Effect of re-ensiling on the quality of sorghum silage

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ABSTRACT

The commercialization of silage in many countries, including Brazil, has increased in recent years. Re-ensiling of previously ensiled forage occurs when silage is relocated from one farm to another, where it will be compacted and sealed again. During this process, silage is exposed to oxygen before being ensiled, which may affect its quality. We exposed sorghum silage to air during the anaerobic storage phase to simulate the transportation of silages between farms. Experimental treatments included silage exposed to air for 0 or 12 h, with or without the use of an inoculant containing a mixture of *Lactobacillus plantarum* and the propionic bacteria *Propionibacterium acidipropionici* (1×10^6 cfu/g of forage; Biomax corn, Lallemand, Saint-Simon, France), totaling 4 treatments: conventional silage, conventional silage with inoculant use, re-ensilage after exposure to air, and re-ensilage after exposure to air with use of an inoculant. The sorghum was stored in experimental silos containing about 9.0 kg of fresh forage per replicate. Treatments were tested in a factorial 2×2 design with 5 replicates each. Chemical composition, in vitro dry matter digestibility, fermentative characteristics, losses (due to gas, effluents, and total dry matter), microorganism counts, and aerobic stability of sorghum silage were evaluated. Dry matter content of sorghum before ensiling was 273.12 g/kg. The 12-h re-ensiling process increased the effluent loss of the silage when compared with conventional silage (456.42 vs. 201.19 g/kg of FM, respectively). In addition, re-ensiled silages presented lower concentrations of lactic acid and higher concentrations of propionic acid than the silages that had not been opened during storage. The aerobic stability of silage was not affected by the re-ensiling process and the use of inoculant. The use of inoculant increased the

pH and loss of dry matter of the silages (4.23 vs. 3.98 and 14.05 vs. 7.82%, respectively) and therefore did not provide any benefits in this study.

Key words: aerobic stability, *Propionibacterium acidipropionici*, *Lactobacillus plantarum*, relocation, silage quality

INTRODUCTION

Forage conservation in the form of silage occurs under anaerobic conditions, where soluble carbohydrates are fermented to organic acids that reduce the pH of the medium, thus conserving the material by inhibiting the growth of undesirable microorganisms. When exposed to air, the silage may deteriorate and lose its nutritional value because of growth of detrimental microorganisms such as yeasts (Pahlow et al., 2003).

In Brazil, the commercialization of silage has become more frequent owing to reduced crop yields as a result of climatic variations during the rainy season and occurs mainly on small farms that do not have sufficient manpower and machinery for the production of silage. Additional factors associated with the decision to purchase silage from other farms include the excessive losses during storage and regional topography (de Lima et al., 2016). To meet the demands of this growing market, some farmers have started specializing in silage production for commercialization. As a result, forage ensiled on the farm must be unpacked and transported to other locations, where it will be compacted and sealed again. During this process, the material is exposed to air for an indeterminate period, which affects the quality of the silage (Michel et al., 2017). The existing literature on the re-ensiling process is very scarce and usually does not take into account the characteristics of the tropical climate. As a result, farmers and technicians are faced with numerous uncertainties regarding possible detrimental effects of silage transport.

Silage stability in the presence of oxygen is an important factor that determines the quality and nutritional value of this material (Filya et al., 2004), and bacterial

Received August 15, 2017.

Accepted February 21, 2018.

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inoculants may attenuate the decline in silage quality during the transportation process. The aim of this study was to evaluate the effect of re-ensiling and the use of microbial inoculants (*Lactobacillus plantarum* and *Propionibacterium acidipropionici*) on the quality of sorghum silage.

MATERIALS AND METHODS

Planting, Harvesting, and Ensiling

The BRS 655 sorghum crop was planted in November 2013 in the experimental area of Embrapa Milho e Sorgo, located in Sete Lagoas, Minas Gerais, Brazil (19°28'S, 44°15'W, altitude 732 m). Sorghum was planted in 5 blocks, each with 2,000 m², to provide samples representing a range of moisture and soil fertility. The space between planting lines was 70 cm. The crop was fertilized at planting (32, 112, 64, and 2 kg/ha of N, P, K, and Zn, respectively), and a top-dressing of 100 kg of N/ha was applied 35 d after planting.

