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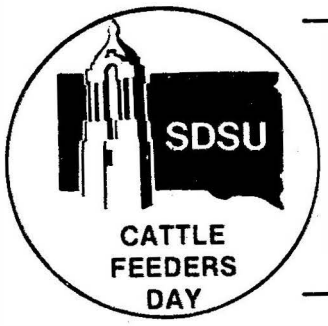

EFFECT OF SILAGE ADDITIVES ON THE QUALITY AND UTILIZATION OF CORN SILAGE BY LAMBS

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Summary

Forty percent dry matter corn forage was ensiled in plastic-lined steel barrel silos. Four silage additive treatments were applied to the forage. They were: (1) untreated, (2) Lactobacillus acidophilus fermentation product at 1 lb per ton of forage, (3) an ammonia-molasses suspension applied at 6.43% of forage dry matter, and (4) an organic acid mixture of 80% propionic and 20% acetic applied at 20 lb per ton of forage. Chemical profile analyses were performed on samples of untreated and treated forage collected at ensiling and on samples of silage during feedout. A digestion-nitrogen balance trial was conducted with lambs averaging 62 pounds.

Chemical analysis of the experimental silages removed from the silos for feeding indicated that methods of preparation and storage used in the study produced good quality silage. Values for pH ranged from 4.0 to 4.5 with no differences between additive treatments. Lactic and volatile fatty acid concentrations were similar for untreated and microbial inoculated silage. Lactic acid was higher in ammonia treated silage but was sharply reduced in organic acid treated silage. Ammoniacal nitrogen levels were higher with the silage treated with an ammonia-molasses suspension and organic acids than with the untreated silage.

Digestibility of dry matter, crude protein and organic matter was reduced by the addition of each of the silage additives. Addition of an ammonia-mineral suspension significantly ($P<.01$) lowered digestibility of nutrients and nitrogen retention as compared to untreated corn silage.

Introduction

Attempts have been made to improve silage formation with commercial products or with the addition of nutrients to the forage. Such materials have been reported to improve the quality of silage, reduce dry matter losses and improve utilization of nutrients. Benefits to be obtained by use of a microbial inoculant, addition of nitrogenous compounds or treating with a fermentation inhibitor such as organic acids have not been well established.

The objectives of this research were to determine the effect of treating corn forage with a viable microbial inoculant, a source of ammoniacal nitrogen and a mixture of propionic and acetic acid. Response to these additives was compared with untreated forage in terms of chemical fermentation characteristics, digestibility of silage nutrients and nitrogen utilization by lambs.

Procedures

Forty percent dry matter corn forage was harvested with a conventional field chopper.[1] The chopped forage was weighed into a feed mixing wagon equipped with a scale. The additives were weighed or measured, added to the forage and allowed to mix for 10 minutes. The microbial inoculant (*Lactobacillus acidophilus* fermentation product)[2] was added at a rate of 1 lb per ton of forage. The ammonia-molasses suspension (Prosil)[3] contained .85% nitrogen and was applied at the rate of 6.43% of forage dry matter. The organic acid mixture contained 80% propionic and 20% acetic acid and was applied at the rate of 20 lb per ton of forage.

Untreated and treated forages were transferred from the mixing wagon to plastic bags placed inside the experimental silos. The silos consisted of steel barrels (about 34 inches high and 22 inches wide) equipped with lids. The lids had a rubber gasket and were secured in place with a ring-lock fastener. The forage was packed into each silo to a level that would just allow the lid to fit in place. The mixing wagon was washed thoroughly with water under pressure between each additive treatment.

Samples of about 2 lb were collected at ensiling, during feedout of silage, and of waste silage separated from good silage as the silos were emptied. The samples were immediately frozen for chemical analyses. A portion of each sample was finely ground and used in determining a chemical profile. The profile included the determination of dry matter by oven drying and by toluene distillation (corrected for acids). Other determinations included pH, titratable acidity, total and ammoniacal nitrogen, lactic acid, organic acids (acetic, propionic, butyric) and ash.

The utilization of nutrients from the silages was determined in a digestion-nitrogen balance trial with lambs. Twenty-four lambs averaging about 62 lb were allotted to the four silage diets with six lambs per diet. The lambs were kept in individual pens and fed the experimental diets for a 2-week period. After adjustment to the diets, the lambs were placed in metabolism crates and a 5-day total collection trial was conducted. Digestion coefficients and values for nitrogen utilization were calculated using dry matter values determined by toluene distillation procedures.

The lambs were fed a full feed of silage with a protein supplement once daily. Composition of the supplements is shown in table 1. The supplement was fed at 140 g per head daily to lambs fed the untreated, Silo-Bac and Organic Acid treated silage. Fifty g of supplement were fed daily to lambs fed the Pro-Sil treated silage.

