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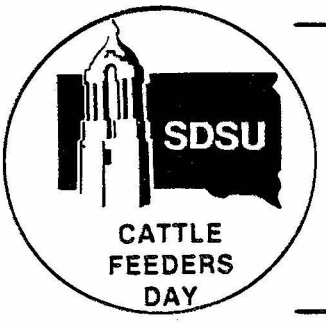
R. M. Luther
South Dakota State University

J. Nothnagel



EFFECT OF SODIUM DIACETATE ON CORN SILAGE CHEMICAL CHARACTERISTICS, PRESERVATION AND UTILIZATION BY BEEF STEERS

R. M. Luther and J. Nothnagel

Department of Animal and Range Sciences

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Summary

Corn forage (57% moisture) harvested from the 1981 corn crop was ensiled in two experimental concrete silos. One silo was filled with 3755 lb of untreated forage and the other with 4060 lb of forage treated with sodium diacetate at a rate of 1 lb per ton of wet forage.

Measurements made on the silage included temperature and chemical characteristics during fermentation, chemical profiles after a 198-day storage period, digestibility of nutrients and nitrogen retained for productive purposes and recovery of dry matter following storage.

The results of the study are:

1. Temperatures during the first 3 weeks of storage were higher for untreated than for treated forage.
2. Forage treated with sodium diacetate exhibited a more rapid drop in pH, higher titratable acidity values and consistently higher lactic acid levels during fermentation than untreated forage.
3. Lactic acid levels after 198 days of storage were higher for the sodium diacetate-treated silage than for untreated forage.
4. There were essentially no differences between the untreated and treated silage in terms of digestibility and nitrogen retention.
5. Sodium diacetate-treated corn silage resulted in 3.4% more dry matter recovered than untreated silage.

Introduction

Silage additives may be categorized or grouped according to how they function during the ensiling process. Three groups appear to emerge: the nutritive additives (nitrogen, whey, molasses, etc.), aids to fermentation (enzymes, microorganisms, antioxidants, flavors, etc.) and fermentation inhibitors (organic acids and acid-forming salts).

Research at SDSU (SHEEP 81-1 and CATTLE 82-8) with a mixture of 20% acetic and 80% propionic acid applied to corn silage (20 lb/ton) resulted in a marked reduction in lactic acid compared to untreated silage. Digestibility of dry matter and crude protein were reduced with the acid-treated silage.

Sodium diacetate[a], available as a commercial silage additive, when applied at lower rates (1 lb/ton) than the acid treatments previously used at SDSU appears to lead to early establishment of lactic acid fermentation. This effect is accompanied by improved preservation of nutrients in corn silage.

The purpose of this study was to compare untreated corn forage and forage treated with sodium diacetate in terms of chemical characteristics that occur during ensiling. Preservation of dry matter and utilization of nutrients by beef steers were also determined.

Procedures

Corn forage from the 1981 corn crop was harvested with a conventional forage chopper. 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 elevated into two concrete experimental silos each with a 2-ton capacity. One silo was filled with untreated corn forage. The other silo was filled with forage treated with sodium diacetate which was applied at the mixing wagon at a rate of 1 lb per ton of wet forage.

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 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 pm daily for 26 days after ensiling.

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[a] Crop-Cure. Domain Industries Inc., New Richmond, WI.

[b] Blair Manufacturing Company, Blair, NE.

Samples were collected at ensiling, daily through the ports during a 26-day fermentation period and as the silage was removed from the silo. The material was placed in double plastic bags, compressed to remove air, closed with a fastener and immediately frozen for chemical analysis. The procedure for port sampling was to use an auger (constructed from a wood-drilling bit) welded to a rod to remove the forage. After taking the sample, carbon dioxide was introduced into the port and the opening closed with a rubber stopper.

A chemical silage-quality profile was determined on each sample of fermented material. The samples were processed for analysis by grinding a portion of frozen material in a high-speed, reversible grinder. Portions of the ground material were used in dry matter and total nitrogen determinations. A second portion was used for preparation of an aqueous extract. Dry matter content was determined by toluene distillation with acid corrections. Measurements made on the extract included pH, titratable acidity, total nitrogen, ammonia nitrogen, lactic acid and organic acids (acetic, propionic and butyric).

