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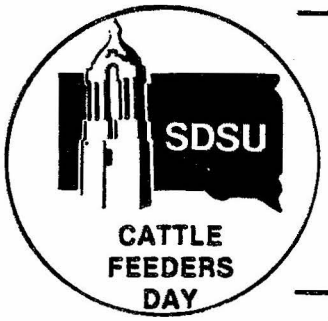


# EFFECT OF ENZYMES ON CORN SILAGE QUALITY, PRESERVATION AND UTILIZATION BY BEEF STEERS

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CATTLE 84-3

## Summary

Corn forage (61% moisture) harvested from the 1981 corn crop was ensiled in two experimental concrete silos. One silo was filled with 4600 lb of untreated forage and the other with 5011 lb of forage treated with a mixture of enzymes applied at the rate of .5 lb per ton of wet forage.

Measurements taken during the experiment included temperatures and chemical characteristics during fermentation, chemical profiles after a 213-day storage period and digestibility of nutrients and retention of nitrogen by beef steers. Dry matter preservation was also determined.

The results of the study were:

1. Temperatures during the 3 weeks of storage were about the same for the untreated as for enzyme-treated silage.
2. Silage treated with a mixture of enzymes (proteinase amylase and gumase) had generally higher lactic acid levels than untreated silage both during the initial storage period and at the time of feeding.
3. Formation of organic acids was slightly lower for enzyme-treated silage during fermentation and also at time of feedout.
4. There were no differences between the experimental silages in digestibility of nutrients. However, steers fed the enzyme-treated silage retained less nitrogen for productive purposes than steers fed the untreated silage.
5. Dry matter recovery was 99.8% for untreated silage and 97.6% for treated silage.

## Introduction

Research at the South Dakota Experiment Station has been directed toward methods of improving of corn silage quality and preservation. The use of various commercial additives in silage making continues to be of interest to farmers and ranchers of South Dakota. The additives researched at SDSU include viable and nonviable bacterial inoculants, organic acids, sodium diacetate, an ammonia-molasses-mineral suspension and enzymes.

Enzymes are grouped among the additives which appear to alter or aid the silage fermentation process. Enzyme additions may influence the degradative processes which occur during the fermentation and subsequently affect acid formation. The purpose of this study was to determine the effect of a mixture of enzymes[a] applied at storage on corn silage fermentation characteristics. Nutrient utilization by cattle and preservation of dry matter were also measured in comparisons which included untreated and enzyme-treated silage.

## Procedures

Corn forage from the 1981 corn crop was harvested with a conventional forage chopper. Although grain content of forage was not determined, the forage was from well-eared corn plants and contained 61.4% moisture at the time of ensiling. The chopped forage was weighed into a feed mixing wagon[b] equipped with a scale and allowed to mix for 10 minutes. The forage was transferred by means of an elevator to two experimental concrete silos. One silo was filled with untreated forage. The other silo was filled with forage treated with an enzyme product applied at a rate of .5 lb per ton of wet forage. The product contained a mixture of proteinase, amylase and gumase enzymes. Weighing and handling procedures were the same for both silages.

The silo structures were reinforced concrete culverts 6 feet high with a 5-foot inside diameter and a 4-inch wall. Each silo was equipped with a 14-inch door opening the height of the silo and six sampling ports. The sampling ports were either 1 or 1 1/2 inches in diameter, situated in the silo wall 3 feet above the bottom and spaced at 60° angles. The silos were placed on a concrete slab equipped with a "U" shaped trough for collection of seepage liquids. Packing was accomplished by two persons walking on the surface of the silage during filling. The silos were covered with a plastic cover and a wooden lid placed on the plastic such that the lid fit inside the silo. Cement blocks were placed on the lid to provide approximately 1200 lb of weight. An indoor-outdoor thermometer was installed through one sampling port with a sensor located in the center of the silo. Temperatures of the silage were recorded at 5 p.m. daily for 26 days after ensiling.

Samples of forage were collected at ensiling, placed in double plastic bags, closed with a fastener and immediately frozen for chemical analyses. Samples of ensilage were collected daily through the port openings and as the silage was removed from the silo for feeding.

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[a] Zymo-Best, Premier Malt Products Inc., Milwaukee, WI.

[b] Blair Manufacturing Company, Blair, NE.

Dry matter content of the forage at ensiling was determined by drying triplicate quantities (100 grams) in a forced air oven at 70 C for 24 hours. A chemical silage quality profile was completed on all remaining samples. Moisture and total nitrogen content were determined on frozen material finely ground in a reversible homogenizer. Moisture was determined by toluene distillation with corrections for acid content. The battery of tests performed on the samples included pH, titratable acidity, ammonia nitrogen, lactic acid and organic acids (acetic, propionic, butyric).

