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EFFECT OF ADDITIVES ON ENSILED HIGH-MOISTURE EAR CORN QUALITY AND UTILIZATION BY LAMBS

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SHEEP 83-2

Summary

High-moisture ground ear corn (34% moisture) was treated with one of four additives and stored for 206 days before feeding to lambs. Quality characteristics of corn treated with Lactobacillus acidophilus were similar to those of untreated corn. Corn treated with an ammonia-mineral suspension resulted in higher ammonia-nitrogen, total nitrogen, propionic acid and pH values but with less total acid than untreated corn. A combination of L. acidophilus and ammonia additives gave a chemical profile similar to that of ammonia alone. Digestibility of dry matter and organic matter by lambs was not affected by treatment. Crude protein digestibility for the microbe-treated corn was higher than for other treatments. Lambs fed ear corn inoculated with L. acidophilus retained more nitrogen than lambs fed untreated or ammonia-treated corn. Dry matter recovery was 93% for the control, 97% for the microbial additive and 96% for the ammonia-treated corn. For reasons unknown, the combination treatment (microbes plus ammonia) lowered the dry matter recovery to 85% of that stored.

Introduction

Interest continues in the use of various additives with fermentable feedstuffs such as corn and sorghum forage and high-moisture corn. Additions of commercial products to improve silage formation are reported to reduce dry matter losses and improve utilization of nutrients. Benefits of using a microbial inoculant or the addition of a nitrogen-containing compound have not been well established. Limited research is available as to the value of these two additives when applied in combination. Early work with corn forage showed that L. acidophilus inoculations lowered temperature and increased the formation of lactic and volatile fatty acids during the fermentation period. Subsequent digestion-nitrogen balance and growth trials showed no major differences between untreated silage and silage treated with a microbial inoculant containing L. acidophilus or L. plantarum.

Application of an ammonia-mineral suspension (See SHEEP 81-1) to corn forage increased lactic and propionic acid levels in silage but lowered digestibility of dry matter and crude protein compared to untreated silage. This treatment also lowered the nitrogen retained for productive purposes in growing lambs.

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The objectives of this research were to determine the effects of adding a microbial inoculant (L. acidophilus[1]) and a nitrogen-containing compound[2] either separately or in combination to high-moisture corn. Measures of treatment effects included chemical quality parameters, preservation of stored dry matter and utilization of nutrients by lambs.

Procedures

High-moisture ear corn used in this study was harvested with a conventional forage harvester equipped with a corn head which removed the partially husked or snapped ears. The chopped material consisted of corn grain, cobs and a small quantity of husks. The moisture content averaged 34% at ensiling. The additives were weighed or measured and mixed with a weighed quantity of corn in a feed mixing wagon[3]. Mixing was allowed to proceed for 10 minutes and the ensilage was then transferred to plastic bags placed inside experimental silos. The silos were 55-gallon steel barrels with lids. The lids were equipped with a rubber gasket and were secured in place with a ring-lock fastener providing anaerobic conditions. Each silo contained approximately 205 lb of corn dry matter. Three barrels of high-moisture corn were prepared for a total of 616 lb of dry material stored per additive treatment. The silos were stored in an unheated building for 206 days before being opened for feeding.

The four treatments used were:

Treatment 1 - untreated - control
Treatment 2 - L. acidophilus inoculant applied at 1 lb per ton
Treatment 3 - ammonia-mineral suspension applied at 6.43% of ensilage dry matter (12.45 lb ammonia-nitrogen/ton, wet basis)
Treatment 4 - combination of treatments 2 and 3 with the ammonia added first and allowed to mix followed by the microbial inoculant.

Samples of about 1.5 lb were collected at ensiling, during feedout and as the waste material was separated from good corn as the silos were emptied. All samples were frozen for chemical analysis. The samples were processed for analysis by grinding a portion of frozen material in a high-speed, reversible grinder. A chemical profile was determined on the silage matter and on a water extract made from the silage.

The profile included dry matter determination by oven drying and by toluene distillation (corrected for acids). Other measurements included pH, titratable acidity, total nitrogen, ammonia nitrogen, lactic acid and organic acids (acetic, propionic and butyric).