The silos were opened for feeding in April after being ensiled for approximately six months. Dry matter recovery of spoiled silage was determined.

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[1] Blair Manufacturing Company, Blair, NE.

[2] Sila-Bac Silage Inoculant, Microbial Products Division, Pioneer Hi-Bred International.

[3] Pro-Sil, Pro-Sil Division, Terra Chemicals International, Inc.

TABLE 1. COMPOSITION OF SUPPLEMENTS

Ingredient	Untreated Sila-Bac[a] Organic acids[c]	Pro-Sil[b]
Ground corn, %	32.52	90.25
Soybean oil meal (50% P.), %	65.04	---
Ground limestone, %	2.44	5.87
Dicalcium phosphate, %	---	3.88
Vitamin A premix[d], g	8	2

[a] Lactobacillus acidophilus fermentation product applied at rate of 1 lb per ton of forage.
[b] Applied at rate of 6.43% of forage dry matter.
[c] Applied at rate of 20 lb per ton of forage.
[d] 30,000 International Units of vitamin A/gram.

Results

The chemical profiles of the experimental forages following application of the additive (at ensiling) are presented in table 2. Dry matter content

TABLE 2. CHEMICAL PROFILES OF CORN SILAGE AT STORAGE AS AFFECTED BY SILAGE ADDITIVES

Item	Silage additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Organic acids[c]
Dry matter[d]	40.52	41.20	39.62	39.83
Dry matter[e]	40.75	40.58	40.42	40.45
pH	5.79	5.90	8.62	4.67
Titratable acidity[f]	1.52	1.33	0.00	8.10
Ammonia nitrogen[g]	1.55	1.50	5.12	1.57
Percent dry matter				
Ash	4.59	5.45	5.52	[illegible].04
Crude protein	7.43	7.25	15.06	7.86
Lactic acid	0.05	0.03	0.14	0.06
Volatile fatty acids				
Acetic	0.00	0.00	0.00	0.00
Propionic	1.10	0.44	0.1[illegible]	1.89
Butyric	0.00	0.18	0.[illegible]0	0.00
Total	1.10	0.62	[illegible].10	1.89

[a,b,c] see footnotes, table 1.
[d] Oven dried at 70°C for 24 hours.
[e] Toluene distillation with acid correction.
[f] Milliliters .1N KOH to raise pH to 7.
[g] Percent of total nitrogen.

as measured by toluene distillation was similar across treatments averaging 40.6%. Ensilage treated with an ammonia-molasses suspension (Pro-Sil) resulted in a more alkaline pH (8.62) and higher ammoniacal nitrogen concentrations at storage than the other silage additive treatments. Application of organic acids, as expected, increased the titratable acidity as compared to the other additive treatments. Addition of Pro-Sil increased the crude protein content from 7 to 15%.

Some fermentation of forage was observed at ensiling with each silage treatment. Small quantities of lactic and volatile fatty acids were formed at this early stage. It is not uncommon to observe some chemical changes between harvesting and storage in forage of this maturity and moisture content.

Results of chemical analyses of silage samples taken during feedout of the silages are presented in table 3. The procedures used in this study for

TABLE 3. CHEMICAL PROFILES OF CORN SILAGE FOR FEEDING AS AFFECTED BY SILAGE ADDITIVES

Item	Silage additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Organic acids[c]
Dry matter[d]	42.82	41.02	39.59	40.67
Dry matter[e]	44.35	43.93	42.21	43.33
pH	4.03	4.06	4.49	4.44
Titratable acidity[f]	11.90	10.11	9.60	9.06
Ammonia nitrogen[g,h]	3.55	3.80	28.84	6.63
Percent of dry matter				
Ash	4.64	5.23	5.66	5.37
Crude protein	8.60	8.03	12.15	8.46
Lactic acid[h]	3.71	3.37	4.50	0.38
Volatile fatty acids				
Acetic	1.72	1.39	1.45	0.99
Prophionic[h]	0.59	0.49	0.53	1.68
Butyric	0.00	T[i]	0.00	0.00
Total	2.31	1.88	1.98	2.67

[a,b,c] See footnotes, table 1.
[d,e,f,g] See footnotes, table 2.
[h] Difference between treatments significant (P<.01).
[i] T = trace.

preparation and storage of experimental silages appeared to result in satisfactory silage formation. Evidence of this is in the low pH values (4.0-4.5), adequate levels of lactic and volatile fatty acids and the absence of butyric acid in the silages. Ammoniacal nitrogen was markedly higher for silage treated with Pro-Sil and for silage treated with organic acids as compared to untreated silage. Ammonia level in silage treated with Sila-Bac was similar to untreated silage. Concentration of lactic acid was about the same for untreated and microbial treated silage. Addition of Pro-Sil increased the lactic acid concentration while treatment with organic acids

lowered the concentration of this acid. Formation of acetic and propionic acids was similar for untreated silage and silage treated with either Sila-Bac and Pro-Sil. Ratios of these acids differed, with the silage treated with organic acids reflecting a somewhat different proportion than was applied.

