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Effect of a Bacterial Silage Inoculant on Quality, Preservation and Utilization of Corn Silage by Beef Steers

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EFFECT OF A BACTERIAL SILAGE INOCULANT ON QUALITY, PRESERVATION AND UTILIZATION OF CORN SILAGE BY BEEF STEERS

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Summary

Corn forage harvested from the 1979 corn crop was ensiled in two experimental concrete silos. Moisture content of the forage was 62%. One silo (untreated) was filled with 3680 lb. of forage and the other was filled with 3628 lb. of forage inoculated with a Lactobacillus acidophilus fermentation product applied at a rate of 1 lb. per ton of wet forage. Silage fermentation was monitored by collecting samples through sampling ports in the silos over a 27-day period. Heat of fermentation was determined by temperature probes within the silos. Temperatures were higher in untreated than in treated silage during the fermentation period. Peak temperature (91 F) for treated silage was recorded 2 to 3 days earlier than untreated silage which peaked at 95 F. Chemical profiles were obtained on samples collected at ensiling, during fermentation and as the silage was removed for feeding.

Lactic acid formation was generally higher for treated than for untreated silage throughout the fermentation period. Highest concentrations of lactic acid were observed in untreated silage 4 days later than in treated silage. Organic acid (acetic and propionic) concentrations were also higher in treated silage. Butyric acid was detected at very low concentrations in either silage. Ammonia nitrogen levels were lower in treated silage. Differences in chemical profiles between untreated and treated silage were less evident as the silage was removed from the silo for feeding. Lactic and total volatile fatty acids were only slightly higher in the treated silage. Recovery of dry matter was 82.9% for untreated silage and 84.2% for treated silage. Digestibility of dry matter, crude protein and organic matter by beef steers was similar for the two silages. Nitrogen retention was only slightly lower for the treated silage. Results of these studies show that treatment of corn forage with a microbial silage inoculant improved the fermentative characteristics of the silage. Benefits of lower heat production and increased organic acid concentration observed throughout the fermentation did not appear to carry through to the silage as it was removed and fed to beef steers. Problems of moisture entering the silos appear to be related to the disparity in fermentation characteristics and the quality of silage removed from the silo.

Introduction

The making of quality silage is largely dependent upon the fermentation process that takes place in the forage after ensiling. It is generally believed that the number and type of microorganisms present in the ensiled forage is sufficient to initiate fermentation, especially in corn forage, a favorable material for ensiling. However, research has shown that microbial numbers can vary widely even in corn forage. Low microbial populations appear to slow the rate and extent of fermentation. The conditions which contribute to low microbial numbers are not known. Inoculation of forage with desirable bacteria offers a means of providing additional bacteria to initiate rapid fermentation and to allow it to proceed at a faster rate with reduced heat production. The expected result would be to improve preservation of nutrients and produce higher quality silage.

The objectives of this study were to determine the effect of treating corn forage with a microbial silage inoculant (Lactobacillus acidophilus fermentation product[1]. Response to inoculation was compared with untreated forage in terms of chemical fermentation characteristics, preservation of dry matter and digestibility by beef steers.

Procedures

Corn forage from the 1979 corn crop was harvested with a conventional forage chopper. The yield of corn grain was 108 bushels per acre (15% moisture). The chopped forage was weighed into a feed mixing wagon[2] equipped with a scale and allowed to mix for about 10 minutes. The forage was transferred to two concrete experimental silos used for silage preparation. One silo was filled with untreated forage. The other silo was filled with forage inoculated with Lactobacillus acidophilus at a rate of 1 lb. of product per ton of wet forage.

The silo structures were reinforced concrete culverts 6 feet high, 5 feet inside diameter with 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 1 and 1 1/2 inches in diameter, situated in the silo wall 3 feet above the bottom and spaced at 60^{o} 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 1200 lb. 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 noon and at 5 p.m. daily for about 1 month after ensiling.

Samples were collected during ensiling, twice weekly through the ports during the fermentation period of 27 days and as the silage was removed from the silo. The material was placed in double plastic bags, closed with a fastener and immediately frozen for later chemical analysis.