Nutrient utilization by lambs was determined for each corn treatment using a total collection digestion-nitrogen balance trial. Twenty-four lambs averaging 66 lb were allotted by weight to the four treatments with 6 lambs each. The lambs were kept in individual pens, adapted to the experimental diets and then placed in metabolism crates. The diet consisted of a full feed of high-moisture corn plus a protein supplement. A 40% protein supplement

[1] Lactobacillus acidophilus fermentation product, Pioneer Hi-Bred International, Durant, Iowa.
[2] Pro-Sil, Terra Chemicals International Inc., Blair, Nebraska.
[3] Blair Manufacturing Company, Blair, Nebraska.

used for treatments 1 and 2 consisted of 84% soybean meal and 16% ground limestone. A 7% protein supplement used for treatments 3 and 4 (with added ammonia) consisted of 81% ground corn and 19% ground limestone. Vitamin A was included in both supplements. The supplements were fed at a rate of .2 lb per head daily. Digestion coefficients and values for nitrogen utilization were calculated following a 5-day collection period.

Dry matter recovery was determined on the basis of corn stored and amount of fermented corn removed from each silo. Spoiled and moldy corn which appeared at the top of the silo was separated from feedable corn, weighed and analyzed for moisture.

Results

Chemical profiles of the high-moisture corn treatments at ensiling are presented in table 1. The dry matter content of the corn ranged from 62 to 66% with values about two percentage units higher by the toluene distillation method. Addition of the ammonia compound raised the pH (made it alkaline) well above neutral. Use of the ammonia additive increased the protein content from about 9% to about 12%.

TABLE 1. CHEMICAL PROFILES OF HIGH-MOISTURE GROUND EAR CORN AT TIME OF STORAGE

		Additive treatment		
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Sila-Bac + Pro-Sil[c]
Dry matter, %[d]	63.93	64.13	61.86	63.14
Dry matter, %[e]	65.68	66.04	64.28	66.61
pH	5.68	5.78	8.45	8.30
Titratable acidity[f]	.72	.81	None	None
Percent of dry matter				
Ash	1.47	1.43	1.65	2.35
Crude protein	9.13	9.47	11.55	12.00
Ammonia nitrogen[g]	Trace	Trace	13.78	12.94
Lactic acid	.14	None	.08	.08
Volatile fatty acids				
Acetic	.28	.20	.40	.43
Propionic	.08	.08	.10	.18
Butyric	None	None	None	None
Total	.36	.28	.50	.61

[a] Inoculated with Lactobacillus acidophilus fermentation product at rate of 1 lb per ton of forage.
[b] Added at rate of 6.43% of ensilage dry matter (12.45 lb ammonia-nitrogen per ton, wet basis).
[c] Rates same as a and b.
[d] Oven-dried at 70 C for 24 hours.
[e] Toulene distillation with acid correction.
[f] Milliliters .1N KOH to raise pH to 7.
[g] Percent of total nitrogen.

Some fermentation activity occurred as indicated by the small quantities of lactic acid and volatile fatty acids present at ensiling. It is not uncommon to observe fermentation between harvesting and ensiling, even with material of this maturity and moisture content.

The chemical characteristics of the experimental high-moisture corn treatments during feedout are shown in table 2. Quality measures for corn treated with L. acidophilus were similar in almost every category to those of untreated corn. Corn treated with ammonia alone or in combination with L. acidophilus had higher pH values (6.22 and 6.68 vs 4.21 and 4.36), lower titratable acidity and contained substantially more ammonia-nitrogen (19.25 and 16.47 vs 2.02 and 2.22) than either the L. acidophilus-treated or untreated corn. Ammonia addition increased the crude protein content in excess of 12% as compared to 9.25% for untreated corn. However, calculated nitrogen recovery was about 87% of that which was applied.

Lactic and acetic acid levels were somewhat variable with no definite trends between additive treatments. Levels of propionic acid were higher with the addition of ammonia alone or in combination with the microbial additive. Butyric acid concentrations were either absent or quite low, with measurable quantities observed for the treatments in which ammonia was added. Total volatile fatty acid levels tended to be higher for the ammonia treatments than for L. acidophilus-inoculated or untreated high-moisture corn.

Results of chemical studies indicate that a high quality, fermented feed was produced with only minor changes in acid formation. A feeding phase of the research was conducted to determine if differences in nutrient utilization occurred between treatments. These results are presented in table 3. Dry matter and organic matter were digested by lambs to about the same extent with all additive treatments. Crude protein digestibility was higher (75.81%) for the high-moisture corn inoculated with L. acidophilus than for untreated corn (69.99%). Addition of ammonia gave protein digestibility values similar to those of the untreated control.

