Evaluation of Silaferm as an additive for corn silage production.

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Abstract

The effect of different additives upon ensiling of corn silage was compared with non-treated control silage. Silaferm, dried or not, and urea were added to fresh cut corn plant to equal 10 lbs. of added nitrogen per ton of fresh forage weight. Silage moisture content in this trial was low and resulted in low production of organic acids in all treatments except Urea. Urea had higher lactic, acetic and butyric acid levels compared with all other treatments ($P < 0.05$). The high butyric acid in Urea resulted in an off-smelling silage and is common when adding non-protein nitrogen to overly dry corn plant for silage making. Silaferm treatments had higher levels of true protein compared with Control and Urea ($P < 0.05$). Liquid Silaferm had lower ADF compared with Control ($P < 0.05$). Aerobic stability of silages was low for all silages, probably due to low organic acid content. These data suggest that Silaferm prevents plant protein proteolysis and reduces ADF values in silage. Further, adding Silaferm to low dry matter silages may not result in unfavorable butyric acid production compared with other non-protein nitrogen sources such as urea.

Introduction

In previous experiments, it has been shown that Silaferm is a beneficial additive when used in production of corn silage. The primary benefits found to result from Silaferm addition are increased stability of silage when exposed to air and less proteolysis of plant protein during ensiling. The recommended level of addition is 50 – 100 lbs of Silaferm per ton of fresh forage weight. Applying Silaferm as a dry material could effectively reduce the amount of material required to be handled and would eliminate the need for liquid storage and handling equipment. A trial was designed to develop some information about the effectiveness of dried Silaferm compared with liquid Silaferm as an additive in corn silage production.

Objective

The objective of this trial was to evaluate the effectiveness of Silaferm, dried or not, as a silage additive compared with urea and a non-treated control.

Materials and Methods

Silage production

The test additive was obtained from Ajinomoto Food Ingredients, LLC. A portion of this liquid was also dried by combining with oat hull screenings 77:33 weight ratio and drying in a forced air oven at 60^{o}C. The oat hull screenings served as a carrier. Dry, feed grade urea was dissolved into water. The additives (liquid Silaferm; Dried Silaferm and Urea) were added to fresh chopped corn plant, obtained from a local farm, to equal 10 lbs. added N per ton of fresh forage weight. Each treatment was replicated 4 times (10 kg per replicate) and from each replicate, approximately 2.5kg was placed into each of three mini-silos, 16 X 28 cm cryovac bags. Air was evacuated from the silos using a vacuum pump and they were weighed and designated to be opened for sampling at either 5, 7 or 160 days. A day 0 sample of the forages was also taken at the time of ensiling.

Sampling method

At each silo opening time, the contents were weighed and thoroughly mixed before sampling. All fresh and ensiled forage samples were processed identically, except for day 160 and 167 (7 days exposed samples), which were used for enumeration of yeasts and molds in addition. Dry matter content was determined by drying 200 g in a 60C^{o} forced air oven for 48 hours. Silage pH was determined after 50g was added to 400 ml of water. The water-silage mixture, used to extract organic acids and ammonia, was placed in a refrigerator overnight. The following morning, a portion of the extract was filtered using Whatman 54 paper, acidified with 50% sulfuric acid and frozen for later analysis.

Laboratory analyses

Yeast and molds were extracted from day 160 and spoiled samples (after 7 days exposure) by placing 20 grams of silage into 200ml of ¼ strength Ringers solution. A portion of this extract was filtered through 2 layers of cheeseclothe into a test tube. Ten fold serial dilutions were made from the filtrates and duplicate 1 ml samples of each were pour-plated onto malt extract agar. Plates were read after incubating at 22Co for 96 hours.

For evaluation of silage aerobic stability, sixteen 2mm diameter holes were made at the top of each mini silo after sampling on day 160. The min silos were weighed before and after aerobic exposure. Silage temperature was monitored daily b inserting a digital thermometer into the center of each silo. After 7 days of aerobic exposure, the silages were thoroughly mixed and sampled.

Total nitrogen was determined using the Kjeldahl procedure. True protein nitrogen was that which was insoluble in 10% tungstic acid after 12 hours. Insoluble true protein nitrogen was that which was insoluble in a borate-phosphate buffer after 2 hours. Ammonia nitrogen was determined using the phenol-hypochlorite procedure.

