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

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Summary

Corn stover forage harvested from the 1979 corn crop was ensiled in experimental steel barrel silos. The moisture content of the forage averaged 55%. Four silage additive treatments were applied to the forage. They were (1) untreated, (2) Lactobacillus acidophilus fermentation product[1] (1 lb. per ton of forage), (3) a nitrogen-mineral mixture[2] (6.43% of dry matter per ton of forage) and (4) an organic acid mixture (20 lb. per ton of forage). A chemical profile analysis was performed on samples collected on treated forage at ensiling and as the silage was removed for feeding. A digestion-nitrogen balance trial was conducted in which lambs averaging 60 lb. were fed the experimental silages.

Chemical analyses of the treated forage at ensiling showed that a small amount of fermentative activity had occurred prior to storage. Crude protein (dry basis) averaged 4.5% with the untreated, microbial-inoculated and organic acid-treated forage. Addition of a nitrogen-mineral mixture increased the protein content to 7.4%. Organic acids were applied in a ratio of 4 to 1 of propionic to acetic acid, but the chemical analysis showed a ratio of 2 parts propionic and 1 part acetic in the forage at the time of storage.

Chemical analyses on silage removed for feeding showed that the methods of preparation and storage used in the study produced good quality silage. Values for pH averaged 4.5 with no important differences between additive treatments. Lactic acid and volatile fatty acid concentrations were similar for untreated, the microbial inoculant and the nitrogen-mineral mixture treatments. Lactic acid was noticeably lower in stover treated with organic acids, indicating the additive was effective in inhibiting the fermentation process. Ammoniacal nitrogen values as a percentage of silage dry matter were higher for stover treated with the nitrogen-mineral mixture (1.01) and for the organic acid treatments (.82) than for the untreated and microbial-treated stover (.15 each).

Digestibility of dry matter, crude protein and organic matter was about the same for the untreated and the microbial-inoculated stover diets. Lower digestibility of these nutrients was observed with the diets in which the stover was treated with organic acids. Results from utilization of the diet

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[1] Sila-Bac Silage Inoculant, Microbial Products Division, Pioneer HiBred International.

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

in which the stover was treated with a nitrogen-mineral mixture are not reported because of a lower nitrogen intake by lambs on this treatment which apparently was a major factor in affecting digestibility of this forage. Percentage of nitrogen consumed that was retained by lambs fed diets in which the stover was untreated or treated with a microbial inoculant and organic acids were 35.3, 30.1 and 35.3%, respectively.

Introduction

Residues from corn crop production are abundantly available feeds for beef cattle and sheep. Cornstalks make suitable feeds when properly supplemented for growing animals and for wintering brood cows and ewes. Corn stover may be conveniently harvested following removal of corn grain and fed as chopped forage. Interest continues in the use of stover forage as silage.

Attempts to improve silage fermentation with commercial products or to add certain nutrients to the silage have been made with a number of compounds. Such materials have been reported to improve the quality of silage, reduce dry matter losses and improve utilization of nutrients. Benefits to be obtained for the use of a microbial inoculant, the addition of nitrogen compounds and the effect of a fermentation inhibitor such as organic acids have not been well established with a low-quality forage such as corn stover. These additives have had more use with forages harvested at stages of maturity or moisture levels more typical for silage crops.

The objectives of this research were to determine the effect of treating corn stover forage with a microbial silage inoculant (Lactobacillus acidophilus fermentation product), a source of ammoniacal nitrogen (Pro-Sil) and a mixture of organic acids (80% propionic and 20% acetic acid). Response to these additives was compared with untreated forage in terms of chemical fermentation characteristics, digestibility of major constituents and utilization of nitrogen by lambs.

Procedures

Corn stover forage from the 1979 corn crop was harvested in early November. Cornstalks were gathered into windrows with a rotary scythe and chopped with a field chopper equipped with a hay-forage head. The chopped forage was weighed into a feed mixing wagon[3] equipped with a scale. The additives were weighed or measured, added to the forage and mixed for 10 minutes. The microbial inoculant was added at the rate of 1 lb. per ton of forage. The nitrogen-containing additive (.85% nitrogen) was applied at the rate of 6.43% of the dry matter per ton of forage. The quantity applied in this study was estimated to increase the protein content of the stover silage about 2.5 percentage units. The organic acid mixture (80% propionic and 20% acetic acid) was applied at the rate of 20 lb. per ton of forage.

