control (Table 3). As *L. buchneri* is a heterolactic bacteria, it can control the yeast population by producing acetic acid (Moon, 1983), thus it was expected that it would control yeast DM consumption by giving a lower gas production, but this did not occur. Compared to the gas production observed by Siqueira et al. (2010), that was 112 g/kg DM in burnt sugarcane silage treated with *Lactobacillus buchneri*, the result observed in the present study was better (236 g/kg DM gas loss). Explanations for this fact may include the differences in the action of this microorganism in the sugarcane cultivars and the quantity of sugars in the plant.

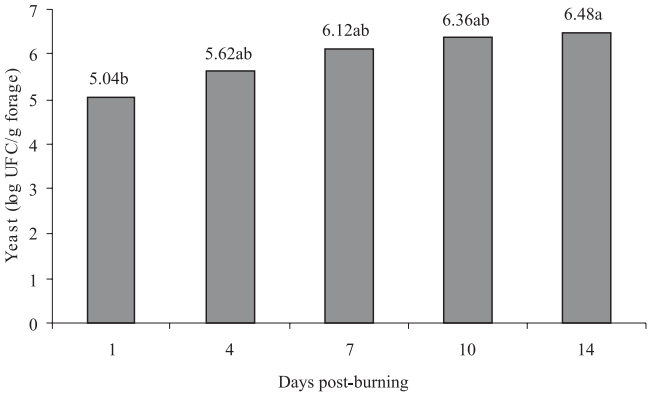

Figure 1 - Means of scores of epiphytic yeasts of sugarcane five times after burning.

The silages treated with calcium oxide micro pulverized presented the lowest gas production (Table 3), probably because of the alkaline action of the calcium oxide micro pulverized, that controls the yeast. There was greater gas production on the first day of ensilage post burning (Table 3), but this production decreased over time. This reduction over the days may have been caused by the alteration in the sugar fractions of the sugarcane before ensilage. One of the parameters that indicated alteration was decrease in pH because of the prolonged post-burning time (Table 2). Allied to a possible change in the sugar profile, the influence of the initial pH itself on the microbial development is emphasized. Consequently the silage that presented possible changes in sugar profile might reduce or alter the action of the microorganisms.

According to the data (Table 3), the effluent production was the highest on the seventh day in all the silages, because on this day the forage presented the lowest DM content in the silage (Table 1). On the other days, effluent production and DM content were similar (Table 1 and 3). The silages without additives and with *Lactobacillus buchneri* produced the most effluent, while those treated with calcium oxide micro pulverized and *Lactobacillus buchneri* + calcium oxide micro pulverized had the lowest production.

Table 2 - pH values of fresh sugarcane and silage at different days after burning and treated with additives

Additive	Days post-burning					Mean
	1	4	7	10	14	
			Fresh sugarcane			
Control	5.5Ba	5.0Bb	4.8Bc	4.5Bd	4.3Ce	4.8
L. buchneri	5.6Ba	4.9Bb	4.8Bb	4.4Bc	4.5Cc	4.8
Calcium	12.1Aa	10.7Aab	10.8Aab	10.8Aab	10.3Ab	10.9
L. buchneri+calcium	11.7Aa	11.1Ab	10.5Ab	10.9Ab	9.7Bc	10.7
Mean	8.7	7.9	7.7	7.7	7.2	7.8
CV%						3.17
			Silage			
Control	3.7Bab	3.6Bbc	3.4Bd	3.5Bcd	3.8Ba	3.6
L. buchneri	3.6Ba	3.5Ba	3.4Bb	3.6Ba	3.5Cab	3.5
Calcium	4.2Aa	3.9Ab	4.2Aa	4.2Aa	4.1Aa	4.1
L. buchneri+calcium	4.1Aa	3.9Ab	4.2Aa	4.2Aa	4.1Aa	4.1
Mean	3.9	3.7	3.8	3.9	3.9	3.8
CV%						2.00

Means followed by the same uppercase and lowercase in the column on the line do not differ (P>0.05) by LSMEANS.
Calcium: calcium oxide micro pulverized; CV% = coefficient of variation.

