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Evaluation of an experimental silage inoculant in laboratory and farm silos using alfalfa and forage sorghum

Abstract

An experimental microbial inoculant dramatically increased the speed of pH drop and rate and amount of lactic acid production in alfalfa at both 60 and 90 F storage temperatures. In two trials with forage sorghums, the inoculant did not affect the silage fermentation at 60 F but it did produce small improvements in silages at 90 F. In general, sorghum silages at 60 F fermented slower and had high pH values, lower lactic acid, and higher acetic acid contents than silages at 90 F. The response to the additive in a farm silo trial was not consistent for the criteria measured. Ensiling temperatures, chemical compositions, and dry matter recoveries were similar for control and inoculated silages. However, calves fed treated silage had a 5.9% better feed conversion, which resulted in 4.4 lb more gain per ton of ensiled crop

Keywords

Cattlemen's Day, 1986; Kansas Agricultural Experiment Station contribution; no. 86-320-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 494; Beef; Silage; Alfalfa; Forage sorghum; Laboratory; Farm silos

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Evaluation of an Experimental Silage Inoculant in Laboratory and Farm Silos Using Alfalfa and Forage Sorghum[1,2]

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Summary

An experimental microbial inoculant dramatically increased the speed of pH drop and rate and amount of lactic acid production in alfalfa at both 60 and 90 F storage temperatures. In two trials with forage sorghums, the inoculant did not affect the silage fermentation at 60 F but it did produce small improvements in silages at 90 F. In general, sorghum silages at 60 F fermented slower and had higher pH values, lower lactic acid, and higher acetic acid contents than silages at 90 F. The response to the additive in a farm silo trial was not consistent for the criteria measured. Ensiling temperatures, chemical compositions, and dry matter recoveries were similar for control and inoculated silages. However, calves fed treated silage had a 5.9% better feed conversion, which resulted in 4.4 lb more gain per ton of ensiled crop.

Introduction

The primary objective of the four trials reported here was to determine how an experimental silage inoculant affected the rate and efficiency of fermentation and nutritive value of alfalfa and forage sorghum silages. A secondary objective was to measure the effect of storage temperature on the ensiling process.

Experimental Procedures

The laboratory silo used in Trials 1, 2, and 3, and the silo filling techniques were similar to those described on page 110 of this report. The experimental inoculant (USO_3M) from Sanofi Sante Animale was applied in dry form in all four trials. Chemical composition and microbiology of the fresh crop materials are presented in Table 37.1.

Trial 1. Silages were made from 2nd-cutting alfalfa on July 5, 1984 and the crop was field-wilted to approximately 35% dry matter (DM) prior to ensiling. Four treatments were compared: (1) control (no additive), with laboratory silos stored at 60° F (control-60); (2) control (no additive), with silos stored at 90° F (control-90); (3) USO_3M inoculant, with silos stored at 60° F (inoculant-60); and (4) USO_3M inoculant, with silos stored at 90° F (inoculant-90). Twenty-four silos were filled for each treatment, with three silos per treatment opened at 12, 24, 36, and 48 hours and 4, 7, 21, and 56 days post-filling.

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[1]The experimental inoculant contained Lactobacillus plantarum and Lactobacillus casei and was provided by Sanofi Sante Animale, 37 Avenue George V, 75008 Paris, France.

[2]Partial financial assistance was provided by Sanofi Sante Animale.

Trial 2. Silages were made from early-dough stage forage sorghum (DeKalb 25E variety) on September 29, 1984; the crop contained approximately 25% dry matter. The four treatments were the same as in Trial 1. There were 21 laboratory silos filled for each treatment, with three silos per treatment opened at 12, 24, and 48 hours and 4, 7, 14, and 42 days post-filling.

Trial 3. Silages were made from late-dough stage forage sorghum (Acco 351 variety) on October 10, 1984; the crop contained approximately 36% dry matter. All other treatments and procedures were the same as those described in Trial 2.

Trial 4. Two whole-plant forage sorghum silages were compared in farm silos: (1) control (no additive) and (2) inoculated with USO_3M at the silage blower. The harvested crop was ensiled using the alternate load method in 10 x 50 ft concrete stave silos on October 9, 1984 from DeKalb FS 1A forage sorghum harvested in the hard-dough stage at about 33% dry matter. Ensiling temperatures were monitored for the first 5 weeks and nylon bags (nine per silo) were buried for additional observations of silage DM recoveries. The silos were opened on November 16, 1984 and emptied at a uniform rate during the following 8 weeks.