Volatile fatty acids were analyzed by gas chromatography. The column used was a capillary column coated with polyethylene glycol. The method conditions were: injector temperature 220C^{o}, detector temperature 280C^{o} and the column initial temperature was set at 60C^{o} and increased to 250C^{o} by 15C^{o}/minute. Sample preparation consisted of: to 5ml of sample 1ml of 25% metaphosphoric acid containing 2g/L of ethylbutyric acid as an internal standard was added; the samples were centrifuged at 5,200 X g for 20 minutes and a portion of the supernatant was decanted for analysis.

Lactic acid was analyzed using HPLC. The column was coated with octadecylsilane and the program consisted of: oven temperature 60C^{o}, mobile phase 0.1M ammonium phosphate, isocratic flow rate 2.0 ml/min. Sample preparation was the same as used for VFA analysis.

Neutral detergent and acid detergent fiber was determined sequentially using an Ankom fiber analyzer.

Results and Discussion

The dry matter content of the chopped fresh forage before ensiling was 45.5% (Table 1.). The ideal dry matter content for optimal fermentation is between 35 and 40%. High dry matter content, or low moisture content tends to inhibit adequate fermentation which is needed for production of acids to develop a good silage. The corn plant used in this trial was dryer than intended and also had less nitrogen content than expected (Table 3).

Urea had significantly higher levels of lactic, acetic and butyric acid after ensiling for 160 days and 7 days of aerobic exposure (Table 2.). Liquid Silaferm and Dried Silaferm were not different compared with Control. Overall, the amount of organic acid production was low for typical corn silage and indicated a poor fermentation. The concentration of butyric acid in Urea was unusually high. A high concentration of butyric acid in silage is unfavorable and has resulted in reduced palatability and feed intake.

The total nitrogen content of Control was low for typical corn silage and by design, both total nitrogen and ammonia nitrogen were higher in treated silages compared with Control (Table 3). There was a linear decrease in true protein and insoluble true protein during ensiling for all silages. However, Liquid Silaferm and Dried Silaferm contained more true protein and insoluble true protein during the complete ensiling period compared with Control or Urea. Previously we found Silaferm has no effect on initial true protein levels (almost no true protein content in Silaferm) but these silages had greater concentrations after the ensiling period ended, apparently due to reduced plant protein proteolysis. In the present trial, the magnitude of change from day 0 to day 160 between Liquid or Dried Silaferm and Control was similar. That is they all lost about 0.16% true protein nitrogen during ensiling.

The percentage of both NDF and ADF was statistically similar between all treatments at day 160 (Table 4.). However, a couple of interesting effects were found. First, the fiber (NDF and ADF) content of Liquid and Dried Silaferm tended to increase during ensiling and this was significant for Dried Silaferm. In addition, Urea had a quadratic response and Control did not vary.

Comparisons of pH between treatments for each sampling day are shown in figure 1. As expected, urea increased pH of silage compared with Control. At the end of the 7-day aerobic exposure period, Urea pH was similar to what it had been on day 160 while all others had substantial increases.

Silage temperature during aerobic exposure increased rapidly (Figure 2.). Liquid Silaferm and Dried Silaferm both had delayed heating by about one day compared with Control. Urea had delayed heating slightly longer compared with Silaferm treatments. However, such a rapid rise in temperature is a result of the poor fermentation and low lactic acid content of silages. It is interesting to note that although the Silaferm treatments did not increase acid production compared with Control, silage stability was increased by about 100%.

Yeast and mold content of silages (Figure 3.) was comparable to values reported in the literature except for Urea, which lacked any detectable colonies on day 160. During the 7-day exposure period, yeast and mold content increased in all silages; however, Urea maintained a lower amount.

Table 1. Dry Matter Content.

	Treatment			
Day	Control	Liquid Silaferm	Dried Silaferm	Urea
		g/100g		
0	45.51	45.49	49.95	43.70
160	44.74	44.02	50.24	43.56
7 day exp.	44.64	43.06	49.35	44.46

Table 2. Organic Acid Content of Silages.