Table 3 - Values of gas losses, effluent losses and dry matter recovery of sugarcane silage at different days after burning and treated with additives

Additive	Days post-burning					Mean
	1	4	7	10	14	
			Gas losses (g/kg DM)			
Control	360Aa	264Ab	185Ac	242Ab	241Ab	258
L. buchneri	362Aa	259Ab	195Ac	234Abc	130Bd	236
Calcium	189Ba	126Bb	108Bbc	79Bc	121Bb	125
L.buchneri+calcium	172Ba	111Bb	91Bb	90Bb	97Bb	112
Mean	271	190	145	161	147	183
CV%						13.64
			Effluent (kg/t MN)			
Control	90.5Aa	69.4Ab	93.9ABa	59.0Bc	54.6Cc	73.5
L. buchneri	74.1Bb	70.6Ab	90.8Ba	58.2Bc	69.6Bb	72.7
Calcium	40.5Ce	77.4Ab	99.4Aa	68.7Ac	53.6Cd	67.9
L.buchneri+calcium	36.3Cc	67.7Bb	87.0Ba	65.6ABb	83.4Aa	68.0
Mean	60.4	71.3	92.8	62.9	65.3	70.5
CV%						7.29
			Dry matter recovery (g/kg DM)			
Control	522Cc	611Bb	611Bb	622Bb	698Ba	613
L. buchneri	591Bb	636Bab	642Ba	631Bab	654Ba	631
Calcium	789Aab	823Aa	760Ab	836Aa	828Aa	807
L.buchneri+calcium	825Aab	852Aa	793Ab	866Aa	824Aab	832
Mean	682	731	702	739	751	721
CV%						4.06

Means followed by the same uppercase and lowercase in the column on the line do not differ (P>0.05) by LSMEANS.
Calcium: Calcium oxide micro pulverized; CV% = coefficient of variation.

Generally, the control silages and those with *Lactobacillus buchneri* had smaller DM recovery (Table 3), that can be justified by the greater gas production that resulted in DM loss and, as already reported, the yeast consumed DM for ethanol and carbon dioxide production. It was expected that *Lactobacillus buchneri* would help in yeast control, but this did not occur.

When calcium oxide micro pulverized was added, DM recovery increased because the yeast was controlled by the additives and the reduced in gas production. The assessments of the silage produced on the first day post burning indicated a small DM recovery, probably because this day presented the greatest gas production, one of the main forms of DM loss. On the seventh day there was also little DM recovery, explained by the high effluent production, that could have up to 37 g/kg DM (Bernardes et al., 2003), also a form of dry matter loss. On the other assessment days, DM recovery was higher and there was no statistical difference among the days.

The NDF contents (Table 1) were smaller in the forage treated with calcium oxide micro pulverized, possibly because the effect of alkaline hydrolysis on the fiber occurs quickly. Furthermore, during the drying in the forced air chamber, this reaction may still be happening, that justified the reduction in the NDF fraction. In a study by Pires et al. (2006), who assessed NaOH doses (0, 2.5, 5 and 7.5% DM) on sugarcane bagasse storage for 1, 3, 5 and 7 days, did not report effect of days on any cell wall constituent, but the doses had an effect on all these parameters, that proved the rapid action of the sodium hydroxide. The control silages and those treated with *Lactobacillus buchneri* presented the greatest NDF contents before ensilage.

The sugarcane without additives presented the lowest NDF content in fresh forage on the first day (Table 1), because over time loss may have occurred of the sugarcane cell content post burning the sugar cane plantation. The decrease in NDF on the seventh day, compared to the fourth day, may be justified by the possible transformation of the carbohydrates because of rain, that also altered the DM concentration (Table 1). In the silages treated with calcium oxide micro pulverized, the same performance was also observed reported in the control forage. There was statistical difference in the NDF contents before ensilage in all the forages except the forage treated with *Lactobacillus buchneri*.

NDF contents higher than those observed in the present experiment were reported by Siqueira et al. (2009), who observed 498 g/kg DM NDF in fresh sugarcane. The NDF contents in the sugarcane treated with *Lactobacillus buchneri* in the present study (515 g/kg DM) were lower than that observed by Siqueira et al. (2009).

At silo opening, the lowest NDF contents were observed in the silages treated with calcium oxide micro pulverized, because there was better preservation of the cell content, that is, calcium oxide micro pulverized was shown to be a good additive for microorganism control during fermentation. Alkaline hydrolysis of the cell wall may also have taken place, decreasing the NDF content in the silage, a reaction that has been observed previously at ensilage. The silages treated with *Lactobacillus buchneri* and the control presented high NDF content, that can be justified by the consumption of the cell content by uncontrolled microorganisms during fermentation. The NDF contents in the silage treated with calcium oxide micro pulverized were greater than those observed by Balieiro Neto et al. (2007) *in nature* sugarcane silage treated with calcium oxide micro pulverized at 1% and 2% (5853 g/kg DM and 495 g/kg DM, respectively).