Each silage was fed to 16 crossbred steer and heifer calves in a 56-day growing trial that began November 16, 1984. The calves (average initial wt., 476 lb) were randomly allotted to four pens of four calves per silage. Silages were full-fed and all calves received 2.0 lb of supplement daily (as-fed basis). Rations were formulated to provide 12.25% crude protein (DM basis), 200 mg of Rumensin® per calf daily, and equal amounts of calcium, phosphorus, and vitamins A, D, and E.

One week before the trial began, all calves were fed a limited ration of grass hay and sorghum grain to provide a daily DM intake of 1.75% of body weight. Calves were weighed individually on two consecutive days after 16 hr without feed or water at the start and end of the trial. Three days before the final weighing, the calves were fed their respective silage ration at a restricted daily DM intake of 1.75% of body weight.

Feed intake was recorded daily for each of the eight pens and the quantity of silage fed adjusted daily to ensure that fresh feed was always in the bunks. Feed not consumed was removed, weighed, and discarded as necessary. Samples of each silage were taken twice weekly.

Results and Discussion

Trial 1. Presented in Table 37.2 are the fermentation dynamics of the four alfalfa silages. At hour 24 post-filling, inoculant-90 silage had a dramatically lower pH and higher lactic acid content than the other three silages. At day 4, both inoculated silages had lower pH and higher lactic acid contents than the two control silages and these differences were maintained through day 56 post-filling. These rapid lactic acid fermentations in the inoculated silages likely reflect the low lactic acid bacteria count for the pre-ensiled alfalfa (Table 37.1) and demonstrate the efficacy of the inoculant under these crop and environmental conditions.

Silages made at 60 F underwent very little fermentation during the first 24 hours; however, the inoculant-60 silage had a rapid drop in pH and an increase in lactic acid content between hour 36 and day 4 post-filling. The inoculant-60 silage reached a lower ($P<.05$) pH than control-90 silage at hour 48.

Trial 2. Presented in Table 37.3 are the fermentation dynamics of the four DeKalb 25E forage sorghum silages. The fresh crop had a low DM (24%), high WSC content (24.3%), low crude protein (5.31%), and 10^4 lactic acid bacteria per gram. The crop was harvested at 8:30 a.m. after a heavy frost and had an initial ambient temperature of 30 F. The ensiled material did not reach the 60 and 90 F storage temperatures until about 12 to 14 hours post-filling.

The inoculant had only small effects on pH and lactic acid values throughout the 42 day test. However, four observations can be made: 1) the control-90 silage fermented very rapidly and reached a pH of 4.00 at hour 48; 2) the 60 F storage temperature delayed fermentation until after hour 48 post-filling; 3) the inoculant-60 silage was nearly identical to the control-60 silage at each time; and 4) only at day 42 did inoculant-90 silage have a higher ($P<.05$) lactic acid content than control-90 silage.

Trial 3. Presented in Table 37.4 are the fermentation dynamics of the four Acco 351 forage sorghum silages. The fresh crop had a higher DM (36%) and lower WSC content (12.2%) than the 25E forage sorghum used in Trial 2 and the initial ambient temperature was warmer at harvest (62 F). As was observed in Trial 2, the inoculant had very little influence on the rate of the ensiling process at 60 F. However, at 90 F the inoculant-treated silages had lower pH and higher lactic acid values on days 7, 14, and 42 post-filling.

Trial 4. Visual appraisal indicated that both silages were well preserved. Chemical analyses showed similar compositions for the two silages; both had undergone a normal lactic acid fermentation (Table 37.5). Ensiling temperatures were nearly identical for the two silages. Both silages were unstable during the first 3 weeks of unloading and feeding; they heated after less than 24 hours of exposure to air. But as the feeding trial progressed, the inoculated silage became more stable in air than the control.

Silage DM recoveries and losses were similar for the control and inoculated silages (Table 37.6). The average loss from the buried bags was 6.7% of the DM ensiled, which is within the range observed in numerous other trials. The 15.4% average loss from the concrete stave silos was somewhat higher than expected and likely reflected the rather unstable nature of both silages.

Performance of the calves during the 56-day feeding trial was excellent, with daily DM intake being approximately 2.6% of body weight (Table 37.7). Although average daily gains were similar, calves receiving the inoculated silage were 5.9% more efficient (6.90 vs. 7.33 lb of DM per lb of gain). Also shown in Table 37.7 are calf gains per ton of forage sorghum ensiled, which combines farm-silo recovery and cattle performance results. Inoculated silage produced 4.4 lb more gain per ton of ensiled crop than the control.