A chemical silage quality profile was completed in the laboratory on all samples. Moisture was determined by drying a 100-gram quantity in a forced air oven at 70 C for 24 hours and also by a toluene distillation method. Other characteristics of the profile determined were pH, titratable acidity, total nitrogen, ammonia nitrogen, organic acids (acetic, propionic, butyric), lactic acid and inorganic ash.

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[1] Sila-Bac Silage Inoculant, Pioneer Hi-Bred International.
[2] Blair Manufacturing Company, Blair, Nebraska.

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

Utilization of nutrients from untreated and treated silage was determined in a digestion-nitrogen balance trial with beef steers. Twelve steers averaging 628 lb. were placed in individual pens at the Animal Science Complex. The pens were equipped with automatic waterers and were situated over a concrete slatted floor. The steers were fed 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 full-fed for an additional week and the steers were placed in metabolism crates. A supplement consisting of soybean meal, 91.18%; dicalcium phosphate, 6.08% and trace mineral salt, 2.73% was fed to each steer at a rate of 1.65 lb. per day. Vitamin A was added to the supplement to provide 15,700 I.U. of vitamin A 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 silage twice daily and refusals were weighed the following morning. Urine and feces were collected once daily, measured or weighed and a 10% aliquot saved for chemical analysis. The fecal material was dried in a forced air oven at 70 C for 36 hours. Measures of utilization included digestible dry matter, crude protein, organic matter and nitrogen retention.

Results

Silage Fermentation Characteristics

Heat production for untreated and treated silage is indicated by the temperature curves presented in figure 1. The temperatures of the forage following ensiling were 68 F and increased rapidly the first week after ensiling. The highest temperatures observed for untreated and treated silage were 95 and 91 F, respectively, with the treated silage reaching a peak 2 to 3 days earlier than untreated silage. Temperatures were higher in untreated silage than in treated silage throughout the fermentation period.

Lactic acid formation was greater in treated silage than in untreated silage as shown in figure 2. Concentrations of the acid increased rapidly early in the fermentation of treated silage. In the untreated silage, lactic acid formation appeared to be slowed for about 6 days after ensiling but then increased rapidly to 10 days. Peak lactic acid production was observed at 13 days following ensiling with the treated silage and at 17 days with the untreated silage. Formation of lactic acid tended to decline thereafter in both silages. Variation in acid formation during the fermentation period appeared to be caused by collecting the fermented samples from sampling ports located at different positions in the silo.

Formation of total volatile fatty acids was higher in inoculated silage than in untreated silage as shown in figure 3. Acetic acid, a major component of volatile fatty acids in silage, accounted for 2.95% of the dry matter in treated silage when acid production was at its peak. This compares with 4.13% in untreated silage at peak acid production (14 days after ensiling). Propionic acid comprised a smaller proportion of the fatty acids and was generally higher in treated than in untreated silage. Butyric acid, an indicator of improper fermentation, was present at very low concentrations in either silage.

