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Effect of Enzyme and Inoculant Additives on Preservation and Feeding Value of Wheat and Forage Sorghum Silages[1,2,3]

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Summary

Enzyme and inoculant additives produced more efficiently preserved wheat and forage sorghum silages and improved their feeding value. In general, treated silages had lower pH, acetic acid, and ammonia-nitrogen values and higher lactic acid and lactic to acetic acid ratios than untreated silages. In two of the three trials, cell wall and acid detergent fiber fractions were lower in treated than untreated silages. In Trial 2, the treated sorghum silages were extremely unstable in air and cattle performance was similar for control and treated silages. In Trial 3, gains and feed conversions in steers were improved for those fed treated forage sorghum silages.

Introduction

Kansas is the leading state in wheat production and one of the leaders in forage sorghum production. Silage made from these two crops has often been associated with high ensiling losses, low intakes, and low digestibilities, particularly when harvested in the dough stage. Our objective was to evaluate the effect of enzymes and bacterial inoculants on the preservation and feeding value of whole-plant wheat and forage sorghum silages.

Experimental Procedures

Trial 1. Four whole-plant, soft-dough stage, Centurk wheat silages were compared: 1) control (no additive), 2) Clampzyme experimental (X)-treated, 3) SI Concentrate 40 A/F (SI Conc) inoculant-treated, and 4) Clampzyme X + SI Conc-treated. Clampzyme X was applied in liquid form at .4 liters per ton and SI Conc at 4 grams of product diluted in 1.0 liter of water per ton. The wheat was swathed on May 24, 1985 and chopped immediately with a Field Queen forage harvester.

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[1]Enzymes and partial financial assistance were provided by Finnish Sugar Co., Inc., Shamburg, Illinois; Espoo, Finland; and Redhill, England.

[2]Clampzyme® (experimental) and Clampzyme® contain cellulases, hemicellulases, and glucose oxidase.

[3]SI Concentrate 40 A/F® silage inoculant contains L. plantarum, L. brevis, P.acidilactici, S. cremoris, and P. diacetylactis and was provided by Great Lakes Biochemical Co., Inc., Milwaukee, Wisconsin.

Silages were made in 55-gallon capacity, plastic lined, pilot silos and stored at ambient temperature for approximately 120 days. Each silage was fed to four wether sheep in a three-period voluntary intake and digestion trial. Rations were 90% of the appropriate silage and 10% supplement on a DM basis and other procedures were similar to those described on page ## of this report.

Trial 2. Four, whole-plant, hybrid forage sorghum silages were compared: 1) control (no additive), 2) Clampzyme X-treated, and 3) Clampzyme X + SI Cone inoculant-treated silages from DeKalb 25E, and 4) a control (no additive) silage from Pioneer 947. The silages were made in 8 x 50 ft Ag Bags® and were harvested in the late-dough stage (30 to 32% DM for DeKalb 25E on October 31 and 34% DM for Pioneer 947 on September 24, 1985). The silos were opened on December 6, 1985 and emptied at a uniform rate during the following 12 weeks.

Each silage was fed to 16 steer and heifer calves (four pens of calves per silage) in a 70-day growing trial. Two pens on each silage received a ration containing 87.6% silage and 12.4% supplement; the other two pens received 62.6% silage, 25.0% rolled grain sorghum, and 12.4% supplement (DM basis). Rations were formulated to provide 12.0% crude protein (DM basis), 200 mg of Rumensin® per calf daily, and required amounts of calcium, phosphorus, and vitamin A. All calves received hormonal implants at the start of the trial.

For 1 week before the growing trial, all calves were limit-fed a grass hay and grain ration to provide a 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. For 2 days before the final weighing, the calves were fed their respective silage ration at a restricted intake of 1.75% of body weight.

Samples of each silage were taken twice weekly. Feed intake was recorded daily for each of the 16 pens, and the quantity of silage fed was adjusted daily to assure that fresh feed was always in the bunks. Feed not consumed was removed, weighed, and discarded as necessary.

