Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 352

2002

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Recommended Citation

Uriarte-Archundia, M.E.; Bolsen, K.K.; and Brent, B.E. (2002) "A study of the chemical and microbial changes in whole-plant corn silage during exposure to air: effects of a biological additive and sealing technique," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 1. https://doi.org/10.4148/2378-5977.1755

A STUDY OF THE CHEMICAL AND MICROBIAL CHANGES IN WHOLE-PLANT CORN SILAGE DURING EXPOSURE TO AIR: EFFECTS OF A BIOLOGICAL ADDITIVE AND SEALING TECHNIQUE

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Summary

The objectives of this study with whole-plant corn silage were to determine the effects of a biological additive and sealing technique on yeast and mold populations; and to examine the relationship between the microbial and chemical changes in the silages during exposure to air. Whole-plant corn was harvested at 80% milkline (36% DM), and ensiled at a density of 35 lb of fresh matter/ft^3. Half of the pre-ensiled forage was treated with a biological additive (A) (Sil-All 4×4, Alltech, Inc.); the other half of the pre-ensiled forage was the untreated control (C). Half of the silos in the A and C groups were sealed immediately after filling (S=sealed) and the other half of the silos were sealed 48 hours after filling (DS=delayed seal). Treatments consisted of combinations of the two factors: additive (A and C) and sealing technique (S and DS). There were three, 5-gal capacity, laboratory silos per treatment. Silos were opened after 150 days, and the chemical and microbial compositions and aerobic stability of the silages determined. All four silages were moderately stable during exposure to air. The C, DS silage was the first to show a rise in temperature, which occurred after 65 hours. The two DS silages were 48 hours less stable than their S counterparts, and the two A silages were 24 hours more stable than their C counterparts. Deterioration of the silages during exposure to air was accompanied by an increase in temperature and pH, a decrease in lactic acid content, and a rapid increase in the lactate-assimilating yeast population. Treatment with a biological additive significantly improved aerobic stability, and delayed sealing reduced the aerobic stability of silages.

(Key Words: Corn Silage, Inoculant, Aerobic Deterioration, Sealing.)

Introduction

Efficient forage preservation as silage requires minimizing losses during the aerobic, fermentation, storage, and feedout phases. While the efficiency of the fermentation phase has been improved, the same cannot be said about aerobic stability during the feedout phase. This improvement in silage quality, which prevented the production of butyric acid and minimized the amount of acetic acid during the fermentation phase, increased the risk of aerobically unstable silages. These volatile fatty acids (VFAs) possess antimycotic activity, and thus inhibit the growth of yeasts and molds upon exposure to air during the feedout phase. In general, well-preserved silages are considered more prone to aerobic deterioration than their poorly-preserved counterparts. The addition of homofermentative lactic acid bacteria (LAB) has improved silage quality by promoting fast and efficient production of lactic acid, which results in a rapid pH decrease. However, aerobic stability has often been less for homolactic compared to heterolactic silages.

The objectives of this study with whole-plant corn were to determine the effects of a biological silage additive and sealing technique on yeast and mold populations; and to examine the relationship between the microbial and chemical changes in the silages during exposure to air.

Experimental Procedures

Whole-plant corn was harvested at 80% milkline (36% DM) on September 21, 1999. It was precision-chopped to approximately 12 mm, ensiled in laboratory silos, and packed at a density of 35 lb of fresh matter/ft^3. Half of the pre-ensiled forage was treated with a biological additive (A) (Sil-All 4×4 supplied by Alltech, Inc.), which contained a mixture of bacteria (*Streptococcus faecium*, *Pediococcus acidilactici*, *Lactobacillus plantarum*, *Bacillus pumulis*) and enzymes (cellulase, hemicellulase, amylase, and pentosanase). The other half of the pre-ensiled forage was the untreated control (C). Half of the silos in the A and C groups were sealed immediately after filling (S=sealed), and the other half were sealed 48 hours after filling (DS=delayed sealed). The laboratory silos were 5-gal capacity plastic pails. Treatments consisted of combinations of the two main effects: additive (A and C) and sealing technique (S and DS).