The ADF contents (Table 1) observed in the control forage were lower than those reported by Bernardes et al. (2007) of 415 g/kg DM in burnt sugarcane silage. Regarding days post burning, the lowest contents were observed on the 7th, 10th and 14th days and the highest, on the first and fourth days. The ADF contents in the forages treated on the fourth, seventh and 14th days were close to the ADF content observed by Siqueira et al. (2009) in burnt sugarcane silage treated with *Lactobacillus buchneri*, that was 316 g/kg DM.

The ADF contents observed in the silages treated with calcium oxide micro pulverized were close to those reported by Balieiro Neto et al. (2007) that of 335 g/kg DM ADF at the ensilage of *in nature* sugarcane treated with 1% calcium oxide micro pulverized. On the tenth day the ADF content in the forage was the lowest observed in the silage with calcium oxide micro pulverized, and on the first day the highest NDF content was observed with the use of this additive. When calcium oxide micro pulverized and *Lactobacillus buchneri* were used the highest ADF contents were observed in the fresh sugarcane on the tenth and fourth days.

At silo opening, the highest ADF contents were observed in the silage treated with *Lactobacillus buchneri* (Table 1), that were superior to those observed by Siqueira et al. (2009) in burnt sugarcane silage treated with this additive (477 g/kg DM). The ADF contents observed in the silage treated with calcium oxide micro pulverized + *Lactobacillus buchneri* were the lowest and were lower than those reported by Balieiro Neto et al. (2007) in *in nature* sugarcane silage treated with 1% calcium oxide micro pulverized, of 459 g/kg DM.

Regarding time post burning, when the silage was treated with *Lactobacillus buchneri*, the ADF contents tended to decrease over time, while in the control silage this content did not differ statistically (Table 1).

The silages treated with calcium oxide micro pulverized associated or not to *Lactobacillus buchneri* performed similarly for days post burning so that, from the first to the fourth day, the ADF content increased and from the fourth to the tenth day it decreased and then increased again until the 14th day (Table 1).

In the sugarcane without additives, the highest lignin content was observed on the fourth day post burning that was the same day on which the NDF and ADF contents were the highest. The lignin content observed by Siqueira et al. (2009) in the burnt sugarcane forage was 87 g/kg DM and was higher than that observed in the fresh sugarcane without additives on the first, seventh, 10th and 14th days post burning.

The lignin contents observed during ensilage in the forages treated with *Lactobacillus buchneri* on the first, fourth and seventh days were close to those reported by Siqueira et al. (2009) of 72 g/kg DM in burnt sugarcane silage treated with *Lactobacillus buchneri*.

Using calcium oxide micro pulverized as additive resulted in the lowest lignin contents in fresh sugarcane assessed on the fourth, seventh, 10th and 14th days post burning when calcium oxide micro pulverized alone was used and on the 1st and 4th days when calcium oxide micro pulverized was used in association with *Lactobacillus buchneri*. The contents observed were close to those reported by Balieiro Neto et al. (2007) of 62 g/kg DM in sugarcane silage treated with calcium oxide micro pulverized at 1%.

At silo opening, the lignin contents in the control silages and silages treated with *Lactobacillus buchneri* (Table 1) were higher than those observed by Siqueira et al. (2009) in untreated sugarcane silage and silage treated with *Lactobacillus buchneri*, of 99 g/kg DM and 80 g/kg DM, respectively. The highest lignin contents at silo opening in the silages treated with calcium oxide micro pulverized associated or not with *Lactobacillus buchneri* were observed on the 4th and 14th days. These contents were superior to those observed by Balieiro Neto et al. (2007) of 80 g/kg DM at opening of *in nature* sugarcane silage treated with calcium oxide micro pulverized at 1%.

The CP contents in the fresh sugarcane (Table 4) were higher than those reported by Siqueira et al. (2009) at the ensilage of this burnt forage without additives (13 g/kg DM) and treated with *Lactobacillus buchneri* (14 g/kg

DM) and close to those reported by Balieiro Neto et al. (2007) for *in nature* sugarcane silages without additives (30 g/kg DM) and treated with 1% calcium oxide micro pulverized (27 g/kg DM).