When the grain reached the milk stage, the crop was harvested and chopped into 1-to-2-cm segments with a conventional forage harvester (JF C120 AT; JF Agricultural Machines, Itapira, Brazil). The chopped forage was sampled (1 sample of 800 g/block) and analyzed before being inoculated. Half of the material harvested in each block was weighed and inoculated; the other half was weighed and water was added at a rate identical to that of the inoculated silage (200 mL for 100 kg of fresh forage). A total of 9.0 ± 0.1 kg of sorghum was placed in each silo, and the forage was then manually compacted into experimental silos. For each block, a silo was made for each of the 4 treatments, amounting to 20 experimental silos in total. Silos were made from 20-L plastic buckets equipped with a Bunsen valve to allow for the release of fermentation gas. A cotton bag was placed inside each bucket with approximately 2 kg of dry sand to allow the measurement of effluent.

Experimental Design

The re-ensiling process and the use of a microbial inoculant during ensiling and re-ensiling of silage after 12 h of air exposure were evaluated, and 12 h was considered to be the minimum time required for ensiling and re-ensiling processes in Brazil. The treatments were arranged in a 2 × 2 factorial scheme, with 5 replicates each (blocks). The first variable examined was the re-ensiling process (with or without), and the second variable investigated was the use of inoculant (used or not used).

The inoculum comprised the facultative heterofermentative lactic acid bacteria *L. plantarum* MA18/5U

and the propionic bacteria *P. acidipropionici* MA26/4U (Biomax corn, Lallemand, Saint-Simon, France). Inoculation (1 × 10⁶ cfu/g of forage) was performed at ensiling. The inoculum was diluted in water and was uniformly sprayed onto the forage with a backpack sprayer and mixed.

Fifty-six days after ensiling, half of the silos were opened and re-ensiled. The silos were opened in a shed, and the material was removed and re-ensiled after 12 h of air exposure. The temperature ranged between 20.0 and 26.0°C during the exposure period, and relative humidity was between 61 and 92% (data obtained from the automatic weather station of the Brazilian National Institute of Meteorology, located 2.4 km from the shed).

All silos were opened 240 d after the re-ensiling process (296 d of storage in total). Samples were obtained for analysis of chemical composition, in vitro digestibility, silage quality (pH, NH₃-N, and lactic, acetic, propionic, and butyric acids), loss of material (gas, effluent, and total DM), aerobic stability, and total count of molds, yeasts, and aerobic bacteria.

Chemical Analysis and In Vitro DM Digestibility

Fresh forage samples were oven-dried at 55°C for 72 h and were subsequently processed in a knife mill (sieve size = 1 mm; Thomas Wiley model 4, Thomas Scientific, Swedesboro, NJ). Dry matter at 105°C, CP, ash, and ether extract (EE) were determined according to procedures outlined by AOAC International (2005).

Cell wall components (NDF, ADF, and lignin) were determined by the sequential method according to methods described by Van Soest et al. (1991). The NDF and ADF residues were subjected to ash and CP analyses to determine the amount of neutral detergent insoluble protein and acid detergent insoluble protein. These values were used to correct NDF and ADF for ash and protein. The NFC levels were calculated using the equation proposed by NRC (2001); NFC = 100 - (% NDF + % CP + % EE + MM), where MM is the amount of mineral matter or ash. In vitro DM digestibility (IVDMD) was determined on the DaisyII digestion apparatus (Ankom Technology, Fairport, NY) according to methods described by Tilley and Terry (1963) and adapted by Holden (1999). Ruminal fluid was collected from a cannulated cow that was fed a diet comprising 10 kg (DM) of sorghum silage and 3 kg (DM) of commercial concentrate.

