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AEROBIC STABILITY OF CORN AND SOYBEAN SILAGE MIXED AT DIFFERENT RATIOS

ESTABILIDADE AERÓBIA DE SILAGENS DE MILHO E SOJA EXCLUSIVAS OU ASSOCIADAS

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SUMMARY

The objective of this work was to evaluate the aerobic parameters of corn and soy silage mixed at different ratios. The randomized experimental design evaluated 5 treatments (100% of corn silage - CS; 95% CS + 5% of soy silage - SS; 90% CS + 10% SS; 85% CS + 15% SS; 100% SS), with four replicates. The lowest average temperature and pH were recorded for 100% corn silage (23.69ºC and 5.39), while the highest pH (8.25) and the highest temperatures were recorded in the silage containing 10 and 15% of soy (25.36 and 25.29ºC). The silage containing corn and soy exclusively had the lowest heating rates (0.082 and 0.072ºC/hour) compared to the others. The 100% soy and 100% corn silages were the most stable aerobically, since the first signs of instability appeared after 56 hours. Therefore, the combination of corn and soy in silage is not recommended since it favors the deterioration of the product.

KEY-WORDS: Deterioration. Microorganisms. pH. Temperature.

RESUMO

Objetivou-se por meio deste trabalho avaliar as características de silagens de milho e soja exclusivas ou associadas em aerobiose. Utilizou-se o delineamento experimental inteiramente casualizado, estudando-se 5 tratamentos (100% de silagem de milho - SM; 95% SM + 5% de silagem de soja - SS; 90% SM + 10% SS; 85% SM + 15% SS; 100% SS), com quatro repetições. Notou-se menor temperatura e pH médio para a silagem de milho exclusiva (23,69ºC e 5,39), assim como pH máximo (8,25) e temperaturas mais elevadas nas massas com 10 e 15% de silagem de soja (25,36 e 25,29ºC). As silagens de milho e soja exclusivas apresentaram menor taxa de aquecimento (0,082 e 0,072ºC/hora) em relação às outras silagens. As massas que levaram maior tempo para apresentar sinais de instabilidade aeróbia foram àquelas compostas por 100% de silagem de milho e 100% de silagem de soja (56 horas). Portanto, não se recomenda a associação entre as silagens de milho e soja em virtude de favorecer a deterioração das massas.

PALAVRAS-CHAVE: Deterioração. Microrganismos. pH. Temperatura.

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INTRODUCTION

The seasonality of forage production in tropical countries results in low performance of animals kept in extensive systems. Therefore, the use of stored forage is a viable alternative that can ensure the supply of high quality fodder during the period of food shortage, thus improving production indicators (PEREIRA et al., 2008).

Corn is one of the most used species to produce silage, due to ease of cultivation, adaptability, high mass production, ease of fermentation in the silo, good energetic value and high animal consumption (GIMENES et al., 2006). However, corn silage has low protein content, which limits considerably its exclusive use, especially for animals with high nutritional requirements (RIGUEIRA, 2007).

In this context, the use of leguminous plant silage is an option to increase the protein content of the diet (MARCHEZAN et al., 2002), to provide greater amounts of calcium and phosphorus, thus reducing the production costs, since it decreases the need for supplemental protein concentrate (BAXTER et al., 1984) and enhances dry matter degradation in the rumen (DAMASCENO et al., 2002). However, there are factors that hinder soybean conservation as silage, such as low concentration of dry matter and high protein, oil and mineral matter contents at the time of harvesting, which characterizes soy as difficult forage for silage because it also has high buffering capacity (PEREIRA et al., 2009).

Evangelista et al. (1983) and Obeid et al. (1992) evaluated soybean and corn mixture at different ratios, aiming to increase the protein content of the silage and reported that mixed silage resulted in higher animal consumption and weight gain compared to corn-only silage.

Although there are reports in the literature about corn-soybean silage, they address the aspects inherent to the fermentation process (DIAS et al., 2010) and the nutritive value of the silage, leaving aside silo post-opening period, a step that may cause the silage to lose nutritional and sanitary quality (level of toxins produced by fungi), resulting in poor animal performance.

Therefore, this study aims to evaluate the aspects related to the characteristics of corn-only, soy-only and corn-soy silage mixed at different ratios under aerobic conditions.

MATERIAL AND METHODS

The study was conducted at the Forage Sector, Animal Science College of José do Rosário Vellano University (UNIFENAS), in Alfenas, during 2010. Corn silage was produced with the commercial hybrid (BM3061) and soy silage with the soybean cultivar Conquista, both suitable for planting in the region.