The CP contents decreased from the first to the fourth day post burning, but they increased from this day to the 14th day, regardless of the additives used. At silo opening, the highest CP contents were observed in the control silage and the silage treated with *Lactobacillus buchneri*. Siqueira et al. (2009) observed lower CP contents in untreated burnt sugarcane silage (23 g/kg DM) and sugarcane silage treated with *Lactobacillus buchneri* (21 g/kg DM). The CP contents were close to those observed by Bernardes et al. (2007) of 32 g/kg DM in burnt sugarcane silage.

The CP contents were lowest when the silages treated with calcium oxide micro pulverized associated or not with *Lactobacillus buchneri* were opened. Balieiro Neto et al. (2007) observed greater CP contents (31 g/kg DM) in the *in nature* sugarcane silage treated with calcium oxide micro pulverized at 1%.

The lowest CP contents were on the fourth day post burning, the same day when the lowest CP contents were observed at ensilage. The highest CP content was observed on the 14th day, when the highest CP content was observed at ensilage. Differences were not observed in the digestibility values at ensilage (Table 5).

The sugarcane presented lower digestibility only on the fourth day post burning, probably because of the higher NDF and lignin contents compared to the other days, and these fractions are related negatively to forage digestibility.

At opening, the control silages and silages treated with *Lactobacillus buchneri* presented the lowest digestibility

Table 4 - Crude protein of fresh sugarcane and silage at different days after burning and treated with additives

Additive	Days post-burning					Mean
	1	4	7	10	14	
			Fresh sugarcane (g/kg DM)			
Control	29Aa	22Ac	25Abc	27Aab	29Aa	26
L. buchneri	30Aa	22Ab	24Ab	28Aa	30Aa	27
Calcium	25Bab	20Ab	24Ab	26Aab	31Aa	25
L. buchneri+calcium	23Cbc	22Ac	23Abc	25Ab	29Aa	24
Mean	27	21	24	27	30	26
CV%						6.08
			Silage (g/kg DM)			
Control	40	34	40	43	41	39A
L. buchneri	37	32	37	43	45	39A
Calcium	28	22	24	28	29	26B
L. buchneri+calcium	25	21	26	25	29	25B
Mean	32b	27c	31b	35ab	36a	32
CV%						8.75

Means followed by the same uppercase and lowercase in the column on the line do not differ (P>0.05) by LSMEANS.
Calcium: Calcium oxide micro pulverized; CV% = coefficient of variation.

Table 5 - True *in vitro* digestibility of the dry matter of fresh sugarcane and silage at different days after burning and treated with additives

Additive	Days post-burning					Mean
	1	4	7	10	14	
			Fresh sugarcane (g/kg DM)			
Control	666	603	626	612	675	637A
L. buchneri	637	595	647	610	660	630A
Calcium	657	564	625	637	680	632A
L. buchneri+calcium	639	585	636	690	658	642A
Mean	650a	587b	633a	637a	668a	635
CV%						5.23
			Silage (g/kg DM)			
Control	424Bab	393Bb	403Bb	480Ba	483Ba	437
L. buchneri	455Bab	401Bb	417Bab	469Ba	461Bab	441
Calcium	630Ab	553Ac	681Aa	604Abc	551Ac	604
L. buchneri+calcium	658Aa	537Ab	619Aa	643Aa	609Aa	613
Mean	542	471	530	549	526	524
CV%						7.10

Means followed by the same uppercase and lowercase in the column on the line do not differ (P>0.05) by LSMEANS.
Calcium: Calcium oxide micro pulverized; CV% = coefficient of variation.

values compared to those treated with calcium oxide micro pulverized. Balieiro et al. (2007) assessed *in nature* sugarcane silage with calcium oxide micro pulverized and reported that soluble carbohydrate consumption by microorganisms resulted in a proportional rise in the fiber fraction, reducing the nutritive value of the silage and further observed that the silages with the highest digestibility values were those that had the highest nonfibrous carbohydrate contents and the lowest NDF contents.

The highest digestibility values were observed in the silage treated with calcium oxide micro pulverized that also presented the lowest DM losses and the lowest NDF contents. At opening, the performance was the same as at ensilage, so that the digestibility on the fourth day was the lowest and the NDF contents, the highest.

Conclusions

The time post burning alters the nutritive value of the fresh sugarcane and its silage, and the size of the losses from the ensilage process, but the maximum time for the sugarcane harvest could not be determined.

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