Another measure of feed utilization is how well the nitrogen is used for productive purposes. Nitrogen balance data (table 3) show no differences between additive treatments in nitrogen consumed or fecal and urinary nitrogen. Lambs fed high-moisture corn inoculated with L. acidophilus retained more nitrogen (7.3 g/day) than did lambs fed untreated corn (5.2 g/day). Daily nitrogen retention for each ammonia treatment was about the same as for the untreated corn. On the basis of percent nitrogen retained of nitrogen consumed, the best response was with the inoculated corn which differed statistically from untreated corn or corn treated with ammonia alone. Lambs fed corn treated with a combination of microbes and ammonia retained less nitrogen than lambs fed the microbial-treated corn but retained more nitrogen when ammonia was applied alone.

Dry matter recovery is presented in table 4. Recovery following a 206-day storage period was 93% of that stored for untreated corn, 97% for corn treated with L. acidophilus and 96% for the ammonia treatment alone. Recovery was only 85% with the combination treatment due to increased surface spoilage and nonrecoverable losses. There appears to be no explanation for these high losses. However, all silos in this treatment exhibited about the same quantity of loss.

TABLE 2. CHEMICAL PROFILES OF HIGH-MOISTURE GROUND EAR CORN AT TIME OF FEEDING

	Additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Sila-Bac + Pro-Sil[c]
Dry matter, %[d]	63.48	63.32	63.96	63.11
Dry matter, %[e]	63.47	65.23	65.36	64.31
pH	4.21	4.36	6.22	6.68
Titratable acidity[f]	5.81	5.98	1.74	.68
Percent of dry matter				
Ash	2.43	2.31	2.38	1.96
Crude protein	9.25	9.50	12.12	12.39
Ammonia nitrogen[g]	2.02	2.22	19.25	16.47
Lactic acid	1.08	1.27	1.22	.83
Volatile fatty acids				
Acetic	.61	.59	.67	.58
Propionic	.33	.32	.47	.48
Butyric	--	--	.01	.02
Total	.99[h]	.91	1.15	1.08

[a-g] See footnotes for table 1.
[h] Traces of valeric acid.

TABLE 3. DIGESTIBILITY AND NITROGEN RETENTION WITH LAMBS FED HIGH-MOISTURE GROUND EAR CORN

	Additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Sila-Bac + Pro-Sil[c]
Number of lambs	6	6	6	6
Dry matter consumed, g/day[d]	1001	1088	945	929
Nitrogen consumed, g/day[d]	18.5	20.5	18.6	18.4
Digestibility, %				
Dry matter	76.11	78.93[f]	74.44[e]	78.95
Crude protein	69.99[e]	75.81[f]	69.34[e]	68.96[e]
Organic matter	76.46	80.02	78.80	80.16
Nitrogen balance, g/day[d]				
Fecal	5.5	5.0	5.7	5.6
Urinary	7.8	8.2	7.8	7.3
Retained	5.2[e]	7.3[f]	5.1[e]	5.5[e]
Percent nitrogen retained of consumed, %	28.1[e]	35.6[f]	27.4[e]	29.9[e,f]

[a-c] See footnotes for table 1.
[d] One pound = 454 grams.
[e,f] Means in the same row with different superscripts are significantly different ($P<.05$).

TABLE 4. PRESERVATION OF DRY MATTER OF ENSILED HIGH-MOISTURE GROUND EAR CORN

	Additive treatment			
	Untreated	Sila-Bac[a]	Pro-Sil[b]	Sila-Bac + Pro-Sil[c]
Dry matter when ensiled, %[d]	65.68	66.04	66.11	66.61
Corn dry matter stored, lb	572	587	638	634
Corn dry matter for feeding, lb	534	569	612	541
Percent of dry matter ensiled, %	93.3	96.9	96.0	85.4
Corn dry matter spoiled, lb	15	8	16	48
Percent of dry matter ensiled, %	2.6	1.4	2.5	7.5
Corn dry matter not recovered, lb	23	10	10	45
Percent of dry matter ensiled, %	4.1	1.7	1.5	7.1

[a-c] See footnotes for table 1.
[d] Storage period = 206 days.

The quantity of high-moisture corn subjected to the additive treatments in this study was limited. Also, the storage structures used may not have completely equaled the conditions of larger silo structures. However, studies with corn silage stored in experimental silos of the type used in this experiment showed that silage quality was comparable to that stored in tower-type silos. Further research is indicated to relate the chemical characteristics and preservation of high-moisture corn to utilization of nutrients and feedlot performance.