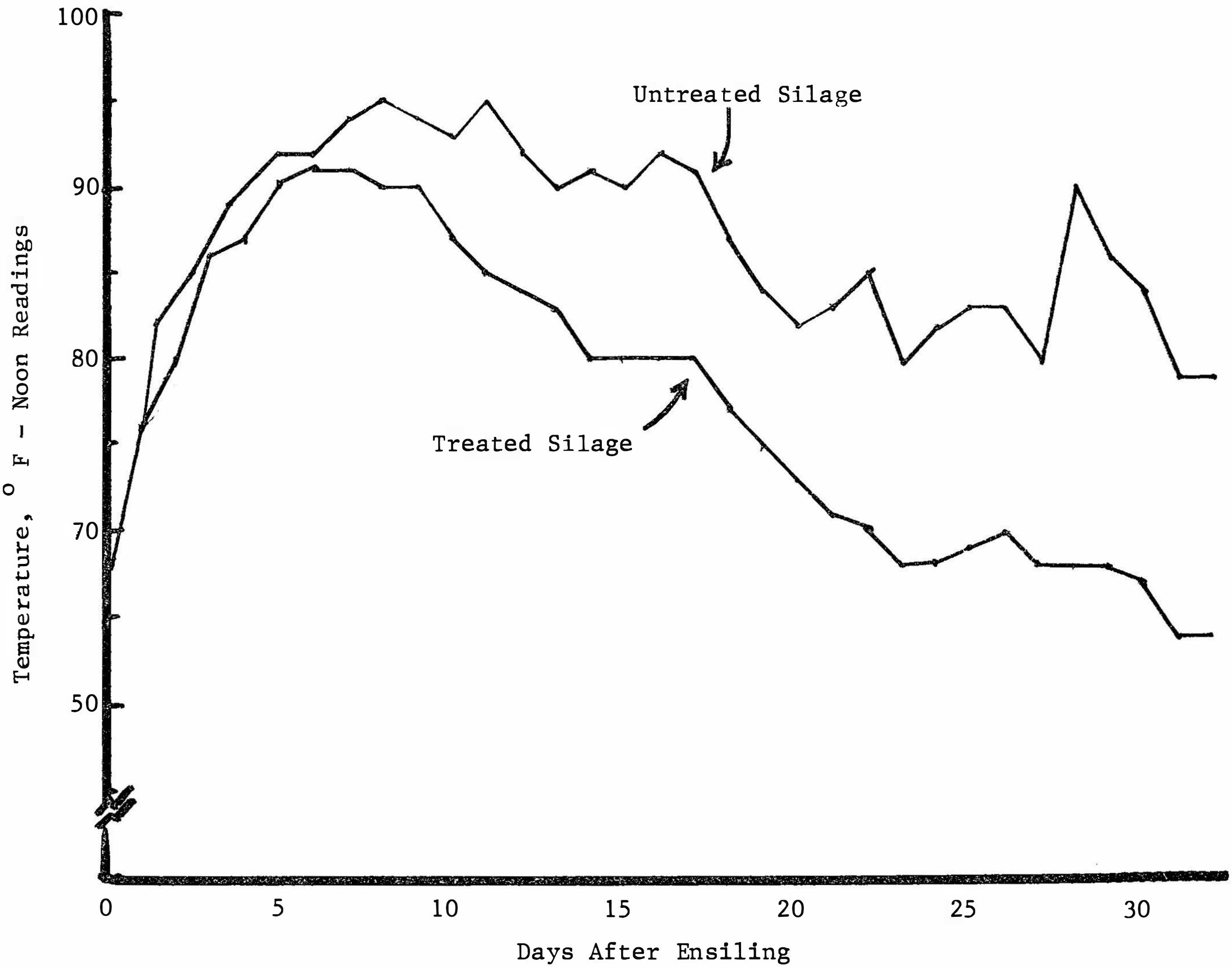

Figure 1. Fermentation Temperatures for Untreated and Treated Corn Silage.