Table 37.1. Composition of the Fresh Crops

Item	Trial and Forage Sorghum Variety			
	Trial 1 Alfalfa	Trial 2 25E	Trial 3 351	Trial 4 FS 1A
Dry Matter, %	36.0	24.3	35.5	32.8
pH	6.1	5.8	5.8	5.9
Water Soluble Carbohydrates[1]	4.9	24.0	12.2	9.4
Crude Protein[1]	18.75	5.31	5.63	9.06
Buffer Capacity[2]	56.3	26.3	19.9	36.5
Microbiology (colony-forming units per gram):				
Mesophilic	4×10^5	6×10^5	9×10^6	4×10^7
Lactic Acid Bacteria	$< 10^3$	1×10^4	$< 10^3$	7×10^4
Yeasts and Molds	$< 10^3$	$< 10^3$	6×10^4	3×10^5

[1]Expressed as a % of the dry matter.

[2]Milliequivalents NaOH per 100 grams of dry matter.

Table 37.2. Effect of Temperature and Inoculation on pH and Lactic Acid Over Time for the Four Alfalfa Silages in Trial 1

Time Post-filling and Item	Ensiling Temperature and Inoculant Treatment				
	60 F		90 F		
	Control	Inoculant	Control	Inoculant	SE
Time 0					
pH	6.17	6.17	6.17	6.17	—
Hour 12					
pH	6.00^a	6.01^a	6.16^b	6.03^a	.020
Lactic Acid[1]	$<.01^b$	$.04^b$	$<.01^b$	$.20^a$	.038
Hour 24					
pH	6.06^b	6.12^c	6.14^c	4.95^a	.017
Lactic acid	$.06^b$	$.06^b$	$.56^b$	4.75^a	.180
Hour 36					
pH	6.07^c	5.98^b	5.90^b	4.88^a	.027
Lactic Acid	$.05^d$	$.82^c$	1.77^b	4.97^a	.134
Hour 48					
pH	6.10^d	5.34^b	5.78^c	4.87^a	.054
Lactic Acid	$.40^c$	2.36^b	2.27^b	6.59^a	.404
Day 4					
pH	5.49^c	4.71^a	5.58^c	4.84^b	.027
Lactic Acid	2.46^c	6.55^b	3.04^c	7.64^a	.304
Day 7					
pH	5.28^c	4.66^a	5.48^d	4.77^b	.019
Lactic Acid	3.87^b	6.69^a	3.79^b	7.78^a	.340
Day 21					
pH	5.07^b	4.57^a	5.23^c	4.66^a	.048
Lactic Acid	5.60^b	7.93^a	4.95^b	8.66^a	.407
Day 56					
pH	4.87^b	4.44^a	5.15^c	4.54^a	.037
Lactic Acid	7.06^b	9.17^a	3.83^b	9.17^a	.700
Acetic Acid	4.27^{ab}	3.75^a	4.41^b	4.24^{ab}	.200

[a,b,c,d]Values on the same line differ (P<.05).

[1]Acids are expressed as a % of the silage dry matter.

Table 37.3. Effect of Temperature and Inoculation on pH and Lactic Acid Over Time for the Four Forage Sorghum Silages in Trial 2

Time Post-filling and Item	Ensiling Temperature and Inoculant Treatment				
	60 F		90 F		
	Control	Inoculant	Control	Inoculant	SE
Time 0					
pH	5.78	5.82	5.78	5.82	—
Hour 12					
pH	5.81^{b}	5.88^{c}	5.75^{a}	5.83^{b}	.012
Lactic Acid[1]	$.39^{a}$	$.38^{a}$	$.19^{b}$	$.41^{a}$	.050
Hour 24					
pH	5.82^{c}	5.89^{d}	4.54^{b}	4.49^{a}	.013
Lactic acid	$.06^{b}$	$.10^{b}$	$.85^{a}$	1.33^{a}	.010
Hour 48					
pH	5.29^{b}	5.39^{b}	4.00^{a}	4.03^{a}	.054
Lactic Acid	$.21^{c}$	$.71^{b}$	2.35^{a}	2.14^{a}	.147
Day 4					
pH	4.14^{c}	4.17^{c}	3.96^{b}	3.92^{a}	.008
Lactic Acid	2.85^{b}	2.08^{b}	5.00^{a}	5.33^{a}	.380
Day 7					
pH	4.00^{b}	4.02^{b}	3.71^{a}	3.70^{a}	.008
Lactic Acid	2.39^{b}	2.22^{b}	4.76^{a}	4.55^{a}	.140
Day 14					
pH	3.78^{b}	3.80^{b}	3.59^{a}	3.62^{a}	.006
Lactic Acid	4.47^{b}	5.07^{b}	6.97^{a}	6.53^{a}	.299
Day 42					
pH	3.70^{b}	3.72^{b}	3.64^{a}	3.66^{a}	.004
Lactic Acid	4.99^{d}	5.58^{c}	6.24^{b}	6.63^{a}	.308
Acetic Acid	2.70^{b}	2.67^{b}	2.45^{a}	2.42^{a}	.059

^{a,b,c,d}Values on the same line differ (P<.05).