The untreated and treated forages were transferred 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 in each silo to a level that would just allow the lid to

[3] Blair Manufacturing Company, Blair, Nebraska.

fit in place. The mixing wagon was washed thoroughly with water under pressure between each additive treatment.

Samples of about 1.3 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 analysis. The samples were processed for analysis by grinding .22 lb. of frozen material in a Vita Mix Super 3600 grinder[4]. A portion of the finely ground material from each sample was used in determining the chemical profile.

The profile included dry matter determinations by oven drying and by toluene distillation (corrected for acids). Other characteristics determined included pH, titratable acidity, total and ammoniacal nitrogen, lactic acid, organic acids (acetic, propionic, butyric) and ash.

The utilization of nutrients from each experimental silage was determined in a digestion-nitrogen balance trial with lambs. Twenty-four lambs averaging about 60 lb. were allotted to diets containing the stover silage treatments with six lambs each. The lambs were placed in individual pens and fed the experimental diets. Following a 2-week adjustment period, 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 the toluene distillation procedure for determining dry matter.

The lambs were fed a full feed of silage and a protein supplement once daily. The supplement used for the diets containing the untreated, the microbial-inoculated and the organic acid-treated stover consisted of 46.7% ground corn, 46.7% soybean meal (50% protein), 4.7% dicalcium phosphate and 1.9% trace mineral salt. The supplement fed with the nitrogen-treated silage consisted of 87.7% ground corn, 8.8% dicalcium phosphate and 3.5% trace mineral salt. Both supplements were fortified with vitamins A and D. The supplement used with the three silages was fed at 1.1 lb. per lamb daily, while the supplement with the silage containing the extra nitrogen amounted to .57 lb. per lamb daily. It was assumed that the protein added to the forage by Pro-Sil and that of the supplement would complement the protein in the initial forage to adequately meet the needs of lambs of this weight.

The silos were opened for feeding in February after being ensiled for approximately 4 months.

Results

The chemical profile of the experimental forages at ensiling are presented in table 1. The dry matter content of corn stover forage stored the various ways varied between 42 and 48%. Crude protein content of untreated, microbial-inoculated (Sila-Bac) and organic acid-treated stover ranged from 4.1 to 4.9% (dry basis). Use of the nitrogen additive (Pro-Sil) for the forage treatment increased the protein content to 7.4%.

Fermentation activity with each silage treatment is indicated by the formation of small quantities of lactic and volatile acids. It is not uncommon to observe some fermentation between harvesting and ensiling even with forage of this maturity and moisture content.

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[4] Vita Mix Corporation, Cleveland, Ohio.

Table 1. Chemical Profiles of Corn Stover Forage at Storage as Affected by Silage Additives

	Silage additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Organic acids[c]
Dry matter, %[d]	42.51	43.60	45.52	45.79
Dry matter, %[e]	42.59	44.94	47.66	45.06
pH	6.56	6.44	8.56	4.62
Titratable acidity[f]	.16	.24	.00	6.14
Percent of dry matter				
Ash	7.00	6.40	6.33	6.20
Crude protein	4.91	4.14	7.40	4.72
Ammonia nitrogen[g]	.08	.08	.81	.10
Lactic acid	.04	.04	.03	.02
Volatile fatty acids				
Acetic	.00	.00	1.05	1.70
Propionic	.88	.78	.55	3.36
Butyric	0-T[h]	.03	.01	T
Total	.88	.81	1.61	5.06

[a] Inoculated with Lactobacillus acidophilus fermentation product at rate of 1 lb. per ton of forage.
[b] Added at rate of 6.43% of dry matter per ton of forage.
[c] Added at rate of 20 lb. per ton of forage.
[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 crude protein.
[h] T = trace.

The chemical profiles for untreated and microbial-inoculated forage at storage were similar. Corn stover treated with nitrogen was more alkaline in pH (8.56) with the formation of small quantities of volatile acids. The absence of titratable acidity is due to the value being higher than a neutral pH (pH = 7). However, acid formation was observed in this instance which suggests a possible buffering effect of ammonia nitrogen at this pH. Forage treated with organic acids was more acid in pH (4.62), with higher titratable acidity and higher values for acetic and propionic acids. This was as expected because of the addition of a mixture of acetic and propionic acids to the stover.