Preservation of dry matter was determined on the basis of dry matter ensiled versus that removed from the silo. Spoiled silage was separated from the feedable silage, weighed and sampled as the silos were emptied.

Utilization of nutrients by cattle fed the untreated and enzyme-treated silage was determined in a digestion-nitrogen balance trial. Twelve steers averaging 604 lb were placed in individual pens at the Animal Science Complex. The pens were equipped with automatic waterers and were situated over concrete slatted floors. All steers were fed untreated corn silage produced locally for about 2 weeks. The steers were then weighed and allotted to the two silage treatments with six steers per treatment. The experimental silages were fed an additional 10 days and then the cattle were transferred from the pens to metabolism crates. An additional 7 days were allowed for adjustment of the cattle to the crates and a 5-day total collection digestion-nitrogen balance trial was conducted. The steers were fed silage twice daily and refused feed was weighed and sampled the following morning. A supplement containing 58.1% soybean meal (44% protein), 28.7% ground corn, 2% ground limestone, 6.2% dicalcium phosphate and 5% trace mineral salt was fed at a rate of 1.4 lb per steer daily. The supplement contained 10,000 IU of vitamin A per pound. Feed refusals, feces and urine collections were handled according to conventional procedures. Measures of utilization included the digestibility of dry matter, crude protein and organic matter. Nitrogen retained for productive purposes was reported as a percentage of nitrogen consumed.

## Results

### Silage Fermentation Characteristics

Heat production during the fermentation of untreated and enzyme-treated silage is presented in figure 1. Temperatures at ensiling were 72 F. Peak temperatures occurred at day 5 with 86 F and 90 F for the untreated and enzyme-treated silages. These small differences between the silages were observed during the remaining days of fermentation. Numerically, the differences between the silage treatments were small and would be considered within the range of normal variation.

Selected chemical characteristics of untreated and enzyme-treated corn silage are presented in table 1. The fermentation proceeded rather rapidly as indicated by pH values at or below 4 shortly after storage. Ammonia nitrogen formation was variable with somewhat higher values observed in both silages toward the end of the fermentation period. Comparing the two silages in lactic acid content, the enzyme-treated silage had higher levels than untreated silage in 15 days out of a total of 24. Organic acid production was higher for the treated silage than for the untreated silage in only 9 days out of 24.

Chemical profiles of the experimental silages at time of feeding are shown in table 2. There were only small differences between the untreated and enzyme-treated silage for the chemical parameters measured. Lactic acid content in untreated silage was 2.96% of the dry matter and 3.48% in enzyme-treated silage for a percentage increase of 18%. The data for lactic acid and organic acids closely paralleled that observed during the first 3 weeks of storage (table 1).

Nutrient utilization and nitrogen balance in beef steers are presented in table 3. Digestibility of dry matter, crude protein and organic matter was essentially the same for steers fed untreated silage as for those fed the enzyme treated silage. Nitrogen losses via the urine were higher for steers fed the enzyme-treated silage. This resulted in the nitrogen retained for productive purposes of 43.22% and 39.86%, for untreated and enzyme-treated silage, respectively.

Dry matter recovery values are presented in table 4. The recovery of dry matter as feedable silage was 99.82% for untreated silage and 97.60% for enzyme-treated silage. These differences were caused by the greater quantity of spoiled and unrecovered silage with the silo containing the enzyme-treated silage. Further research will be required to determine the magnitude of losses in enzyme-treated silage stored in larger tower-type silos.