The corn for the silage was harvested after 114 days, when dry matter content was 31.55%. It was harvested manually at 10 cm from the soil surface, the plants were cut into pieces of average size 0.5 to 2.0 cm using a stationary cutter, that were further ensiled in PVC containers of 130 kg capacity. Subsequently, the silage was compressed in order to reach specific mass close to 600 kg/m^3, remaining in the fermentation process for 55 days.

Soybean plants were harvested for silage at the R8 stage, when 95% of the beans were ripe. The harvest was performed by an adapted forage harvester and the mass was stored in a trench silo for 60 days, where it was mechanically compressed.

After this period, the silos that contained corn and soy only silage were opened. The soybean silage was removed by cutting a 30 cm ensiled mass at different locations in the silo. The silage was then transferred to plastic trays for later homogenization and preparation of the treatments based on green weight. After this, 4.0 kg-silage samples were revolved in order to let air penetrate the mass, silage heaps were prepared and kept in a covered and cemented warehouse to study stability under aerobic conditions.

The experimental design was completely randomized, where 5 different mixing ratios were evaluated as follows: corn only silage (CS); soybean only silage (SS), 95% CS + 5% SS; 90% CS + 10% SS; 85% CS + 15% SS, with four replicates.

Room and silage temperatures were measured three times daily, at 8 hour intervals, during 7 days. The thermometer was inserted 10 cm into the center of the fodder mass, as described by Kung Jr. et al. (2003) and Bernardes et al. (2007). From the same heap, at the time the temperature was measured, approximately 15 g of mass sample was taken to determine pH, thus characterizing the experiment as split-plot in time.

The experiment was conducted at room temperature since according to Jobim et al. (2007) carrying out the aerobic stability test in an environment with controlled temperature might lower the accuracy of the estimated rate of silage deterioration. Mean temperature measured during the period was 22.41ºC, while at times 6:00, 14:00 and 22:00, mean temperatures were 19.93, 25.63 and 21.21ºC respectively.

The parameters used to evaluate aerobic instability were: silage temperature was increased 2ºC above room temperature after silo opening (MORAN et al., 1996), maximum temperature, time elapsed to reach maximum temperature, the sum of temperature difference between the silage temperature minus the average room temperature from 0 to the 7th day ($tºC_{accumulated} = \sum (tºC_{silage} - tºC_{room})$), according to proposed by O'Kiely et al. (1999), and last, the heating rate (RUPPEL et al., 1995). Another parameter used to evaluate the aerobic stability of silage was the pH, since according to Cherney & Cherney (2003), the pH is a good indicator of the quality of silage with low DM content.

The data were submitted to variance analysis using the SISVAR® software (FERREIRA, 2008), and the means were compared by the Scott-Knott test at 5% significance level, except for the data concerning the time needed to break aerobic stability. However, four of the five treatments resulted in equal values for all repetitions, and since there was no variation, the treatments were dropped due to heteroscedasticity. Therefore, being left with only treatment made the statistical analysis impossible.

RESULTS AND DISCUSSION

Corn-only silage had the lowest mean temperature (p = 0.0001) during aerobic exposure, noting also that the silage containing 10 and 15% soy displayed mean temperature higher than the others (Table 1). The high protein and oil levels present in soybeans (CALDWELL, 1973) associated with corn energy intake seemed to contribute markedly to the development of microorganisms, causing the temperature of the silage to increase.

During silage evaluation days, temperature peaked after 48 and 120 hours (Figure 1). According to reported by Gimenes et al. (2006) and Woolford (1990), the initial temperature increase is caused by yeast and bacteria growth; however, after some time other microorganisms also contribute to overall deterioration of the material. Muck and Pitt (1992) concluded that the bacilli, which are not important until silage pH is above 5.0, cause the second rise of temperature when silage is exposed to air.

Table 1 - Temperature of silage during aerobic exposure[1].