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

Utilization of nutrients in untreated and treated silage was determined in a digestion-nitrogen balance trial with beef steers. Twelve steers averaging 545 lb were placed in individual pens at the Animal Science Complex. The pens were equipped with individual feed boxes and automatic waterers and were situated over concrete slatted floors. The steers were fed silage produced locally for about 2 weeks. The steers were then weighed and allotted to the two silage treatments with six steers each. The experimental silages were fed for 7 days and the steers were placed in metabolism crates. A supplement consisting of soybean meal (44% protein), 58.0%; ground corn, 28.7%; ground limestone, 2.0%; dicalcium phosphate, 6.3% and trace mineral salt, 5.0%, was fed at a rate of 1.14 lb per steer daily. Vitamin A was added to the supplement to provide 10,000 IU of vitamin A per steer daily.

The steers were allowed to adjust to the metabolism crates and a 5-day total collection digestion-nitrogen balance trial was conducted. The steers were fed the experimental silages to appetite on a twice a day basis. Refused feed was weighed and sampled the following morning. Urine and feces were collected once daily, measured or weighed and a 10% aliquot saved for chemical analyses. Fecal materials were dried in a forced air oven at 70 C for 36 hours. Measures of nutrient utilization included percentage digestibility of dry matter, crude protein and organic matter. Retention of nitrogen for productive purposes is reported as a percentage of nitrogen consumed.

Results

Heat production in untreated and sodium diacetate-treated silage is shown in figure 1. Temperatures recorded at ensiling were 64 F and increased rapidly as fermentation was initiated. Untreated silage reached a high of 94 F on day 6 and another high of 108 F on day 14 after ensiling. Temperatures of treated silage increased less rapidly than untreated silage during fermentation, reaching a high of 90 F on day 10 and 88 F on day 12. Temperatures of both silages declined through day 26, with higher temperatures for untreated silage than for the treated silage.

The chemical measurements obtained from daily sampling of the experimental silages during fermentation are presented in table 1. Of the various chemical measurements routinely recorded, only pH, titratable acidity, lactic acid and volatile fatty acid levels are shown. The major differences in chemical characteristics observed with sodium diacetate-treated corn sialge as compared to untreated silage were:

1. pH dropped off more rapidly with initiation of fermentation and tended to be more acidic throughout the fermentation period.
2. Titratable acidity values indicate considerable variability in both silages but tended to be higher in the sodium diacetate-treated silage.
3. Lactic acid levels were consistently higher in treated silage than in untreated silage.
4. Volatile fatty acid levels were highly variable with no consistent trends between the two silages.

The silos were opened for feeding after 198 days of storage. The chemical profiles of the two silages are presented in table 2. Treatment of corn forage with sodium diacetate resulted in feedable silage that had a lower pH and a tendency toward lower concentrations of ammonia nitrogen and volatile fatty acids than untreated silage. Higher titratable acidity values were observed for treated silage and were accompanied by higher concentrations of lactic acid than for the untreated silage. Traces of butyric acid were observed in the untreated silage with an absence of this acid in treated silage.

Digestibility of nutrients and nitrogen retention data for untreated and sodium diacetate-treated corn silage are presented in table 3. Consumption of dry matter was 760 grams (1.7 lb) greater for steers fed sodium diacetate-treated corn silage than steers fed untreated silage. Because of this difference, digestibility may have been depressed, resulting in slightly lower coefficients of digestibility for this treatment. Nitrogen intake was likewise higher for steers fed the treated silage. However, nitrogen retained as a percentage of consumed was about the same as for untreated silage.