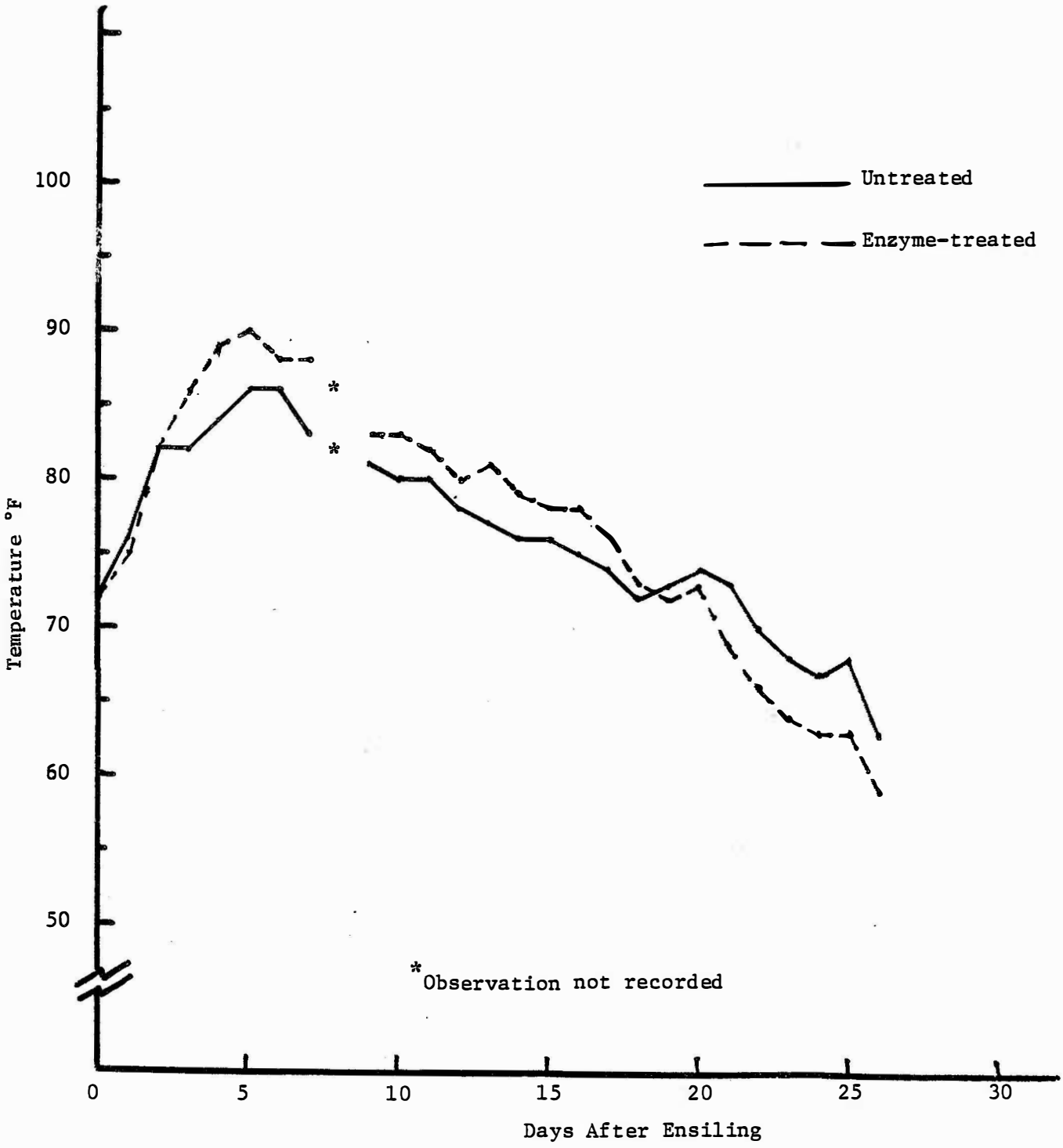


Figure 1. Fermentation Temperatures of Untreated and Enzyme-Treated Corn Silage

TABLE 1. SELECTED CHEMICAL CHARACTERISTICS OF UNTREATED AND ENZYME-TREATED CORN SILAGE DURING FERMENTATION

| Day after ensiling | Untreated silage pH | Ammonia nitrogen[b] | Lactic acid[c] | Organic acids[c] | Enzyme-treated silage[a] pH | Ammonia nitrogen[b] | Lactic acid[c] | Organic acids[c] |
|---|---|---|---|---|---|---|---|---|
| 0 | 4.69 | 0.61 | 0.93 | 1.67[d] | 5.02 | 0.74 | 0.69 | 0.56[d] |
| 1 | 4.21 | 0.64 | 1.85 | 1.98[d] | 4.40 | 0.91 | 1.38 | 1.68[d] |
| 2 | 4.02 | 0.64 | 2.37 | 1.75[d] | 4.08 | 0.68 | 2.03 | 1.24[d] |
| 3 | 4.08 | 0.65 | 2.12 | 1.36[d] | 3.94 | 0.51 | 2.91 | 1.59[d] |
| 4 | 3.82 | 0.64 | 3.66 | 2.06 | 3.86 | 0.77 | 3.46 | 2.88[d] |
| 5 | 4.00 | 0.52 | 3.07 | 1.67 | 3.84 | 0.78 | 3.81 | 1.81 |
| 6 | 3.75 | 0.61 | 4.08 | 1.42 | 3.84 | 0.69 | 3.90 | 1.58[d] |
| 7 | 3.26 | 0.80 | 4.48 | 1.67 | 4.27 | 0.60 | 1.77 | 1.59[d] |
| 8 | 3.32 | 0.75 | 3.96 | 2.03 | 3.22 | 1.05 | 4.79 | 2.04 |
| 9 | 4.34 | 1.42 | 1.43 | 3.13[d] | 3.31 | 0.87 | 5.58 | 2.97 |
| 10 | 3.61[e] | 1.13 | 1.84 | 2.85[d] | 3.81[e] | 0.40 | 2.52 | 1.38[d] |
| 11 | 6.23[e] | .95 | 0.36 | 2.33[d] | 5.20[e] | 1.11 | 1.43 | 1.64[d] |
| 12 | 3.25 | 1.40 | 3.66 | 2.42[d] | 3.17 | 1.09 | 6.29 | 1.35 |
| 13 | 3.14 | 1.14 | 4.47 | 1.71 | 3.12 | 1.03 | 4.81 | 2.25 |
| 14 | 3.61 | 2.32 | 3.33 | 0.98 | 3.62 | 0.86 | 3.22 | 2.02 |
| 15 | 3.40[e] | 1.36 | 2.65 | 4.08[d] | 3.61 | 1.47 | 2.98 | 2.58 |
| 16 | 6.83[e] | 2.28 | 0.23 | 1.44[d] | 3.68 | 1.22 | 5.17 | 3.45[d] |
| 17 | 3.07 | 1.08 | 5.45 | 2.18 | 4.60 | 0.48 | 1.55 | 1.06[d] |
| 18 | 3.53 | 1.03 | 4.02 | 4.06 | 3.70 | 1.11 | 3.40 | 4.01 |
| 19 | 3.46 | 1.89 | 3.16 | 3.19 | 3.68 | 1.14 | 4.44 | 1.53 |
| 20 | 3.52[e] | 1.33 | 3.00 | 4.30[d] | 3.32 | 1.01 | 4.38 | 2.16 |
| 21 | 5.31[e] | 2.50 | 0.73 | 2.67[d] | 3.69 | 1.38 | 1.57 | 1.45[d] |
| 22 | 3.34 | 0.90 | 3.30 | 1.61 | 3.61 | 1.21 | 3.50 | 1.87[d] |
| 23 | 3.34 | 1.28 | 3.18 | 2.65 | 3.27 | 1.26 | 4.63 | 2.53 |