Analysis of Fermentative Parameters

Silage juice was extracted by a hydraulic press (2.5 kgf/cm²) to determine the pH, ammoniacal nitrogen

(NH₃-N), and organic acids. The pH was measured with a digital potentiometer (HI 221, Hanna Instruments, Woonsocket, RI). Distillation to determine NH₃-N was performed in Kjeldahl equipment using magnesium oxide and calcium chloride as a neutralizing medium for the evaporation of ammonia, with boric acid as the receptor solution and 0.1 M hydrochloric acid as the titrant. The levels of organic acids (acetic, lactic, propionic, and butyric acid) were determined by GC (GC-17 Shimadzu gas chromatograph; Shimadzu Corp., Kyoto, Japan) equipped with a flame ionization detector and fitted with a Kukul capillary column according to the methodology described by Playne (1985). The gas chromatograph was operated isothermally with a column temperature of 200°C and an inlet and detector temperature of 225°C. The pH values of samples subjected to the aerobic stability test were determined as follows: fresh silage (9 g) was added to 60 mL of distilled water, and pH values were measured after 30 min (Silva and Queiroz, 2002).

Analysis of Loss

The weight of the empty silos plus lid plus dry sand bags was recorded before the ensiling process. The silos were then filled with forage, compacted, covered, sealed with adhesive tape, and weighed again.

Silos subjected to the re-ensiling procedure were opened at 56 d and weighed before and after forage removal to determine the production of gases and effluents. The DM content in the forage was also determined. The sand deposited at the bottom of each silo was replaced, after which the empty set was weighed. The forage was re-ensiled after 12 h of air exposure. After filling and sealing, the experimental silos were weighed again to determine the total weight.

We weighed all silos 296 d after the initial ensiling to determine the loss of gas. Silages were then removed, and the silos were weighed to quantify the effluent produced. Total DM loss was estimated as the difference between the final and initial dry weight of the experimental silos in relation to silage DM weight, minus the weight of the ensilage set before the silos were opened (Jobim et al., 2007). Gas, effluent, and total DM losses for the re-ensiled silages were obtained from the sum of losses during the opening for re-ensiling and the final opening.

Aerobic Stability Test

Plastic buckets (23 cm height and 66 cm circumference) containing 1.5 kg of silage per replicate were placed

in a room at 25 ± 1°C to evaluate aerobic stability. Silage temperature was monitored every 10 min with the aid of a temperature data logger inserted 15 cm into the center of mass. In addition, 1.5 kg of silage was placed in another set of buckets to track changes in microbial and pH counts. Samples from these buckets were taken on d 0, 2, 6, and 10 following the opening of silos for pH evaluation. Aerobic deterioration was considered to have occurred if the temperature difference between the materials and ambience reached 2°C (Ranjit and Kung, 2000). Microorganisms were counted in silage samples on d 0 and when they lost aerobic stability or on d 10 in silages that remained stable.

Microbiological Analyses

Samples were collected for total aerobic microbial counts (yeasts, mold, and aerobic bacteria). Analysis of the microbiota was performed using a standard dispersion plate method. Total bacterial counts were determined aerobically on plate count agar (Difco, Sparks, MD) following an incubation period of 1 to 3 d at 36 ± 1°C. Total yeast counts were determined on tryptone glucose yeast extract agar according to Pitt and Hocking (2009). Next, aerobic samples were incubated for 1 to 3 d at 30 ± 1°C. Total mold count was determined on dichloran rose-bengal chloramphenicol agar according to Pitt and Hocking (2009) after an aerobic incubation period of 5 to 7 d at 25 ± 1°C. The plates were examined daily for typical colony and morphological characteristics associated with each growth medium. Total microbial counts were expressed as colony forming units per gram. All microbial counts were log₁₀ transformed to obtain lognormal distribution.