Digestibility and nitrogen utilization by lambs fed diets containing corn silage treated with additives are presented in table 4. Dry matter, crude protein and organic matter digestibilities ranged from two to four percentage units lower with diets containing silage treated with additives as compared to the untreated silage diet. However, only the coefficients for the Pro-Sil silage diet were significantly lower ($P<.01$) than the diet with the untreated silage.

TABLE 4. DIGESTIBILITY AND NITROGEN RETENTION WITH SHEEP FED CORN SILAGE DIETS

	Corn silage diets			
Item	Untreated	Sila-Bac	Pro-Sil	Organic acids
Number of lambs	6	6	6	6
Avg weight, lb	59.9	60.8	61.3	63.0
Dry matter intake, g/day	980.2	1112.0	1097.2	1124.2
Nitrogen intake, g/day	19.7	20.3	21.7	21.3
Digestibility, %				
Dry matter	73.18^{a}	71.52^{ab}	68.77^{b}	70.35^{ab}
Crude protein	69.95^{a}	66.17^{ab}	65.34^{b}	65.77^{ab}
Organic matter	74.76^{a}	73.00^{ab}	70.63^{b}	71.87^{ab}
Nitrogen balance, g/day				
Fecal	5.92_{ab}	6.96_{b}	7.57_{a}	7.31_{b}
Urinary	6.52^{ab}	6.11^{b}	7.51^{a}	5.99^{b}
Retained	7.25^{b}	7.19^{ab}	6.61^{a}	8.01^{ab}
Percent retained of consumed, %	36.89^{a}	35.37^{ab}	30.25^{b}	37.58^{a}

^{a,b}Means in the same row with different superscripts are statistically different ($P<.01$).

Nitrogen balance data indicate only small differences in fecal and urinary nitrogen among the silage additive treatments. Fecal nitrogen values were generally higher with diets containing silage treated with additives as compared to the control diet. Significantly higher ($P<.01$) urinary nitrogen excretion was observed when feeding the silage treated with Pro-Sil as compared to the silage treated with Sila-Bac or organic acids. Less nitrogen was retained in terms of g/day or as a percent of nitrogen consumed by lambs fed the silage treated with an ammonia-molasses suspension. This was largely the result of elevated fecal and urinary nitrogen excretions. Greatest nitrogen retention was observed when feeding silage treated with organic acids. However, it was not statistically different from the untreated silage.

The effect of silage additives on dry matter preservation is shown in table 5. Recovery of dry matter was very high for all experimental silages with only small differences in spoiled or waste silage. The storage structures (steel barrels) used in this study were ideal in terms of reducing oxygen penetration of the forage.

TABLE 5. DRY MATTER RECOVERY OF CORN SILAGE TREATED WITH SILAGE ADDITIVES

Item	Silage additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Organic acids[c]
Dry matter of corn forage, %	40.75	40.58	40.42	40.45
Total dry matter ensiled, lb	516.18	526.65	551.69	517.88
Total dry matter of feed silage, lb	509.86	518.96	547.60	512.39
As percent of dry matter ensiled	98.78	98.54	99.26	98.94
Spoiled silage, lb	6.32	7.69	4.09	5.49
As percent of dry matter ensiled	1.22	1.46	0.74	1.06

[a,b,c]See footnotes, table 1.

The chemical parameters frequently used as indicators of silage quality did not relate well to digestibility and utilization of nutrients as determined with lambs in this study. Levels of ammonia were high in Pro-Sil treated silage as were levels of lactic acid as compared to untreated silage. On the other hand, ammonia concentrations were high in organic acid treated silage, but formation of lactic acid was inhibited. The relationship of these two chemical measurements to nitrogen utilization is not clear. Ammonia in these instances may have been in a chemical form (lactate or acetate) which influenced availability of nitrogen, resulting in lowered nitrogen retention in the case of silage treated with Pro-Sil, but increased retention as in the case of a fermentation inhibitor such as organic acids. The diets used in the study of nutrient utilization contained only silage and protein supplement and may not have provided the energy needed for optimum utilization of non-protein nitrogen.