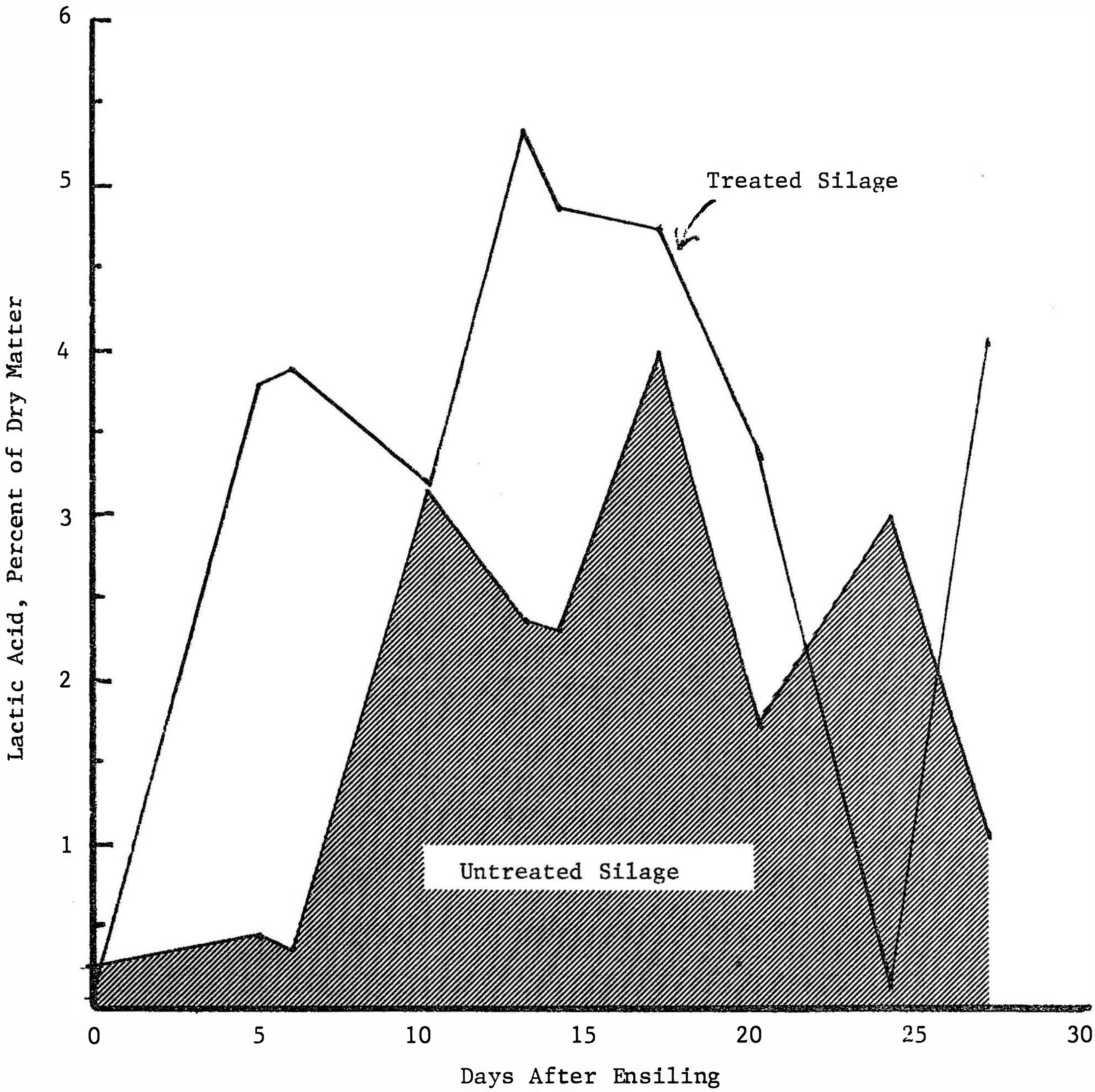

Figure 2. Lactic Acid in Untreated and Treated Corn Silage.