During the filling of the DeKalb 25E Ag Bags, fresh forage was removed from a randomly selected load and the following treatments were prepared and ensiled in PVC laboratory silos: 1) control (no additive), 2) Clampzyme X-treated, 3) SI Conc-treated, and 4) Clampzyme X + SI Conc-treated. Duplicate silos were opened at 12 and 24 hours and 4, 14, and 90 days post-filling for each treatment.

Trial 3. Three whole-plant, DeKaIb 25E silages were compared: 1) control (no additive), 2) Clampzyme-treated, and 3) Clampzyme + SI Conc inoculant-treated. Clampzyme was applied at .2 liters per ton and SI Conc at 4 grams per ton. The silages were made in 10 x 50 ft concrete stave silos and the crop was harvested in the late-dough stage at 28 to 29% DM on October 17 and 18, 1986. The silos were opened on March 27, 1987 and emptied at a uniform rate during the following 10 weeks.

Each silage was fed to 16 yearling steers (four pens of four steers per silage) in a 65-day growing trial. Rations, implants, pre-trial feeding, and beginning and ending cattle weight procedures were identical to those of Trial 2.

During the filling of the concrete silos, fresh forage was removed from a randomly selected load on each of the two days and the following treatments were prepared and ensiled in PVC laboratory silos from each: 1) control (no additive); 2) Clampzyme; 3) SI Conc; and 4) Clampzyme + SI Conc. Duplicate silos were opened at 12, 24, and 48 hours and 4, 14, and 90 days post-filling for each treatment.

During the cattle growing trial, silage from each of the three silos was fed to eight mature wether sheep in a two period, total collection digestion trial. Period one consisted of 7-day silage adaption, 5-day voluntary intake, and 7-day fecal collection phases. Period two consisted of a 7-day silage adaption and 7-day fecal collection phases. Rations were 90% of the appropriate silage and 10% supplement on a DM basis.

Results and Discussion

Trial 1. Voluntary intake, nutrient digestibility, and chemical composition of the four wheat silage rations are shown in Table 47.1. Although intake and DM digestibility tended to be higher in treated silages, none of the values was statistically different. However, NDF and ADF values for the Clampzyme X-treated silages were lower than the values for control silage. Clampzyme X-treated silages also had higher lactic acid and lower ammonia-nitrogen contents than control. SI Conc-treated silage had lower acetic acid, ethanol, and ammonia-nitrogen values than control silage. These data indicate that Clampzyme X decreased cell wall concentrations in the wheat silage and SI Conc improved the efficiency of the ensiling process. The data also indicate that the effects of the two additives were complementary.

Trial 2. Performance by calves fed the eight silage rations in Trial 2 and silage analyses are shown in Table 47.2. Calves fed Pioneer 947 silage had faster gains, higher DM intakes, and better feed conversions than those fed DeKalb 25E silages. Grain addition improved calf performance from all four forage sorghum silages.

The two additive treatments, Clampzyme X or Clampzyme X + SI Conc, did not affect gain, intake, or efficiency, regardless of grain addition treatment. One possible explanation could be the extremely unstable nature of the treated silages which heated within 24 to 48 hrs after exposure to air. It was difficult to keep the exposed silage surfaces from heating prior to feeding.