Statistical Analyses

The results of chemical composition, in vitro digestibility, silage quality, losses, aerobic stability, and total counts of molds, yeasts, and aerobic bacteria were analyzed in randomized blocks in a 2 × 2 factorial scheme with 5 replicates. Analyses were carried out as follows:

$$Y_{ijk} = \mu + R_i + I_j + N_{ij} + B_k + e_{ijk},$$

where Y_{ijk} = observed response values; μ = overall mean; R_i = the effect of the i th level of re-ensiling time (0 or 12 h); I_j = the effect of the j th level of inoculant (with or without application); N_{ij} = the effect of i th re-ensiling and j th inoculant interaction; B_k = fixed effect of the k th block (1, 2, 3, 4, 5); and e_{ijk} = random error.

The pH data on d 0, 2, 6, and 10 of the aerobic stability test were analyzed in randomized blocks with subdivided plots. The sources of variation were blocks, treatments in 2×2 factorial arrangement (plots), and days of evaluation (subplots). Analyses were carried out as follows:

$$Y_{ijk} = \mu + R_i + I_j + D_l + N_{ij} + O_{il} + P_{jl} + Q_{ijl} + B_k + e_{ijk},$$

where Y_{ijk} = observed response values; μ = overall mean; R_i = the effect of the i th level of re-ensiling time (0 or 12 h); I_j = the effect of the j th level of inoculant (with or without application); D_l = the fixed effect of the l th days of evaluation (0, 2, 6, and 10); N_{ij} = the effect of the i th re-ensiling and j th inoculant interaction; O_{il} = interaction between the i th re-ensiling and l th days of evaluation; P_{jl} = interaction between the j th inoculant and l th days of evaluation; Q_{ijl} = the interaction between the i th re-ensiling time, the j th inoculant present, and the l th days of evaluation; B_k = fixed effect of the k th block (1, 2, 3, 4, 5); and e_{ijk} = random error.

Data were submitted to ANOVA. When significant interactions were identified, further analyses of simple effects were conducted (sliced ANOVA). When interactions were found to be insignificant, the effects of the re-ensiling process and inoculation were analyzed separately by F -tests at 5% significance. Regression analysis at 5% significance was carried out to examine the effect of days of evaluation on silage pH during the aerobic stability test. The analysis was performed using the PROC GLM software from SAS (SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

The process of re-ensiling has been adopted as a common practice for Brazilian farmers in recent years. Once exposed to oxygen, the ensiled material can be stored for several months after re-ensiling. Most farmers use the re-ensiled material within a short time (approximately 60 d or less). However, many farmers purchase large amounts of silage at low prices and re-ensile the silage for use throughout the year. Thus, aiming to simulate scenarios like this, we decided to keep the stored re-ensiled material for 240 d.

Our results demonstrated that re-ensiling sorghum silage did not significantly affect silage quality. In addition, the use of microbial inoculant containing *L. plantarum* and *P. acidipropionici* did not cause improvements in the silages.

The DM content of the fresh sorghum before ensiling and inoculation was 273.12 g/kg; the sorghum contained 66.5 g/kg of DM CP, 42.1 g/kg of DM ash, 23.7 g/kg of DM EE, 558.7 g/kg of DM NDF, 301.9 g/kg of DM ADF, and 47.93 g/kg of DM lignin. The chemical composition of the re-ensiled silages did not present alterations regarding the conventional silages (Table 1). Silages exposed to air deteriorate as a result of aerobic microbial activity, leading to loss of nutritional value (Filya et al., 2006). However, the deterioration process depends on the quality of the ensiled material and the air exposure time (Chen and Weinberg, 2014; de Lima et al., 2016).

Silages inoculated with microbial additives exhibited higher levels of neutral detergent insoluble protein compared with noninoculated silages (23.3 vs. 20.2 g/kg of DM). In addition, NDF values were higher in inoculated silage materials. Furthermore, inoculated silages demonstrated lower NFC content compared with untreated silages. Filya et al. (2000) also reported lower NFC content in silages inoculated with microbial additives than in noninoculated silages. According to the authors, lower NFC contents represent a greater extent of silage fermentation.