The silos were opened after 150 days. All three replicates from each treatment were composited and mixed, and 2.2-lb pooled samples for each treatment were placed in 1.7-gal capacity polystyrene foam containers. There were 10 containers per treatment. Silages were exposed to air for 4 days. Thermocouples were placed in the center of the silage in each container, and temperature of silages was recorded daily at 6:00, 12:00, 18:00, and 24:00 h. Ambient room temperature was kept constant at 75°F ± 1.5. A silage was considered aerobically unstable when the temperature raised 2.7°F above room temperature. Two containers of each treatment were removed on days 1 through 4, and two samples were taken for chemical and microbial analyses.

Results and Discussion

The chemical composition of the corn silages after 150 days of storage and a 4-day exposure to air is shown in Table 1. Silage pH and lactic acid concentration were indicative of an efficient preservation. Exposure of the silages to air led to an increase in pH and a decrease in lactic acid content in the delayed seal silages ($P<0.01$).

All four silages were moderately stable during the exposure to air period (Figure 1). Extremely good aerobic stability was observed in the two sealed silages. The two DS silages were 48 hours less stable than their S counterparts, and the two A silages were 24 hours more stable than their C counterparts.

The microbial composition of the corn silages after 150 days of storage and a 4-day exposure to air is presented in Table 2. Additive and sealing technique had no significant effects on yeast and mold or lactic acid bacteria populations. Aerobic deterioration of the two delayed seal silages was accompanied by an increase ($P=0.06$) in the lactic acid assimilating yeast population.

Treatment with a biological additive significantly improved aerobic stability, but the mechanism of action was not evident. Delayed sealing after the silos were filled reduced the aerobic stability of the silages.

Table 1. Chemical Composition and pH of the Four Corn Silages Before ensiling (day 0) and After Exposure to Air (day 4)

	DM (%)		pH		Lactic Acid[1]	
	Day		Day		Day	
Treatment	0	150	0	150	0	150
Control						
S	35.1	36.1	3.7	3.9	5.5	4.0
DS	33.8	32.9	3.7	8.0	3.3	0.3
Additive						
S	33.0	35.0	3.5	3.6	5.9	4.9
DS	32.5	32.2	3.6	7.2	5.5	1.5

[1]Percent of the silage DM.

Table 2. Microbial Composition (log_{10} CFU per g of fresh material) of the Corn Silages Before (day 0) and After Exposure to Air (day 4)

	Y and M[1]		LAY[2]		LAB[3]	
	Day		Day		Day	
Treatment	0	150	0	150	0	150
Control						
S	NA	9.2	NA	8.2	5.6	8.4
DS	2.9	9.7	2.8	9.4	3.6	8.0
Additive						
S	NA	9.1	NA	7.0	NA	7.9
DS	5.1	8.6	2.5	8.7	NA	NA

[1]Yeast and mold.
[2]Lactate-assimilating yeast.
[3]Lactic acid bacteria.

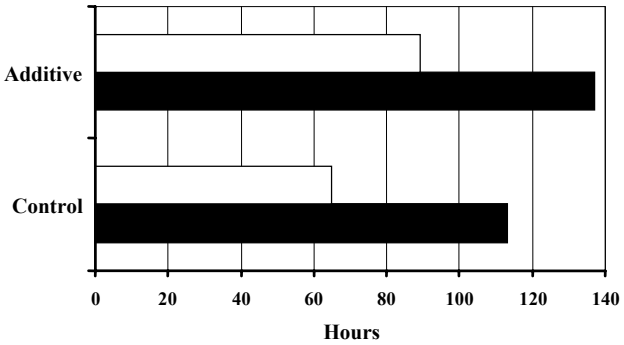

Figure 1. Hours to the Initial Rise in Temperature for the Four Corn Silages During Exposure to Air. ■ Sealed, □ Delayed seal