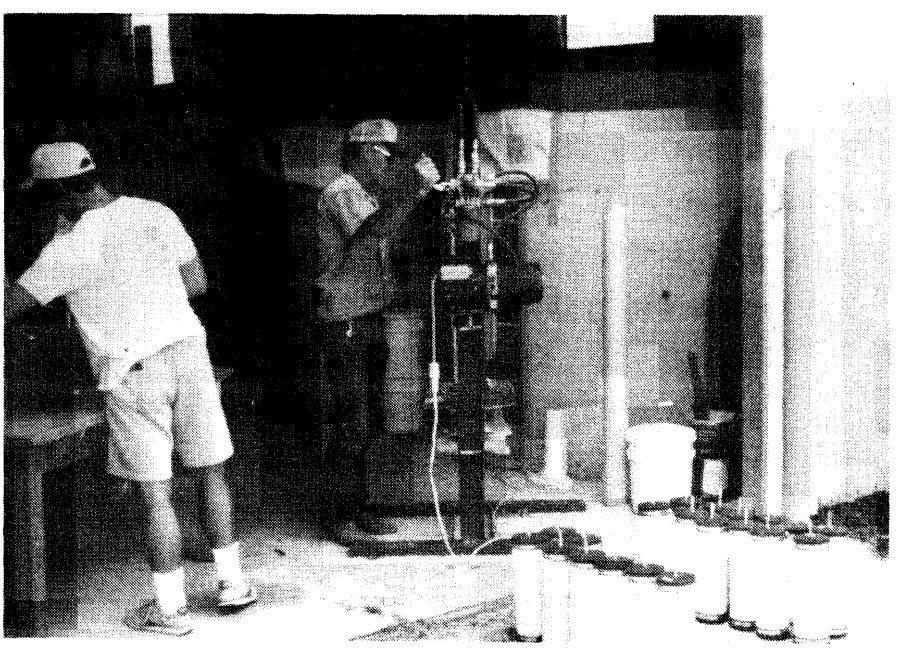
Chemical composition of the silages actually fed to the cattle from the two treated silage Ag Bags showed higher pH and lower lactic acid values compared to silage from the control Ag Bag. In contrast, analyses of silages from the PVC laboratory silos showed just the opposite, with treated silages having lower pH and higher lactic acid values than control silage.

Trial 3. Performance by steers fed the six silage rations in Trial 3 and silage fermentation-results are shown in Table 47.3. Steers fed each of the three silages with 25% additional grain had faster gains, higher DM intakes, and better feed conversions, which is consistent with results in Trial 2 and results of similar trials contained on pages ## and ## of this report.

Both of the silage additive treatments improved steer performance, with steers fed Clampzyme silage gaining faster ($P<.05$) and more efficiently ($P<.05$) than those fed control silage. In contrast to results in Trial 2, all three silages from the stave silos were stable in air, even during the mild spring weather. When compared to control silage, treated silages had lower pH, lower acetic acid and ammonia-nitrogen contents, and higher lactic acid contents --all characteristics of more efficiently preserved silage.

Results of the digestion trial and chemical composition of the three silages are shown in Table 47.4. Lambs fed Clampzyme-treated silage had a higher DM intake than those fed control silage. In general, there were only small differences in nutrient digestibilities, although values for treated silages tended to be slightly higher than those for control silage.

Silage analyses results clearly indicate that Clampzyme decreased cell wall fiber, because both treated silages had lower NDF and ADF values than control. This explains, at least in part, the improved feed conversions by steers fed the treated silage rations. Silage fermentation results from both the digestion trial and PVC silos (Table 47.5) were consistent with results from silages fed in the cattle trial -- lower pH, acetic acid, and ammonia-nitrogen and higher lactic acid values for the two treated silages.



Small laboratory silos (lower right) are a valuable research tool for following silage fermentation dynamics. Here, silage is uniformly packed into the laboratory silos using a hydraulic press.

Table 47.1. Voluntary Intake, Nutrient Digestibility, and Chemical Composition of the Four Wheat Silage Rations in Trial 1