Results of chemical analyses of silage samples during feedout of the silages are presented in table 2. The procedures used in this study for the preparation and storage of experimental silages appeared to result in satisfactory silage formation. This is indicated by the low pH values (4.2 to 4.8), the adequate levels of lactic and/or volatile acids and essentially the absence of butyric acid in the silages. Concentrations of lactic acid and acetic and propionic acids were about the same for silage treated with microorganisms or with ammoniacal nitrogen when compared to untreated silage. Lactic acid, however, was noticeably lower in the silage treated with a mixture of organic acids which suggests the inhibitory influence of this additive on the

Table 2. Chemical Profiles of Corn Stover Silage for Feeding as Affected by Silage Additives

	Silage additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Organic acids[c]
Number of samples	11	10	10	10
Dry matter, %[d]	41.12	42.26	44.38	44.05
Dry matter, %[e]	41.24	42.62	46.32	44.09
pH	4.21	4.52	4.88	4.45
Titratable acidity[f]	7.20	4.78	5.58	8.43
Percent of dry matter				
Ash	6.91	7.08	7.70	7.42
Crude protein	5.35	4.78	8.23	4.87
Ammonia nitrogen[g]	.15	.15	1.01	.82
Lactic acid	2.13	2.06	2.19	.46
Volatile fatty acids				
Acetic	1.84	1.81	2.27	2.23
Propionic	1.33	1.50	1.26	2.67
Butyric	.02	.01	.00	.00
Total	3.19	3.32	3.53	4.90

[a-h] See footnotes for table 1.

fermentation process leading to lowered formation of this acid. The addition of nitrogen to corn stover silage increased the protein content (8.23% versus 5.35% for untreated) and markedly increased ammonia nitrogen as compared to the other silages. The ratio of acetic to propionic acid was altered with the nitrogen (2.27:1.26) additive or with organic acids (2.23:2.67). In the latter case a shift from propionic to acetic was observed during fermentation and storage as compared to the ratio of these acids in the forage at ensiling.

Digestibility and nitrogen utilization of lambs fed diets containing corn stover silage with and without additive treatments are presented in table 3. About 57% of the diet dry matter was provided by corn stover silage. The remainder was supplied by a supplement composed mainly of ground corn and soybean meal. Protein provided by these ingredients along with a much smaller quantity from stover silage was adequate in meeting the protein requirements for lambs of this weight. The digestibility values reflect utilization of the entire diet and are considerably higher than those reported for low quality forages such as corn stover.

Data for the diet in which the nitrogen-mineral mixture was added to the stover (Pro-Sil) have been omitted from this report because intake of protein was considerably lower than for the other diets. Inclusion of the data for this treatment would not allow justifiable comparisons to be made. Further research is needed with this additive to fully evaluate its effect on nutrient utilization.

Digestibility of dry matter, crude protein and organic matter was about the same for lambs fed the diet in which the stover was inoculated as for the control diet. The diet containing stover treated with organic acids (80%

Table 3. Digestibility and Nitrogen Retention With Sheep Fed Corn Stover Silage Diets

	Stover silage diets		
	Untreated	Sila-Bac[a]	Organic acids[c]
Number of lambs	6	6	6
Composition of diet consumed (dry basis), g.			
Corn stover silage	434	436	466
Ground corn	154	152	156
Soybean meal (50% protein)	154	152	156
Dicalcium phosphate	16	16	16
Trace mineral salt	6	6	6
Vitamins A and D	+	+	+
Total	764	762	800
Avg. daily nitrogen intake, g.	23.5	22.6	23.0
Digestibility, %			
Dry matter	70.81	71.34	68.45
Crude protein	79.32	78.02	76.40
Organic matter	74.32	74.30	72.39
Nitrogen balance, g./day			
Fecal	4.87	4.99	5.44
Urinary	10.34	10.84	9.63
Retained	8.31	6.81	8.12
Percent retained of consumed, %	35.33	30.08	35.26

[a,c] See table 1.

propionic and 20% acetic acid) resulted in lower nutrient digestibilities than the diet containing untreated stover.

Nitrogen balance data indicate slightly lower nitrogen intake with lower nitrogen retention for lambs fed the diet containing stover inoculated with a microbial silage additive. Retention of nitrogen by lambs fed stover treated with organic acids was about the same as that for lambs fed the untreated stover diet.

The chemical values used as indicators of silage quality relate well to the utilization of nutrients as determined with lambs in this study. Apparently, profiles for the corn stover silages were not enough different in lactic and volatile acids content (except organic acid-treated stover) to have much influence on digestibility and nitrogen retention. The organic acid-treated stover which had lower lactic acid and higher volatile fatty acid concentrations resulted in slightly lower digestibility of nutrients. The level of acids added to the stover did not appear to reduce feed consumption.