The success of an introduced inoculant depends on several factors, such as the properties of plants and inoculants used (Kristensen et al., 2010; Muck, 2010). It was observed that the use of inoculant led to a decrease in silage quality (decreased NFC and IVDMD). Because NFC are highly digestible organic compounds, their reduction in concentration may result in reduced digestibility of the material (McDonald and Heron, 2001), as observed in silages that received microbial inoculants (Table 1). There was no difference in IVDMD between conventional and re-ensiled silages. The use of microbial inoculants resulted in a 3% reduction in IVDMD compared with noninoculated silages (616.6 vs. 635.2 g/kg of DM).

Table 2 outlines measurements of fermentation parameters. Results indicated that re-ensiling reduced the $\text{NH}_3\text{-N}$ content of the material. In addition, re-ensiled materials had lower lactic acid and higher propionic acid contents compared with conventional silages (29.0 vs. 46.7 and 8.7 vs. 2.7 g/kg of DM, respectively). This was expected, as exposure of silage to air enables the growth of deteriorating aerobic microorganisms such as molds, yeasts, and certain bacteria, which can use VFA for metabolism. One of the main products consumed by yeasts is lactic acid, producing CO_2 and water in the process (Tabacco et al., 2011).

The use of inoculant increased silage pH, reduced lactic acid content of the material, and increased propionic acid concentration. It has been shown that in addition

Table 1. Chemical composition (g/kg of DM) of sorghum silage treated with inoculants and after re-ensiling

Parameter ¹	Treatment ²				SEM	<i>P</i> -value ³		
	Control		Inoculant			I	R	I × R
	SIL	RE	SIL	RE				
DM	263.9	264.3	245.8	259.2	3.70	NS	NS	NS
Ash	41.8	45.1	46.6	43.7	0.76	NS	NS	<0.05
CP	83.2	90.2	84.6	91.7	1.67	NS	NS	NS
NDIP	18.9	21.6	23.9	22.7	0.62	<0.05	NS	NS
ADIP	12.9	13.8	13.5	13.1	0.28	NS	NS	NS
EE	27.7	24.5	25.8	25.4	0.84	NS	NS	NS
NDF	600.7	619.5	634.0	648.9	6.55	<0.01	NS	NS
NDFap	568.4	584.5	613.2	611.7	7.32	<0.01	NS	NS
ADF	337.9	334.0	325.4	349.0	5.44	NS	NS	NS
ADFap	324.3	318.9	310.9	334.8	5.42	NS	NS	<0.05
NFC	246.7	220.6	202.6	190.3	7.15	<0.01	NS	NS
Lignin	40.9	37.9	37.9	38.5	0.98	NS	NS	NS
IVDMD	636.8	633.5	628.3	604.8	5.23	<0.05	NS	NS

¹NDIP = neutral detergent insoluble protein; ADIP = acid detergent insoluble protein; EE = ether extract; NDFap = neutral detergent insoluble fiber corrected for ash and protein; ADFap = acid detergent insoluble fiber corrected for ash and protein; IVDMD = in vitro DM digestibility.

²Experimental treatments included silage exposed to air for 0 or 12 h with or without the use of an inoculant containing a mixture of *Lactobacillus plantarum* and the propionic bacteria *Propionibacterium acidipropionici* (1×10^6 cfu/g of forage; Biomax corn, Lallemand, Saint-Simon, France), totaling 4 treatments: conventional silage (SIL), conventional silage with inoculant use, re-ensilage (RE) after exposure to air, and re-ensilage after exposure to air with inoculant use.

³I = inoculant effect; R = re-ensiling effect; I × R = interaction effect.

to carbohydrates, *P. acidipropionici* uses lactic acid as substrates during the fermentation process (Filya et al., 2004). It is possible that in this study, the use of inoculant promoted the reduction of lactic acid and an increase of propionic acid compared with untreated silages.

