Effect of Inoculants on the Fermentation of Wheat, Alfalfa, and Sorghum Silages[1]

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Summary

Results from three laboratory silo experiments showed that four commercial silage inoculants increased fermentation rate, particularly during the first 4 days of the ensiling process. The effects of the additives on pH drop and lactic acid production were greater in wheat and alfalfa than in forage sorghum.

Introduction

Silage additives are receiving fairly widespread acceptance in the U.S. As farmers learn more about the ensiling process and improve their silage-making techniques, the risk of producing a bad smelling, poor quality, unpalatable silage has decreased. Thus, most farmers today are fine-tuning their silage management to make good silage superior—not bad silage acceptable.

Recently, Bolsen and Heidker (1985)[2] published a guide to over 150 silage additive products marketed in the U.S. Those additives contained over 120 different active ingredients. Microbial inoculants were the most numerous. Generally, inoculants are combinations of several bacterial species selected to rapidly convert part of the crop's soluble carbohydrates to lactic acid, thus improving silage preservation and reducing dry matter loss. Silage additives are usually formulated for low volume usage rates (.5 to 2.0 lb per ton of fresh crop) and most are available in either dry or liquid form. In Europe, most forage harvesters are equipped to apply additives in the field. In the U.S., most farmers prefer to use the additive at the silo.

Over 40 claims are made by the 91 manufacturers or distributors cited in the guide. These include increased dry matter recovery, greater aerobic stability, faster ensiling rate, increased lactic acid, greater nutrient retention, and increased palatability—all characteristics of improved silage. With so many products and claims, how does the silage-maker assess the value of a silage additive? Efficacy is the first consideration. Does it work? Will it work under all farm conditions? What evidence does the manufacturer or distributor have to document efficacy? The buyer should look for good evidence that the product improves the fermentation and conservation processes. Results from laboratory-scale experiments are helpful, especially if the crops used are similar to the buyer's. Under laboratory conditions, effective silage inoculants should speed the drop in pH through a faster and greater production of lactic acid.

[1]Partial financial assistance was provided by Moorman Manufacturing Company, Quincy, Illinois.

[2]Bolsen, K.K. and J.I. Heidker. 1985. Silage Additives USA. Chalcombe Publications, Box 1222, Manhattan, Kansas 66502.

The objective of these experiments was to determine the effects of commercial silage inoculants on the rate and efficiency of fermentation of wheat, alfalfa, and forage sorghum.

Experimental Procedures

The laboratory silos used were 4 x 14 inch PVC pipes closed with a Jim-Cap on each end. One cap was fitted with a Bunsen valve to allow gases to escape. For filling, 125 lb of fresh crop was placed on a plastic sheet and the inoculant applied and mixed thoroughly. After all silage treatments were prepared, the silos were filled on an alternating schedule which distributed the time from harvest through silo filling equally across the treatments. The silos were packed with a hydraulic press, which excluded air and filled all silages to similar densities.

Experiment 1. Silages were made from heading-stage, hard red winter wheat (Centurk variety), with the crop field-wilted to approximately 35% dry matter (DM) prior to ensiling. The five treatments were:

1) H/M Plus Liquid (from Triple "F" Feeds, Des Moines, Iowa and containing Streptococcus faecium M-74, Lactobacillus plantarum, and Pediococcus sp.).
2) Kem Lac (from Kemin Industries, Inc., Des Moines, Iowa and containing Lactobacillus plantarum, Lactobacillus bulgaricus, and Lactobacillus acidophilus).
3) Biomate Lab Concentrate (from Chr. Hansen's Laboratory, Inc., Milwaukee, Wisconsin and containing Lactobacillus plantarum and Pedicoccus cerevisiae).
4) SI Concentrate 40 A/F (from Great Lakes Biochemical Co., Inc., Milwaukee, Wisconsin and containing Lactobacillus plantarum, Lactobacillus brevis, Pediococcus acidolactici, Streptococcus cremoris, and Streptococcus diacetylactis).
5) Control (no additive).

Silos were stored at approximately 85 F and three silos per treatment were opened at 12, 24, and 48 hours and 4, 7, and 42 days post-filling.