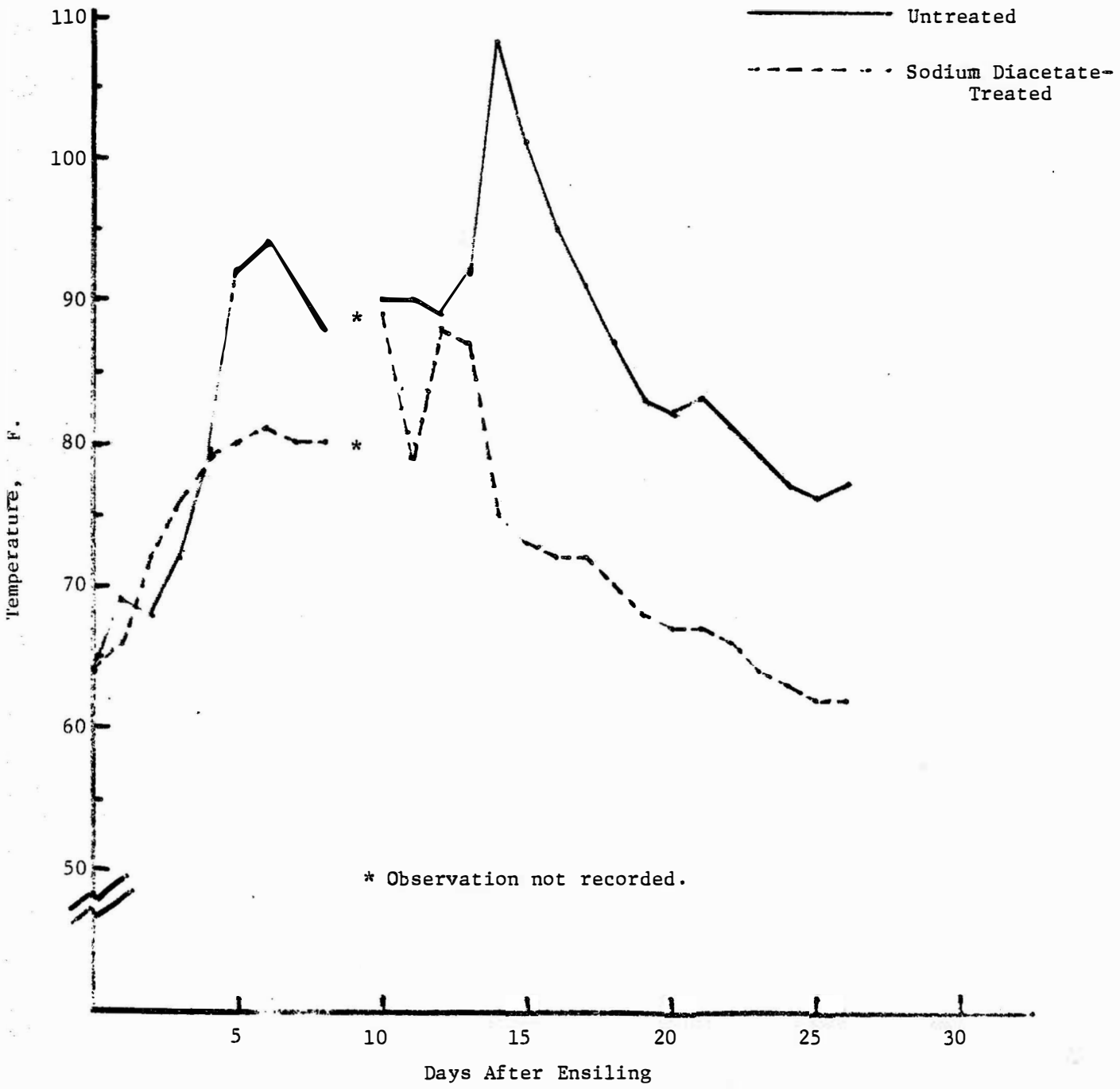

Figure 1. Fermentation Temperatures of Untreated and Sodium Diacetate-treated Corn Silage.

TABLE 1. FERMENTATION CHARACTERISTICS OF UNTREATED AND SODIUM DIACETATE-TREATED CORN SILAGE

Day of ensiling	Untreated pH	Untreated Titratable acidity[b]	Untreated Lactic acid[c]	Untreated Volatile acids[c]	Sodium diacetate[a] pH	Sodium diacetate[a] Titratable acidity[b]	Sodium diacetate[a] Lactic acid[c]	Sodium diacetate[a] Volatile acids[c]
0	5.10	2.17	0.70	2.22	5.24	1.81	0.83	2.21
1	4.73	2.67	1.09	1.45	4.52	3.32	1.67	1.76
2	4.42	3.38	1.08	1.87	4.27	4.32	1.41	1.65
3	4.22	4.57	1.72	2.39	4.08	5.40	1.94	2.35
4	4.01	6.01	2.69	1.82	4.02	6.58	3.25	2.65
5	4.05	6.61	3.65	2.20	4.06	6.48	3.07	1.8
6	4.44	3.51	2.33	2.02	4.01	6.30	3.14	1.44
7	4.97	2.16	1.04	1.60	3.91	7.46	3.20	2.09
8	4.01	5.01	2.80	1.36	3.40	4.85	2.92	2.30
9	3.79	9.70	2.51	1.83	3.42	6.24	3.66	2.15
10	3.80	8.85	4.54	2.23	3.71	8.74	4.33	1.24
11	3.65	6.06	3.18	2.40	3.87	7.42	3.43	1.81
12	7.46	0	0.11	0.16	3.38	8.51	4.37	1.99
13	3.83	4.22	2.04	1.09	3.26	8.84	4.45	1.94
14	3.48	7.35	3.74	2.03	3.75	9.33	4.09	2.48
15	3.13	9.88	5.50	1.34	3.07	8.76	4.21	1.79
16	3.86	7.75	3.78	1.75	3.22	8.59	4.48	2.05
17	3.31	10.02	5.05	1.54	3.05	9.78	6.03	2.17
18	6.02	0.34	.51	.99	3.22	9.17	4.75	1.42
19	4.46	4.96	1.04	2.10	3.60	6.71	3.97	2.12
20	4.39	8.28	1.70	2.03	3.50	8.88	4.49	1.09
21	3.35	7.94	3.58	1.83	3.22	9.65	5.20	2.00
22	3.52	6.37	2.82	2.13	3.20	10.13	4.22	2.04
23	4.81	2.19	1.07	1.22	3.54	11.38	3.30	2.67