Silage	t°C mean[2]	t°C max.[3]	H t°C max.[4]	□ °C[5]	°C/h[6]
100% SM	23.69[c]	26.25[b]	104[a]	28.25[c]	0.082[b]
95% SM + 5% SS	24.40[b]	29.25[a]	54[a]	44.00[b]	0.167[a]
90% SM + 10% SS	25.36[a]	30.75[a]	68[a]	65.00[a]	0.177[a]
85% SM + 15% SS	25.29[a]	30.25[a]	52[a]	63.50[a]	0.211[a]
100% SS	24.43[b]	27.50[b]	86[a]	44.50[b]	0.072[b]
VC (%)	7.25	4.48	52.43	17.08	30.5

[1]Means followed by the same letter in the column do not differ by Scott-Knott at 5%. [2]t°C mean = mean temperature ; [3]t°C max. = maximum temperature; [4]H t°C max. = hours needed to reach maximum temperature; [5]□ °C = temperature accumulated during aerobic exposure; [6]°C/h = heating rate.

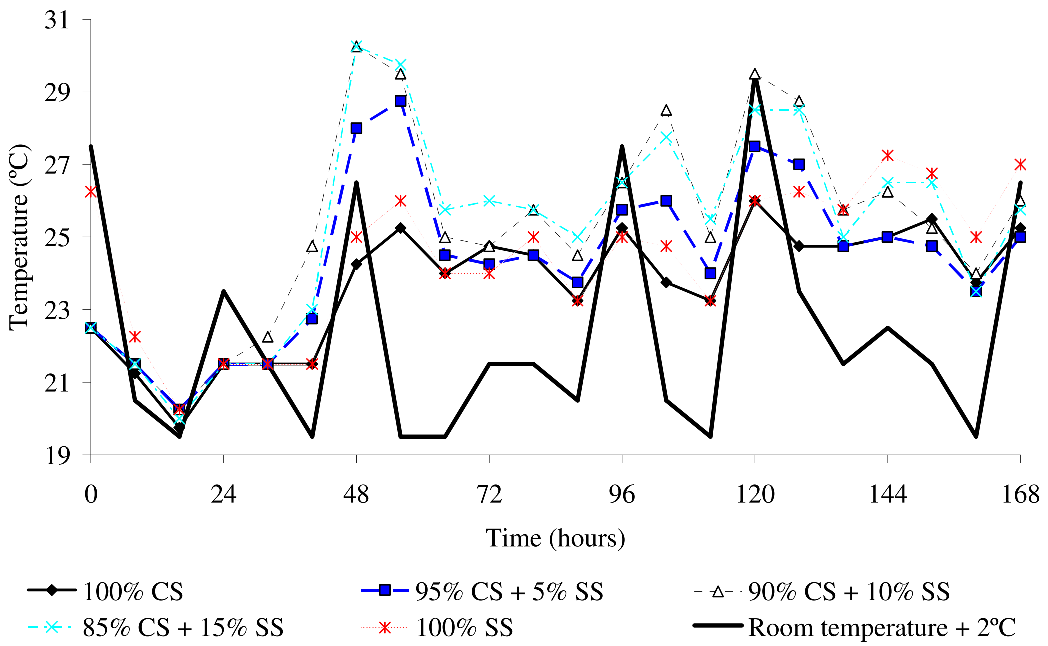

Figure 1 - Silage temperature during the aerobic exposure

The aerobic silage made of 100% corn and 100% soy displayed the lowest means for the maximum temperature (p = 0.0008), whereas this variable increased when they were mixed up in the associated silage. These results corroborate Jobim et al. (2008), who reported maximum temperature between 33.3 and 37.9ºC for silage made of wet corn only and silage made of wet corn and soy, respectively.

Although silage composition influenced maximum temperature, it did not influence the time needed (P>0.05) to reach this temperature. As for accumulated temperature, corn only silage was lower (p = 0.0001), which agrees with the mean temperature observed for this treatment. Likewise, the association of corn and soy at the ratios of 10 and 15% of soy, displayed the highest accumulated temperature during the period under aerobic conditions (Table 1).

According to variance analysis, silage heating rates were higher (p = 0.0011) when corn and soy were mixed compared to corn and soy only silage. Rodrigues et al. (2003) reported heating rate of 0.074ºC/h while working with elephant grass without additives, value similar to those observed in this study for corn and soy only silage.

The mean times (in hours) needed to break silage aerobic stability are shown in Figure 2. Even without statistical analysis, it can be seen that corn-only and soy-only silage took longer to break this stability, which can be explained by the lower protein content of corn silage and high oil content of soy-only silage, since both factors inhibit or hinder the development of deteriorating aerobic microorganisms. The aerobic deterioration of silages, in addition to reducing their nutritional value, may increase the risk of proliferation of potentially pathogenic or undesirable microorganisms (DRIEHUIS et al., 2001), thus affecting significantly the performance of animals fed these silages.