[1]Acids are expressed as a % of the silage dry matter.

Table 37.4. Effect of Temperature and Inoculation on pH and Lactic Acid Over Time for the Four Forage Sorghum Silages in Trial 3.

Time Post-filling and Item	Ensiling Temperature and Inoculant Treatment				
	60 F		90 F		
	Control	Inoculant	Control	Inoculant	SE
Time 0					
pH	5.74	5.75	5.74	5.75	—
Hour 12					
pH	5.70^{b}	5.72^{b}	4.63^{a}	4.65^{a}	.034
Lactic Acid[1]	$.21^{c}$	$.05^{d}$	$.52^{a}$	$.45^{b}$	.021
Hour 24					
pH	4.91^{b}	4.91^{b}	4.20^{a}	4.22^{a}	.011
Lactic Acid	$.26^{c}$	$.36^{c}$	1.54^{b}	1.69^{a}	.035
Hour 48					
pH	4.15^{b}	4.25^{c}	4.05^{a}	4.14^{b}	.018
Lactic Acid	1.63^{b}	1.27^{c}	2.47^{a}	1.78^{b}	.104
Day 4					
pH	4.20^{b}	4.21^{b}	4.19^{b}	4.14^{a}	.009
Lactic Acid	1.89^{bc}	1.67^{c}	2.16^{a}	1.97^{ab}	.074
Day 7					
pH	4.21^{c}	4.27^{d}	4.04^{b}	3.95^{a}	.010
Lactic Acid	2.52^{c}	2.18^{c}	3.33^{b}	4.34^{a}	.201
Day 14					
pH	4.22^{c}	4.23^{c}	4.00^{b}	3.87^{a}	.014
Lactic Acid	2.29^{c}	2.51^{c}	3.36^{b}	4.87^{a}	.165
Day 42					
pH	3.96^{b}	3.92^{ab}	3.86^{a}	3.83^{a}	.029
Lactic Acid	3.64^{b}	3.72^{b}	4.09^{b}	4.83^{a}	.332
Acetic Acid	2.64^{a}	2.72^{a}	2.23^{b}	2.32^{b}	.165

^{a,b,c,d}Values on the same line differ (P<.05).

[1]Acids are expressed as a % of the silage dry matter.

Table 37.5. Chemical Composition of the Control and Inoculated Forage Sorghum Silages From the Concrete Stave Silos and From Buried Bags in Trial 4

Item	Control		Inoculant	
	Silos	Buried Bags	Silos	Buried Bags
Silage DM, %	30.79	31.52	31.25	31.42
pH	3.78	3.95	3.78	3.90
	% of the Silage DM			
Total Fermentation Acids	10.0	9.1	9.4	8.4
Lactic Acid	7.35	6.39	6.95	6.29
Acetic Acid	2.52	2.68	2.41	1.99
Ammonia-nitrogen	.18	.18	.18	.19
Lactic:Acetic	3.6	2.4	3.3	3.2

Table 37.6 Dry Matter Recoveries and Losses From the Concrete Stave Silos and From Buried Bags for Control and Inoculated Forage Sorghum Silages in Trial 4

Item	DM Recovery		DM Lost During Fermentation, Storage, and Feedout
	Feedable	Non-feedable (Spoilage)	
	% of the DM Ensiled		
Concrete Stave Silos:			
Control	81.42	3.11	15.47
Inoculant	81.60	3.07	15.33
Buried Bags:			
Control	93.50	—	6.50
Inoculant	93.05	—	6.95

Table 37.7. Performance by Calves Fed the Control and Inoculated Forage Sorghum Silages in Trial 4

Item	Control	Inoculant
No. of Calves	16	16
Initial Wt., lb	216	216
Avg. Daily Gain, lb	1.94	1.96
Daily Feed Intake, lb[1]	14.13	13.64
Feed/lb of Gain, lb[1]	7.33	6.90
Silage fed, lb/Ton Ensiled[2]	1,628.4	1,632.0
Silage/lb of Gain, lb[2]	21.2	20.1
Calf Gain/Ton of Ensiled Crop, lb[2]	76.8	81.2

[1]100% dry matter basis.

[2]Values are adjusted to the same silage DM, 30 percent.