Item[1]	Control	Clampzyme X	SI Conc	Clampzyme X + SI Conc
D ,[2]%	30.7	31.7	31.0	31.1
VI[2]	35.5	37.3	38.3	44.4
Digestibility	---------- % ----------			
DM	51.9	51.5	53.3	53.9
CP	64.8	63.7	62.8	63.4
NDF	48.5	47.7	47.3	48.7
ADF	48.2	45.6	47.5	45.6
Cellulose	59.5	58.4	59.8	57.8
Hemicellulose	49.0	52.5	50.2	54.6
Silage Analyses	---------- % of the Silage DM ----------			
CP	12.1	12.1	12.1	12.1
NDF	62.1	59.6	60.8	58.9
ADF	42.5	40.1	40.8	39.7
Cellulose	30.8	29.0	29.6	27.9
Hemicellulose	19.6	19.4	20.0	19.8
Lactic Acid	8.27	10.25	8.25	10.26
Acetic Acid	3.54	3.47	2.59	2.57
Ethanol	.62	.62	.45	.37
Ammonia-N	.34	.25	.23	.22
pH	4.07	3.87	4.00	3.86

[1] DM = dry matter, VI = voluntary intake, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

[2] Kg of dry matter per kg of body wt.$^{.75}$

Table 47.2. Performance by Calves Fed the Four Forage Sorghum Silages with and without Additional Grain and Chemical Composition of the Silages in Trial 2

Item	Silage* : Grain*:	DeKalb 25E** Control w/o	Control w	Clampzyme X w/o	Clampzyme X w	Clampzyme X + SI Conc w/o	Clampzyme X + SI Conc w	Pioneer 947 w/o	Pioneer 947 w
No. of Calves		8	8	8	8	8	8	8	8
Initial Wt., lb		543	539	543	531	544	530	536	537
Avg. Daily Gain, lb		1.34	1.95	1.22	2.13	1.25	1.93	2.04	2.44
		1.65		1.68		1.59		2.24	
Daily Feed Intake, lb [1]		12.71	14.92	11.98	15.47	11.79	14.64	14.62	16.79
		13.8		13.7		13.2		15.7	
Feed/lb of Gain, lb [1]		9.6	7.7	9.8	7.4	9.5	7.6	7.2	6.9
		8.7		8.6		8.5		7.0	
Silage Analyses									
Dry Matter, %		32.4		32.6		33.0		37.0	
pH		4.04		4.11		4.12		---	
Aerobic Stability, hrs		120		37		46		---	
		----------% of the Silage DM----------							
Lactic Acid		4.87		4.51		4.62		---	
Acetic Acid		2.15		1.61		1.59		---	
Ethanol		.84		.92		1.00		---	
Ammonia-N		.054		.038		.039		---	
Acid Detergent Fiber		37.8		38.1		37.8		32.6	

[1] 100% dry matter basis.

*Statistical analyses showed that both main effects, hybrid (25E vs. 947) and grain addition (w/o vs. w), influenced ($P<.05$) gain, feed intake, and feed/gain.

**Silage treatments within DeKalb 25E (control vs. Clampzyme X vs. Clampzyme X + SI Conc) did not significantly influence calf performance.

Table 47.3. Performance by Steers Fed the Three DeKalb 25E Silages with and without Additional Grain in Trial 3 and Chemical Composition of the Silages

Item	Silage[1] Grain :	Control w/o	Control w	Clampzyme w/o	Clampzyme w	Clampzyme + SI Conc w/o	Clampzyme + SI Conc w
No. of Steers		8	8	8	8	8	8
Initial Wt., lb		607	609	611	612	607	606
Avg. Daily Gain, 1		1.38 [b]	2.01 [z]	1.50 [a]	2.29 [x]	1.43 [ab]	2.15 [y]
		1.69		1.89		1.79	
Daily Feed Intake, lb[2]		13.67	16.19	13.77	16.86	13.20	16.86
		14.9		15.3		15.0	
Feed/lb of Gain, lb[2]		10.0 [b]	8.1 [y]	9.2 [a]	7.4 [x]	9.3 [a]	7.9 [y]
		9.0		8.3		8.6	
Silage Analyses							
pH		4.14		3.92		3.97	
		% of the Silage DM					
Lactic Acid		3.55		5.13		5.48	
Acetic Acid		2.37		1.71		2.27	
Ethanol		.317		.354		.319	
Ammonia-N		.087		.060		.062	

[1]Statistical analyses showed that both main effects, silage (control vs. Clampzyme vs. Clampzyme + SI Conc) and grain addition (w/o vs. w), influenced gain and feed/gain; only grain addition influenced feed intake.