Day	Treatment: Control	Liquid Silaferm	Dried Silaferm	Urea	SEM
lactic acid, % of DM					
0	0.08	0.09	0.10	0.08	0.02
5	1.61^{a}	1.85^{a}	1.31^{a}	3.48^{b}	0.25
7	2.76^{a}	3.79^{ac}	2.49^{a}	5.16^{bc}	0.51
160	2.96^{a}	2.75^{a}	2.80^{a}	4.55^{b}	0.18
7 day exp.	0.29^{a}	0.19^{a}	0.21^{a}	3.99^{b}	0.14
acetic acid % of DM					
0	.02	0.03	0.03	0.02	0.01
5	0.47	0.19	0.39	0.54	0.09
7	0.27	0.27	.014	0.35	0.08
160	0.78^{a}	0.59^{a}	0.38^{a}	1.38^{b}	0.15
7 day exp.	0.07^{a}	0.03^{a}	0.02^{a}	0.69^{b}	0.03
propionic acid, % of DM					
0	nd	nd	nd	nd	
5	nd	nd	nd	nd	
7	nd	nd	nd	nd	
160	0.07	0.02	0.01	0.03	0.01
7 day exp.	0.03	0.01	0.01	0.02	0.01
butyric acid, % of DM					
0	nd	nd	nd	nd	
5	nd	nd	nd	nd	
7	nd	nd	nd	nd	
160	0.06^{a}	0.02^{a}	0.02^{a}	0.60^{b}	0.06
7 day exp.	0.05^{a}	0.02^{a}	0.01^{a}	0.30^{b}	0.02

^{abc}Means within rows with unlike superscripts differ. $P < 0.05$.

nd = not detected above .01% of dry matter.

Table 3. Total Nitrogen Content and Nitrogen Fractions of Silage.

Day	Treatment				SEM
	Control	Liquid Silaferm	Dried Silaferm	Urea	
			total nitrogen, % of DM		
0	0.94[a]	2.55[b]	2.62[c]	2.43[b]	0.03
5	0.95[a]	2.63[b]	2.52[b]	2.50[b]	0.04
7	1.03[a]	2.56[b]	2.58[b]	2.46[b]	0.03
160	1.00[a]	2.74[c]	2.72[c]	2.44[b]	0.04
7 day exp.	1.07[a]	2.73[c]	2.74[c]	2.47[b]	0.03
day 0-160					
linear		††	†		
quadratic	†				
			ammonia nitrogen, % of DM		
0	0.01[a]	1.13[b]	1.43[c]	0.40[d]	0.07
5	0.08[a]	1.26[b]	1.25[b]	0.33[a]	0.08
7	0.04[a]	1.17[b]	0.98[b]	0.36[a]	0.13
160	0.18[a]	1.37[b]	1.48[b]	0.59[c]	0.06
7 day exp.	0.06[a]	1.53[b]	1.60[b]	0.33[c]	0.07
day 0-160					
linear	††			††	
quadratic	†		†		
			true protein nitrogen, % of DM		
0	0.82[a]	1.14[b]	1.16[b]	0.95[c]	0.02
5	0.76[a]	1.16[b]	1.19[b]	0.92[c]	0.02
7	0.85[a]	1.18[b]	1.27[b]	0.94[a]	0.03
160	0.68[a]	0.98[b]	0.99[b]	0.72[a]	0.03
7 day exp.	0.92[a]	1.29[b]	1.25[b]	0.79[c]	0.02
day 0-160					
linear	††	††	††	††	
quadratic			†		
			insoluble true protein nitrogen, % of DM		
0	0.66[a]	0.75[bc]	0.78[b]	0.69[ac]	0.02
5	0.60[a]	0.71[bc]	0.79[b]	0.71[c]	0.02
7	0.61[a]	0.75[b]	0.81[c]	0.66[d]	0.01
160	0.41[a]	0.56[b]	0.59[b]	0.42[a]	0.03
7 day exp.	.067[a]	0.89[b]	0.9[b]	0.51[c]	0.01
day 0-160					
linear	††	††	††	††	
quadratic	†				

[abcd]Means within a row with unlike superscripts differ. $P < 0.05$.

† $P < 0.05$.

†† $P < 0.01$.

Table 4. Fiber Content of Silages.					
	Treatment				
Day	Control	Liquid Silaferm	Dried Silaferm	Urea	SEM
		neutral detergent fiber, % of DM			
0	41.77[a]	36.73[bc]	36.11[b]	39.08[c]	0.62
5	42.79[a]	35.59[b]	35.20[b]	39.28[ab]	1.22
7	40.12[a]	36.8[a]	36.72[a]	42.10[b]	0.84
160	40.75	37.08	38.24	38.92	0.96
7 day exp.	41.21	39.27	38.26	38.55	1.11
day 0-160					
linear			†		
quadratic				†	
		acid detergent fiber, % of DM			
0	21.25[a]	18.69[b]	17.96[b]	19.63[ab]	0.57
5	22.10[a]	18.40[b]	18.03[b]	20.49[ab]	0.76
7	20.91[ab]	19.17[bc]	18.79[c]	21.94[a]	0.46
160	21.97[a]	19.63[b]	20.33[ab]	20.78[ab]	0.55
7 day exp.	21.58	20.44	19.72	20.15	0.68
day 0-160					
linear			††		
quadratic				†	

[abc]Means within rows with unlike superscripts differ. $P < 0.05$.