Silo fermentation produces volatile compounds that may lead to DM reduction in the ensiled material (Kristensen et al., 2010). The re-ensiled silages showed higher losses due to effluent compared with conventional silages (456 vs. 210 g/kg, respectively; Table 2). According to Michel et al. (2017), the higher effluent

Table 2. Fermentation quality parameters (g/kg of DM unless noted) of sorghum silage after re-ensiling and treatment with inoculants

Parameter ¹	Treatment ²				SEM	P-value ³		
	Control		Inoculant			I	R	I × R
	SIL	RE	SIL	RE				
pH	3.98	3.98	4.05	4.42	0.07	<0.01	NS	NS
NH ₃ -N/TN (g/kg)	31.5	25.7	34.9	28.0	0.14	NS	<0.05	NS
Lactic acid	75.65	42.74	17.82	15.23	7.03	<0.01	<0.05	NS
Acetic acid	11.66	38.45	29.91	30.38	4.60	NS	NS	NS
Propionic acid	1.46	4.68	3.97	12.78	1.43	<0.05	<0.01	NS
Butyric acid	4.15	1.14	7.20	7.17	1.09	NS	NS	NS
Gas loss (% of DM)	5.47	6.37	11.08	12.55	1.13	<0.05	NS	NS
Effluent loss (g/kg of FM)	184.64	415.97	235.74	496.86	30.51	<0.01	<0.01	NS
Total loss (% of DM)	6.60	9.04	14.21	13.90	1.37	<0.05	NS	NS

¹NH₃ = ammonia nitrogen; TN = total nitrogen; FM = fresh matter.

²Experimental treatments included silage exposed to air for 0 or 12 h with or without the use of an inoculant containing a mixture of *Lactobacillus plantarum* and the propionic bacteria *Propionibacterium acidipropionici* (1×10^6 cfu/g of forage; Biomax corn, Lallemand, Saint-Simon, France), totaling 4 treatments: conventional silage (SIL), conventional silage with inoculant use, re-ensilage (RE) after exposure to air, and re-ensilage after exposure to air with inoculant use.

³I = inoculant effect; R = re-ensiling effect; I × R = interaction effect.

Table 3. Aerobic stability (h) and microbial total count (log₁₀ cfu/g) under various conditions

Parameter	Treatment ¹				SEM	P-value ²		
	Control		Inoculant			I	R	I × R
	SIL	RE	SIL	RE				
Aerobic stability	240	225.6	240	206.4	8.49	NS	NS	NS
Microbial count at silage opening								
Aerobic bacteria	5.40	5.82	6.04	5.69	0.15	NS	NS	NS
Yeasts	2.89	2.53	3.11	3.09	0.17	NS	NS	NS
Molds	2.90	2.54	2.25	3.02	0.18	NS	NS	NS
Count at loss of stability								
Aerobic bacteria	5.86	6.92	6.09	5.45	0.18	NS	NS	NS
Yeasts	5.76	6.03	1.99	2.15	0.54	<0.05	NS	NS
Molds	4.01	6.31	3.88	2.14	0.43	NS	NS	NS

¹Experimental treatments included silage exposed to air for 0 or 12 h with or without the use of an inoculant containing a mixture of *Lactobacillus plantarum* and the propionic bacteria *Propionibacterium acidipropionici* (1×10^6 cfu/g of forage; Biomax corn, Lallemand, Saint-Simon, France), totaling 4 treatments: conventional silage (SIL), conventional silage with inoculant use, re-ensilage (RE) after exposure to air, and re-ensilage after exposure to air with inoculant use.

²I = inoculant effect; R = re-ensiling effect; I × R = interaction effect.

losses in re-ensiled silages may be related to the fact that this material undergoes 2 compaction processes because the compaction allows the removal of water from the plant cells and thus promotes greater effluent production. However, no differences in total DM losses were detected between the 2 treatments. Similarly, Chen and Weinberg (2014) also did not detect any difference in DM loss of re-ensiled corn silage with up to 48 h of air exposure. Our results indicated that inoculated silages showed higher effluent and gas production losses compared with noninoculated silages (366 vs. 300 and 11.8 vs. 5.9 g/kg, respectively). Dry matter losses in silages inoculated with microbial additives were 6 percentage units higher compared with noninoculated silages (14.05 vs. 7.82%). Similarly, Tabacco et al. (2011) also reported higher DM losses in silages inoculated with microbial additives compared with those in conventional silages.