[2] 100% dry matter basis.

[a b] Silage treatments (w/o grain) differ ($P<.05$).

[xyz] Silage treatments (w grain) differ ($P<.05$).

Table 47.4. Voluntary Intake, Nutrient Digestibility, and Chemical Composition of the Three DeKalb 25E Silage Rations in Trial 3

Item	Control	Clampzyme	Clampzyme + SI Conc
VI, kg DM/Day	1.59 [b]	1.83 [a]	1.69 [ab]
Digestibility	---------- % ----------		
DM	54.2	55.1	54.3
OM	55.1	56.7	55.6
CP	59.7 [b]	60.8 [a]	60.3 [b]
NDF	34.9	37.7	35.2
ADF	31.0 [b]	33.6 [a]	31.3 [ab]
Cellulose	38.1 [b]	42.2 [a]	39.4 [b]
Hemicellulose	42.0	45.1	42.1
Silage Analyses	---------- % of the Silage DM ----------		
CP	7.3	7.1	7.3
Ash	6.6	6.1	6.4
NDF	58.2	54.6	55.0
ADF	36.9	34.5	35.0
Cellulose	26.6	24.4	24.9
Hemicellulose	21.0	20.1	20.0
Lactic Acid	3.76	5.86	5.70
Acetic Acid	2.79	1.23	1.52
Ethanol	.22	.24	.27
Ammonia-N	.08	.05	.05
pH	4.19	3.93	3.93

[1] VI = voluntary intake, DM = dry matter, OM = organic matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber.

[a b] Means on the same line having different superscripts differ (P<.05).

Table 47.5. pH and ChemicaI Composition over Time for the Forage Sorghum Silages in Trials 2 and 3

Time Post Filling[1] and Items	Trial 2				Trial 3			
	Control	Clamp X	SI Conc	Clamp X + SI Conc	Control	Clamp	SI Conc	Clamp + SI Conc
Initial: pH	5.92	5.91	5.92	5.93	5.96	5.95	5.96	5.95
Hour 12: pH	4.84	4.82	4.79	4.86	4.79	4.77	4.78	4.72
Lactic Acid	.73	.76	.83	.71	1.21	1.15	1.19	1.54
Hour 24: pH	4.52	4.52	4.53	4.51	4.38	4.35	4.34	4.30
Lactic Acid	1.18	1.39	1.32	1.38	2.01	2.32	2.15	2.16
Hour 48: pH	---	---	---	---	4.08	4.07	4.06	4.01
Lactic Acid	---	---	---	---	3.36	3.79	3.77	4.64
Day 4: pH	4.09	4.02	4.09	4.01	4.01	3.97	3.99	3.94
Lactic Acid	3.61	4.00	3.54	3.66	4.59	4.33	4.39	5.22
Day 14: pH*	4.00	3.88	4.01[x]	3.88	3.89	3.84[x]	3.90[x]	3.81
Lactic Acid*	4.25	5.13	4.21[x]	5.01	6.33	6.32[x]	6.58[x]	6.99
Day 90: pH*	4.04	3.92	4.07[x]	3.91	3.97	3.91[x]	3.97[x]	3.89
Lactic Acid*	4.54	5.22	4.58[x]	5.29	6.01	6.54[x]	6.18[x]	6.93
Acetic Acid	1.57	1.85	1.67	1.77	1.58	1.52	1.61	1.53
Ethanol	.279	.286	.270	.290	.327	.329	.302	.347
NH_3-N	.082	.073	.069	.057	.057	.052	.054	.053

[1] Acids, ethanol, and NH_3-N are reported as a % of the silage dry matter.

* Statistical analyses showed control vs. treatment means differed ($P<.05$) within a trial, unless the inoculant mean has a superscript(x).