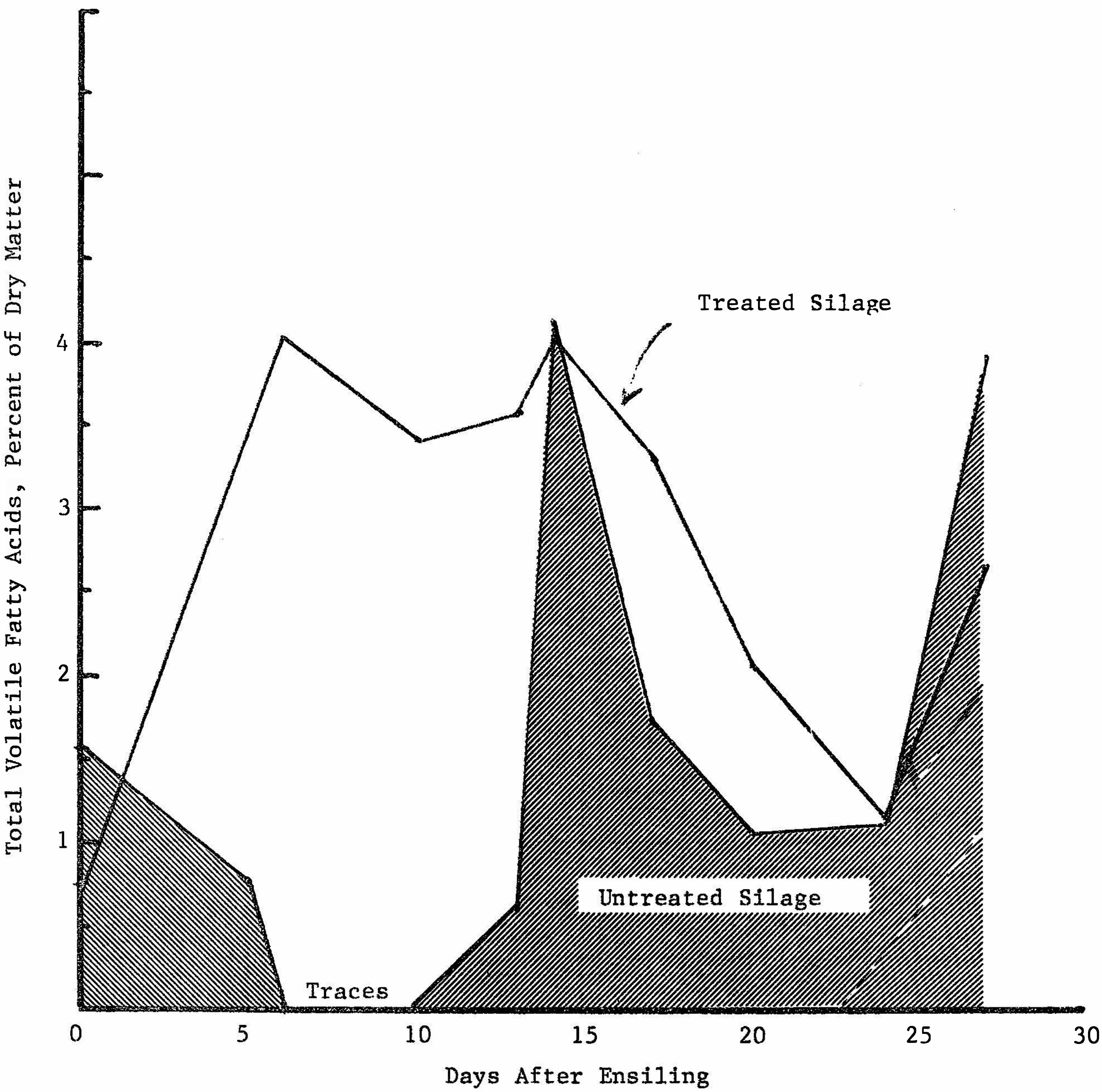

Figure 3. Total Volatile Fatty Acid Content of Untreated and Treated Corn Silage.

Measurements of titratable acidity coincided with organic acid production. Differences in pH were small and tended to parallel titratable acidity and organic acid concentrations. There appeared to be no appreciable reduction in crude protein content in either of the silages during the fermentation period. However, ammonia nitrogen was consistently lower for the treated silage, possibly indicating protein destruction in the untreated silage.

Silage Quality and Preservation

The chemical profiles of corn forage ensiled and those of silage removed from the silo for feeding are presented in table 1. The silo which contained the untreated silage was filled about 2 hours prior to filling of the silo used for treated silage. The forage from both silos was harvested as one load about 3 hours prior to filling the first silo. Therefore, chemical changes in the forage could have occurred in this 5-hour period but were likely to have been minimal. Results of chemical analyses show the formation of small concentrations of lactic and other organic acids. This would indicate that fermentation had been initiated prior to or during the ensiling process. There were only small differences, however, between forage placed in the first silo (untreated) and that place in the second silo (microbial treated).

Table 1. Chemical Profiles of Corn Forage and Silage for Feeding as Affected by Bacterial Inoculation[a]

	Ensiled corn forage		Silage for feeding	
	Untreated	Treated	Untreated	Treated
Dry matter, %[b]	38.81	38.14	36.86	35.17
pH	5.79	5.80	4.38	4.61
Titratable acidity[c]	1.35	1.46	6.42	8.27
Percent of dry matter				
Ash	5.04	5.39	4.84	5.53
Crude protein	7.58	7.50	8.79	8.39
Ammonia nitrogen[d]	.26	.26	.66	.64
Lactic acid	.06	.08	3.15	3.59
Volatile fatty acids				
Acetic	0-T[e]	0-T	.95	1.35
Propionic	1.49	.71	.57	.68
Butyric	.08	.04	.13	.01
Total	1.57	.75	1.65	2.04
Acid-detergent fiber	27.12	26.67	28.50	26.47
Acid-detergent lignin	3.58	3.76	4.21	3.73

[a] Inoculated with <u>Lactobacillus acidophilus</u> fermentation product at rate of 1 lb. per ton of forage.
[b] Toluene distillation.
[c] Milliliters of .1N KOH to raise pH to 7.
[d] Percent of crude protein.
[e] T = trace.