The aerobic stability of silage was not affected by the re-ensiling process and the use of inoculant (Table 3). During the course of the stability test (240 h), the temperature of the material remained relatively stable (mean temperature of the silages at the end of the test was 24.6°C), which indicated maintenance of aerobic stability. This indicates that exposure of the silage to air for a period of 12 h did not promote changes that compromised the aerobic stability of the material, which was also evidenced by the similar microorganism count among all treatments at silo opening (Table 3). The pH of the silage during the re-ensiling process is an important factor for the success of the operation because some microorganisms deteriorating the silage, such as molds, do not develop in an acidic environment

(Muck, 2010), and even some microorganisms that may develop, as is the case of yeasts, have their limited growth rate under these conditions (Pitt and Muck, 1993).

On the other hand, although microorganism counts were similar at silo opening (Table 3), inoculated silages demonstrated lower yeast count compared with untreated silages following the stability test (2.07 vs. 5.89 log cfu/g). This may be due to higher production of propionic acid in inoculated silage, which acts as an important inhibitor of yeast growth (Filya et al., 2004). Tabacco et al. (2009) reported that yeast counts above 5 log₁₀ cfu/g may reduce silage aerobic stability. However, the high yeast counts observed in the present study did not have an effect on silage stability.

During the aerobic stability test, an increase in pH was observed with increased air exposure time for all treatments (Figure 1). At silo opening, yeasts that use lactic acid under aerobic conditions may develop, thereby raising silage pH (Muck, 2010). An increase in pH values with greater air exposure was observed across all treatments. However, this increase was higher in silages inoculated with microbial additives (Figure 2). The pH increase in the inoculated silages during the aerobic stability test was not related to the higher yeast growth because the inoculated silages presented the lowest yeast counts at the end of the test. Inoculated silages had a higher pH from the opening of the silo and consequently a higher pH at the end of the stability test. However, when we observe Figure 2, the pH pattern is very similar between inoculated and noninoculated silages. The expected behavior would be an increase in yeast counts under low-pH (3.5–4.0) aerobic

Figure 1. Changes in pH and SEM during air exposure during evaluation of aerobic stability. Average of all treatments.

conditions. In our experiment, the pH of the inoculated silages was 4.4, so other aerobic microorganisms may have been favored. Thus, the lower yeast count can be explained by lower growth rate in relation to aerobic bacteria (Muck, 2010). Although the aerobic bacteria count did not show statistical differences, counts were high in all treatments.

Overall, our results agree with the few studies on re-ensiling published so far (Chen and Weinberg, 2014; de Lima et al., 2016; Michel et al., 2017) that the re-ensiling process does not significantly affect silage quality. However, it is important that aspects such as the quality of the silage to be relocated are taken into account so that the risks of loss in the process are minimized.

Figure 2. Changes in pH and SEM of silages with and without inoculant.

CONCLUSIONS

Re-ensiling after 12 h of aerobic exposure followed by 240 d of anaerobic storage did not lead to reduced nutritional quality or loss of aerobic stability compared with silages that remained sealed throughout storage. In our study, the inoculant did not contribute measurably to the success of the re-ensiling process.

ACKNOWLEDGMENTS

The authors thank the Brazilian Agricultural Research Corporation (EMBRAPA)—Maize and Sorghum, Sete Lagoas, Minas Gerais, Brazil, the Coordination and Improvement of Higher Level or Education Personnel (CAPES), the Veterinary School of Federal University of Minas Gerais (EVUFMG), and the Pro-Rector of Research of Federal University of Minas Gerais (PRPq-UFGM), Belo Horizonte, Minas Gerais, Brazil, for their support and assistance.

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