The results of this study do not corroborate Griffin (2000), who while evaluating data of leguminous plant silage from four countries of the European Community, between 1997 and 2000, reported that from the 264 evaluated leguminous silage, none heated up or displayed fungal decay when exposed to air during 4 days and 90% remained stable for 7 days. This result is most likely due to the lower room temperatures in these countries, which hinders the development of spoilage microorganisms. On the other hand, the tropical climate favors the development of these microorganisms.

Dias (2007) evaluated aerobic stability of soybean silage at several developmental stages, and observed that silage temperature remained stable and close to room temperature during the 7-day evaluation period. Jobim et al. (2008) evaluated aerobic stability of wet corn-only silage and mixed with wet soybeans, and found that both silages displayed the first signs of aerobic instability after 20 hours, independent of silage nature.

Corn-only silage had the lowest mean pH (P<0.01) compared to other silages and, the silages containing 10 and 15% of soy and soy-only silage had higher mean pH as shown in Table 2. This is due to the fact that soy has a high percentage of crude protein; therefore, soy products promote an increase of the buffering capacity (NILSON, 1959). The mean pH values of corn silage in this study are lower than the mean pH value of 6.64 reported by Gimenes et al. (2006), after 72 hours of aerobic exposure.

On the other hand, the pH values found for soy-only silage in this study were higher than the mean value of 5.3 reported by Dias et al. (2010) at the moment the silos were opened, which has been corroborated by Paula et al. (2009), who reported a pH of 5.54 for soy. Leonel et al. (2008) reported lower pH value for grass only silage compared to grass and leguminous associated silage.

Table 2 - Values of pH during aerobic exposure[1].

Silage	pH mean	H pH >0.2[2]	pH max.[3]	H pH max.[4]	Σ pH[5]
100% SM	5.39^{c}	58^{a}	8.25^{b}	114^{a}	118.62^{c}
95% SM + 5% SS	6.01^{b}	50^{a}	8.80^{a}	106^{a}	132.27^{b}
90% SM + 10% SS	6.41^{a}	40^{b}	8.73^{a}	72^{b}	141.17^{a}
85% SM + 15% SS	6.72^{a}	34^{b}	8.79^{a}	84^{b}	147.86^{a}
100% SS	6.70^{a}	36^{b}	8.86^{a}	102^{a}	147.55^{a}
CV (%)	14.84	19.68	3.09	18.49	3.16

[1]Means followed by the same letter in the column do not differ by Scott-Knott at 5%. [2]H pH >0.2 = hours needed to increase the pH by 0.2 (H pH >0.2); [3]pH max. = pH maximum; [4]H pH max. = hours needed to reach maximum pH; [5]Σ pH = summation of pH values during the 7 days.

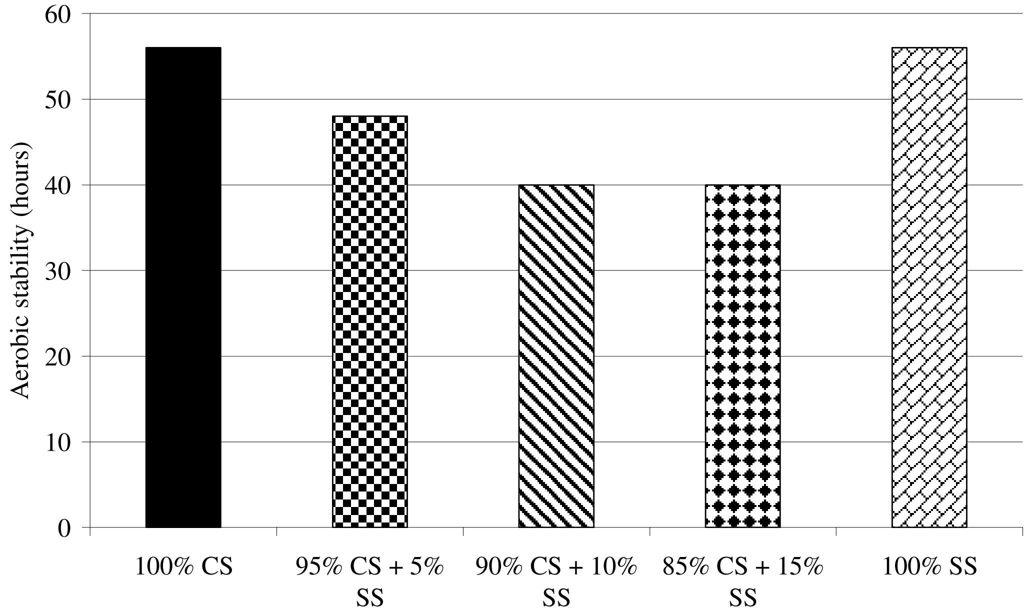

Figure 2 - Aerobic stability of corn and soy silages, exclusive or associated at different ratios