† $P < 0.05$.

†† $P < 0.01$.

Figure 1. Silage pH.

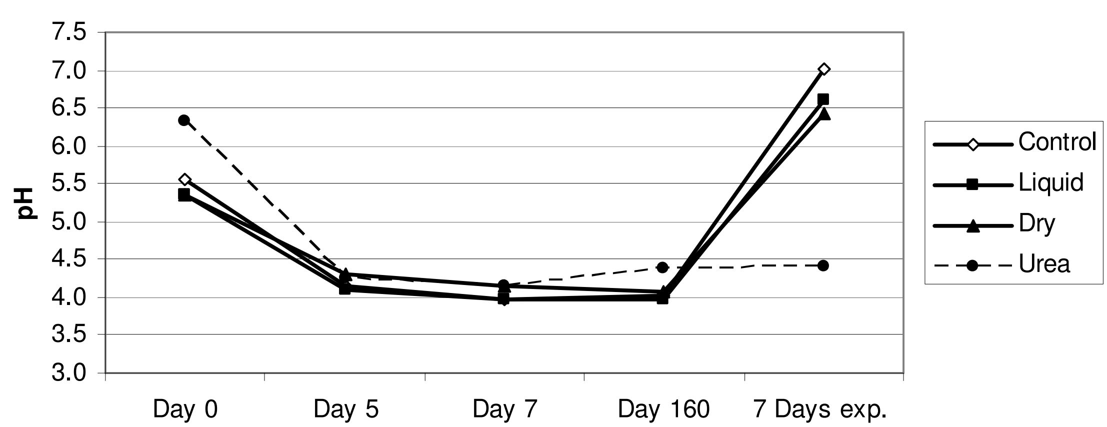

Figure 2. Silage temperature during exposure to air.

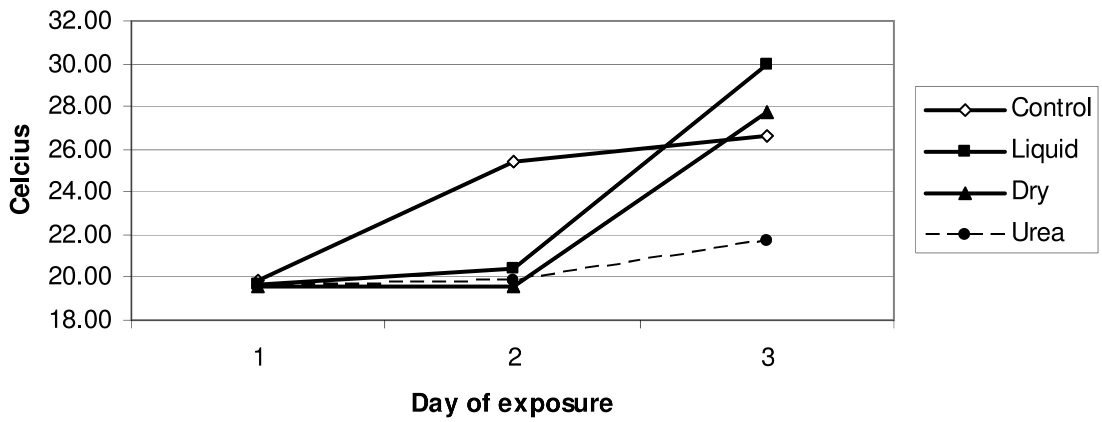

Figure3. Yeast and Mold Content of Silage Before and After Exposure Period.

Conclusions

The corn forage used in this trial was overly mature and low in moisture for ideal silage. As a result, a poor fermentation led to lower than expected accumulation of organic acids along with very low aerobic stability. Adding non-protein nitrogen to low moisture forage prior to ensiling is not recommended and in this trial, adding urea resulted in an increase in butyric acid production and an 'off-smelling' silage. Adding Silaferm had no affect upon organic acid production but silage treated with Silaferm did have a greater amount of true protein and better aerobic stability compared with Control. In this trial, urea improved aerobic stability of silage to the greatest extent. Silaferm appears to be an effective silage additive in overly mature corn forage.