Experiment 2. Silages were made from second cutting alfalfa, with the crop field-wilted to approximately 42% dry matter. All other procedures and inoculant treatments were the same as those described in Expt. 1.

Experiment 3. Silages were made from dough-stage forage sorghum (DeKalb 25E variety) and the crop contained approximately 25% DM at harvest. All other procedures and inoculant treatments were the same as those described in Expt. 1.

In all three experiments, the pre-ensiled crops were analyzed for DM, pH, buffer capacity (BC), water soluble carbohydrates (WSC), and numbers of lactic acid bacteria (LAB). Silages were analyzed for DM, pH, and lactic, acetic, and total fermentation acids.

Results

The fresh, pre-ensiled wheat and alfalfa had less than 10^3 colony-forming units of LAB per gram, whereas the forage sorghum contained 10^4 per gram--10 times more. The wheat and alfalfa had relatively low WSC values (5.4 and 4.9% of the DM, respectively) and the forage sorghum, a high WSC value (24.0%). Only the alfalfa had a high BC (56.3 millequivalents of NaOH per 100 gram of DM).

Experiment 1 (Table 36.1). All five wheat silages underwent a rapid drop in pH (from approximately 6.15 down to 4.6 in 24 hours) and all were well-preserved, as evidenced by a low terminal pH (4.26 or lower) and a sufficiently high lactic acid value (6.70% of the DM or above). All four inoculated silages had a lower ($P<.05$) pH value than control silage at days 4, 7, and 42 and a numerically higher lactic acid content at days 4 and 7. Only Biomate silage contained more ($P<.05$) lactic acid than the control after 42 days.

Experiment 2 (Table 36.2). All four inoculants significantly increased the rate of pH drop and the rate of lactic acid production in the alfalfa silages. Biomate silages had the lowest ($P<.05$) pH at each opening time during the first 4 days and the highest ($P<.05$) lactic acid content at hours 12, 24, and 48 post-filling. All four inoculated silages had a significantly lower pH and higher lactic acid content than control silage at days 7 and 42.

Experiment 3 (Table 36.3). All five forage sorghum silages reached pH 4.0 by hour 48. Only the H/M Plus silage had more ($P<.05$) lactic acid than control at hour 24. At day 4, the Biomate and SI Concentrate silages had a lower ($P<.05$) pH and a higher ($P<.05$) lactic acid content than control silage. All silages had similar pH and lactic acid values at 42 days post-filling; however, Biomate silage had the lowest ($P<.05$) acetic acid content.

Table 36.3. pH and Lactic Acid Over Time for the Five Forage Sorghum Silages in Expt. 3

Time Post-filling and Item		Inoculant Treatment					SE
		Control	H/M Plus	Kem Lac	Biomate	SI Conc	
Initial:	pH	5.78	5.81	5.78	5.80	5.80	—
Hour 12:	pH	5.75	5.79	5.78	5.79	5.80	.014
	Lactic Acid[1]	.19	.41	.39	.41	.35	.054
Hour 24:	pH	4.54^{b}	4.51^{ab}	4.71^{c}	4.73^{c}	4.47^{a}	.013
	Lactic Acid	$.85^{bc}$	1.95^{a}	$.55^{bc}$	$.60^{bc}$	1.04^{b}	.176
Hour 48:	pH	4.00^{c}	3.99^{bc}	4.01^{c}	3.86^{a}	3.95^{b}	.018
	Lactic Acid	2.35^{b}	2.79^{b}	2.51^{b}	3.57^{a}	3.06^{ab}	.247
Day 4:	pH	3.96^{d}	3.88^{c}	3.94^{d}	3.77^{a}	3.82^{b}	.149
	Lactic Acid	5.00^{b}	6.35^{b}	6.08^{b}	8.49^{a}	8.26^{a}	.470
Day 7:	pH	3.71^{b}	3.68^{b}	3.72^{b}	3.65^{a}	3.65^{a}	.011
	Lactic Acid	5.76	5.95	5.76	6.66	6.53	.364
Day 42:	pH	3.64^{a}	3.69^{c}	3.67^{b}	3.70^{d}	3.66^{b}	.004
	Lactic Acid	6.24^{cd}	7.06^{bc}	6.94^{bc}	6.26^{a}	6.42^{b}	.394
	Acetic Acid	2.45^{cd}	2.26^{bc}	2.26^{bc}	1.75^{a}	2.14^{b}	.098