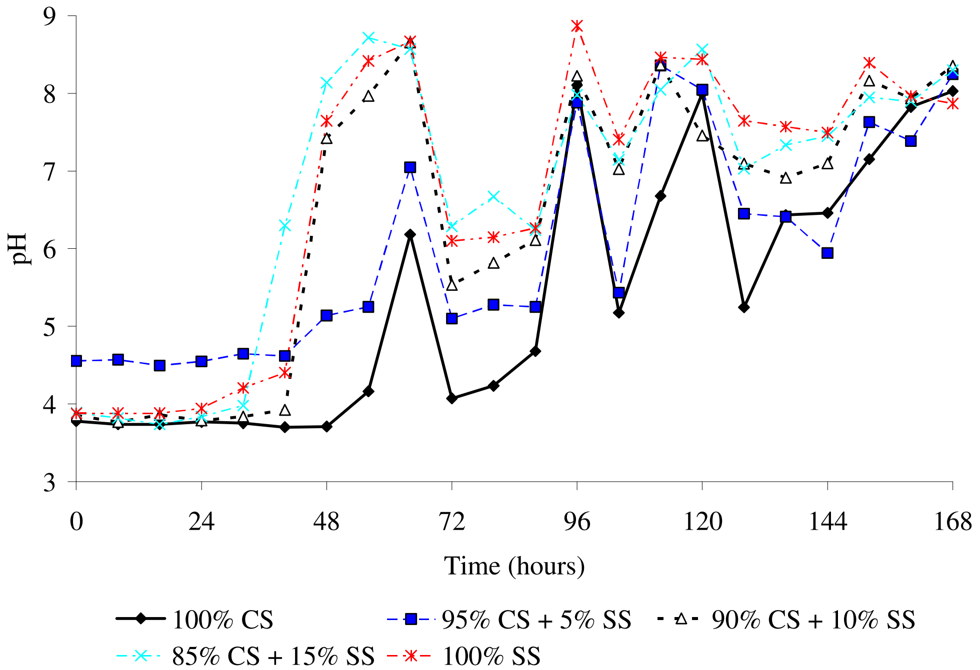

Figure 3 - Silage pH during the aerobic exposure

The pH behavior during the period in which silage remained under aerobic conditions is shown in Figure 3. There was a remarkable increase of pH values with time, which is due to degradation of the organic acids by microorganisms (PAHLOW et al., 2003). In general, pH values remain low only up to 36 hours of aerobic exposure (except for the silage made of 95% corn and 5% soy), which inhibits the development of microorganisms, since as described by Leibensperger & Pitt (1987) pH is the main agent to suppress clostridial growth, and clostridium development is restricted when forage pH is lower than 4.2.

There was wide pH variation during aerobic exposition (Figure 3), values changed from close to 3.5 to more than 8; which according to Kung Jr. et al. (2003) may indicate that silage is deteriorating due to organic acid degradation by the action of undesirable bacteria and opportunistic fungi that reduce the quality of silage in contact with air (KLEINSCHMIT et al., 2005). In order to observe pH changes during silage aerobic exposure, Jobim et al. (2007) determined the time necessary to increase by 0.2 silage pH. Therefore, the effect of silage composition on the pH was determined ($p = 0.0059$), as silage made with 100% corn and 95% corn and 5% soy took 58 and 50 hours, respectively, to increase the pH by 0.2.

The effect of silages ($p = 0.0340$) on maximum pH values has been reported, while corn only silage had the lowest mean pH (8.25) the other silages were not significantly different (Table 2). Corn-only, soy-only, as well as 95% corn and 5% soy silages took longer to reach the maximum pH ($p = 0.0257$). Gimenes et al. (2006) reported mean pH value of 6.64 for corn silage without using inoculant after 72 hours of aerobic exposure and an increase of 3.22 since the opening of the silo.

As expected, corn-only silage had the lowest accumulated pH ($P<0.01$) compared to other silages, due to lower pH values recorded during the seven days in which it remained under aerobic conditions.

CONCLUSIONS

The association of corn and soy in the silage promotes instability, causing the silage to deteriorate faster; therefore, their use is not recommended.

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