[a] Applied at rate of 1 lb per ton of wet forage.
[b] Milliters of .1N KOH to raise pH to 7.
[c] Percent of total dry matter.

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

	Additive treatment	
	Untreated	Sodium diacetate-treated[a]
No. of samples	13	11
Dry matter[b]	40.51	44.73
pH	4.47	4.06
Titratable acidity[c]	9.35	12.64
Ammonia nitrogen[d]	1.65	1.44
Percent of dry matter		
Crude protein	8.20	8.14
Lactic acid	2.34	3.47
Volatile fatty acids		
Acetic	1.89	1.62
Propionic	.40	.35
Butyric	T[e]	None
Total	2.29	1.96

a Applied at rate of 1 lb/ton wet forage.

b Toluene distillation with acid correction.

c Millileters of .1N KOH to raise pH to 7.

d Percent of total nitrogen.

e Traces.

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

	Additive treatment	
	Untreated	Sodium diacetate-treated[a]
No. of steers	6	6
Avg weight, lb	544.3	546.3
Dry matter consumption, g/day[b]	5800	6561
Nitrogen consumption, g/day[b]	90.73	101.18
Digestibility, %		
Dry matter	70.94	69.55
Crude Protein	63.14	62.82
Organic Matter	72.43	70.78
Nitrogen balance, g/day[b]		
Fecal	33.30	37.78
Urinary	16.92	18.27
Retained	40.51	45.13
Percent nitrogen retained of consumed, %	44.65	44.60

[a] Applied at rate of 1 lb per ton of wet forage.

[b] 454 grams = 1 lb.

The effect of sodium acetate treatment on corn silage dry matter preservation is presented in table 4. The dry matter recovered for feeding as a percentage of dry matter ensiled was 87.89 for untreated silage and 91.29 for treated silage. This amounted to a 3.4% increase in dry matter recovery. Spoilage and nonrecoverable losses were low but favored the sodium diacetate treatment.

Discussion

The experimental silages prepared in this study were not of the quantity that would be available in larger tower-type silos. Nevertheless, the chemical characteristics observed during a 3-week fermentation and at the end of a 198-day storage period closely resemble the quality of silage stored in larger structures. Sampling during the fermentation period provides a second dimension in that the basic processes of the ensiling process can be monitored with comparisons between silage additive treatments. Port sampling has a disadvantage in that a port is sampled several times, thus contributing some variation in chemical measurements. The values obtained in this study for dry matter recovery were also quite similar to those observed with corn silage stored in concrete stave silos.

TABLE 4. PRESERVATION OF DRY MATTER OF UNTREATED AND SODIUM DIACETATE-TREATED CORN SILAGE

	Additive treatment	
	Untreated	Sodium diacetate-treated[a]
Dry matter content at ensiling, %	43.26	45.19
Dry matter stored, lb[b]	1624.4	1834.7
Dry matter for feeding, lb	1427.7	1674.9
As a % of dry matter ensiled, %	87.89	91.29
Dry matter spoiled, lb	20.3	18.6
As a % of dry matter ensiled, %	1.25	1.01
Dry matter not recovered, lb	176.4	141.2
As a % of dry matter ensiled, %	10.86	7.70

[a] Applied at rate of 1 lb per ton wet forage.

[b] Storage period = 198 days.