[a] Treated with .5 lb Zymo-Best per ton of wet forage.
[b] Percent of total nitrogen.
[c] Percent of total dry matter.
[d] Contained traces of butyric acid.
[e] Spoiled silage in sample.

TABLE 2. CHEMICAL PROFILES OF UNTREATED AND ENZYME-TREATED CORN SILAGE AT TIME OF FEEDING

| | Additive treatment | |
|---|---|---|
| | Untreated silage | Enzyme-treated silage[a] |
| No. of samples | 20 | 21 |
| Dry matter[b] | 38.84 | 38.85 |
| pH | 4.15 | 4.10 |
| Titratable acidity[c] | 10.80 | 9.25 |
| Ammonia nitrogen[d] | 1.42 | 1.32 |
| Percent of dry matter | | |
| Crude protein | 8.42 | 8.68 |
| Lactic acid | 2.96 | 3.48 |
| Volatile fatty acids | | |
| Acetic | 2.04 | 1.69 |
| Propionic | .44 | .42 |
| Butyric | e | f |
| Total | 2.48 | 2.11 |

[a] Treated with .5 lb Zymo-Best per ton wet forage.
[b] Toluene distillation with acid correction.
[c] Milliliters .1N KOH to bring pH to 7.
[d] Percent of total nitrogen.
[e] One sample showed traces.
[f] Five samples showed traces.

TABLE 3. DIGESTIBILITY AND NITROGEN RETENTION WITH STEERS FED UNTREATED AND ENZYME-TREATED CORN SILAGE

| | Additive treatment | |
|---|---|---|
| | Untreated silage | Enzyme-Treated silage[a] |
| No. of steers | 6 | 6 |
| Avg weight, lb | 605 | 603 |
| Dry matter consumption, g/day[b] | 6717 | 6671 |
| Nitrogen consumption, g/day[b] | 110.8 | 111.2 |
| Digestibility, % | | |
| Dry matter | 72.04 | 73.56 |
| Crude protein | 63.14 | 64.30 |
| Organic matter | 73.58 | 75.15 |
| Nitrogen balance, g/day | | |
| Fecal | 40.94 | 39.73 |
| Urinary | 21.89 | 26.80 |
| Retained | 47.95 | 44.72 |
| Percent nitrogen retained of consumed, % | 43.22 | 39.86 |

[a]Treated with .5 lb Zymo-Best per ton of wet forage.
[b]1 pound = 454 grams.

TABLE 4. PRESERVATION OF DRY MATTER IN UNTREATED AND ENZYME-TREATED CORN SILAGE

| | Additive treatment | |
|---|---|---|
| | Untreated silage | Enzyme-treated[a] silage |
| Forage dry matter at storage, % | 38.24 | 38.89 |
| Dry matter, stored, lb[b] | 1759.0 | 1948.9 |
| Dry matter for feeding, lb | 1755.8 | 1902.1 |
| As a % of dry matter stored, | 99.82 | 97.60 |
| Dry matter spoiled and not recovered, lb | 3.2 | 46.8 |
| As a % of dry matter stored, | 0.18 | 2.40 |

[a]Treated with .5 lb Zymo-Best per ton wet forage.
[b]Storage period = 213 days.