Silage for feeding was removed from the silo in January of 1980, starting 96 days after ensiling. Titratable acidity, lactic and volatile fatty acids were higher in treated silage than in untreated silage. Differences between the two silages, however, were not as prominent as those observed during the fermentation period. Inoculated silage also had a higher moisture content and somewhat less acid-detergent fiber than untreated silage.

Table 2 shows the recovery and losses of dry matter in untreated and treated silage. The moisture content was slightly higher for forage that was inoculated with microorganisms, resulting in fewer pounds of total dry matter ensiled for this treatment. Dry matter recovered as silage for feeding from the treated silage was 84.2% of the dry matter ensiled compared to 82.9% for the untreated silage. Spoilage losses and nonrecoverable losses amounted to 17.0% for untreated silage and 15.8% for treated silage.

Table 2. Dry Matter Recovery of Corn Silage as Affected by a Microbial Silage Inoculant[a]

	Untreated	Treated
Dry matter of corn forage, %	38.83	38.14
Total dry matter ensiled, lb.	1428.6	1383.7
Total dry matter of feed silage, lb.	1184.8	1164.7
As a percent of dry matter ensiled, %	82.94	84.17
Dry matter losses		
Spoilage, lb.	145.9	138.6
As a percent of dry matter ensiled, %	10.21	10.02
Nonrecovered, lb.	97.9	80.4
As a percent of dry matter ensiled, %	6.85	5.81

[a] *Lactobacillus acidophilus* fermentation product applied at 1 lb. per ton of forage.

Silage Utilization

Results of digestion and nitrogen balance studies with beef steers fed the untreated and treated silage are presented in table 3. The silage used in these studies was the material upon which quality and preservation measurements (tables 1 and 2) were obtained. Data from the digestion experiment indicate only small differences between the two silage treatments with respect to the digestibility of dry matter, crude protein and organic matter. The retention of nitrogen (grams/steer/day) was slightly lower for steers fed the treated silage as compared to those fed the untreated silage. Retention

Table 3. Digestibility and Nitrogen Retention With Beef Steers Fed Untreated and Microbial Inoculated Corn Silage

	Untreated	Treated[a]
Number of steers	6	6
Average weight, lb.	628	627
Avg. daily dry matter intake, lb.	12.19	12.36
Avg. daily nitrogen intake, lb.	.26	.25
Digestibility, %		
Dry matter	69.45	68.83
Crude protein	68.06	67.72
Organic matter	71.17	70.65
Nitrogen balance, grams/day		
Fecal	37.2	36.8
Urinary	43.2	44.4
Retained	35.8	32.7
Percent retained of consumed	30.6	28.4

[a] Inoculated with Lactobacillus acidophilus fermentation product at rate of 1 lb. per ton of forage.

of nitrogen based upon nitrogen consumed amounted to 30.6% for steers fed the untreated silage and 28.4% for steers fed the treated silage.

Discussion and Comments

The experimental silos used in these studies were useful in monitoring chemical changes occurring in the silage during fermentation. The quantity of silage produced was adequate to evaluate the treatments in a short-term feeding experiment with smaller numbers of beef cattle. Chemical profiles obtained during this study indicated that silage quality was within the range of that observed with silage produced in larger storage structures.

A problem was encountered during the experiment with moisture, from rain, penetrating the plastic silo cover. A hard rain was experienced about 30 days after ensiling causing water to move into the silo. An amber-colored liquid filled the seepage containers with substantial overflow. The volume of runoff liquid was not measured. However, runoff appeared to be greater for the silo containing the treated silage. Analysis of the runoff showed that it contained rather high concentrations of organic acids, indicating the loss of acidity produced during fermentation.

This might possibly explain the lower concentrations of lactic and volatile fatty acids observed in the silages used for feeding compared to silages taken at the end of the fermentation period. Losses of soluble nitrogen and carbohydrates may also have occurred in the runoff. These losses might be expected to narrow the differences between the silages as was shown in the digestion-nitrogen balance study with cattle.

Silage quality was improved by microbial inoculation of corn forage as indicated by chemical profiles obtained during and at the end of the fermentation period. This improvement was not as pronounced when the silage was removed from the silo. Differences in utilization by beef cattle likewise did not parallel chemical changes that favored the silage inoculated with microorganisms.

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