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

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

Table 36.1. pH and Lactic Acid Over Time for the Five Wheat Silages in Expt. 1

Time Post-filling and Item		Control	Inoculant Treatment H/M Plus	Kem Lac	Biomate	SI Conc	SE
Initial:	pH	6.11	6.18	6.13	6.14	6.09	—
Hour 12:	pH	5.10^{d}	5.07^{cd}	5.01^{b}	4.93^{a}	5.03^{bc}	.015
	Lactic Acid[1]	1.80^{c}	2.25^{a}	1.69^{c}	2.13^{ab}	1.86^{bc}	.095
Hour 24:	pH	4.67^{c}	4.69^{c}	4.59^{b}	4.45^{a}	4.65^{c}	.016
	Lactic Acid	3.24^{b}	3.12^{b}	3.40^{b}	4.17^{a}	3.23^{b}	.096
Hour 48:	pH	4.65^{d}	4.59^{bc}	4.58^{bc}	4.31^{a}	4.62^{cd}	.022
	Lactic Acid	3.40^{c}	3.20^{c}	5.29^{a}	5.28^{a}	3.14^{c}	.264
Day 4:	pH	4.58^{e}	4.33^{b}	4.38^{c}	4.12^{a}	4.50^{d}	.013
	Lactic Acid	3.90^{c}	5.31^{a}	4.93^{ab}	5.21^{a}	4.02^{bc}	.329
Day 7:	pH	4.55^{d}	4.22^{b}	4.27^{b}	4.09^{a}	4.38^{c}	.022
	Lactic Acid	3.77^{b}	8.05^{a}	5.22^{b}	7.82^{a}	4.33^{b}	.764
Day 42:	pH	4.26^{b}	4.06^{a}	4.07^{a}	4.00^{a}	4.05^{a}	.023
	Lactic Acid	7.59^{bc}	8.39^{b}	7.44^{bc}	10.64^{a}	8.45^{b}	.515
	Acetic Acid	$.56^{d}$	$.34^{bc}$	$.27^{b}$	$.17^{a}$	$.46^{d}$	.042

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

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

Table 36.2. pH and Lactic Acid Over Time for the Five Alfalfa Silages in Expt. 2

Time Post-filling and Item		Control	Inoculant Treatment H/M Plus	Kem Lac	Biomate	SI Conc	SE
Initial:	pH	5.94	5.95	5.94	5.95	5.95	—
Hour 12:	pH	5.81^{c}	5.78^{c}	5.77^{bc}	5.65^{a}	5.73^{b}	.017
	Lactic Acid[1]	$.33^{b}$	$.27^{b}$	$.42^{b}$	$.75^{a}$	$.65^{a}$	.048
Hour 24:	pH	5.73^{d}	5.62^{c}	5.64^{c}	4.88^{a}	5.49^{b}	.230
	Lactic Acid	$.81^{c}$	1.67^{b}	1.88^{b}	4.28^{a}	2.15^{b}	.211
Hour 48:	pH	5.43^{d}	4.89^{c}	4.88^{bc}	4.62^{a}	4.81^{b}	.024
	Lactic Acid	2.00^{c}	5.62^{b}	5.14^{b}	7.85^{a}	6.24^{b}	.447
Day 4:	pH	5.11^{d}	4.74^{c}	4.65^{b}	4.54^{a}	4.65^{b}	.014
	Lactic Acid	3.38^{d}	7.35^{b}	7.15^{bc}	10.14^{a}	9.41^{a}	.631
Day 7:	pH	4.97^{d}	4.74^{c}	4.58^{b}	4.49^{a}	4.60^{b}	.020
	Lactic Acid	4.74^{b}	8.56^{a}	7.93^{a}	8.22^{a}	8.54^{a}	.441
Day 42:	pH	4.61^{e}	4.54^{cd}	4.47^{ab}	4.40^{a}	4.51^{bc}	.022
	Lactic Acid	7.13^{b}	11.67^{a}	9.94^{a}	11.26^{a}	9.36^{a}	.549
	Acetic Acid	2.78	2.57	2.03	1.97	2.27	.097

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

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