Preservatives for Silages and Hay
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INTRODUCTION

Each year brings more and more products which claim to improve quality of stored forage when they are added at harvest. Most of these products contain one or more organic acids or their salts, bacterial fermentation products and minerals. Other common ingredients in dry type additives are formaldehyde, salts of benzoic acid or sorbic acid, cereal or molasses products, flavor compounds, fumaric acid, antioxidants, organic esters and propylene glycol. Recently, liquid additives have become available that contain propionic acid, formic acid, formaldehyde or ammonium isobutyrate singly or in combinations. This report contains information on addition of preservatives to forages and benefits obtained.

HOW THEY WORK

Preservatives currently available are designed to: a) inhibit undesirable bacterial and fungal (mold) activity, or b) promote the desired type of fermentation. The organic acid mixtures inhibit bacteria and mold. They work primarily as fungicides, or else make a mixture acid enough so that undesirable bacteria do not grow. For best results, these preservatives should come into contact with as much of the surface area of the stored hay or silage as possible.

Preservatives that "promote the desired type of fermentation" usually consist of cultures of organisms or enzymes that produce lactic acid from starch or other readily available carbohydrates. These preservatives will work only in silage and not in hay.

APPLICATION

You can apply preservatives to forage in the field or at the silage blower. Use pumps driven by tractor pto or tractor battery to spray preservatives directly onto the forage as it enters the baler, silage chopper or blower. Use flowmeters or pressure regulators to provide a recommended rate of application. Alternatively, preservatives can be applied at the blower using a container with spout and a hose.

WHY USE PRESERVATIVES?

Cutting forage at the proper stage of maturity is the most important factor in producing high quality feed. Harvest forages for silage at the proper moisture level (30-45% dry matter for wilted silage or haylage), cut it short (1/4 in. to 3/8 in. theoretical cut) and quickly store in a well sealed silo. Forages for hay should be windrowed at 35-45% moisture, baled beginning at 15-20% moisture and placed in storage immediately.

During storage, forages undergo a heating period due to microorganisms present. This heating results in a loss of energy and decreased dry matter and protein digestibilities. Preservatives designed to inhibit microbial activity lessen the effects of heat on forage quality.

For hay a preservative should cut losses by inhibiting microbial activity during storage and decrease the time required between cutting and baling. Hay baled at a higher than normal moisture level has less leaf and respiration losses in the field, so it retains more of the original nutritional value. However, a preservative may be needed to decrease storage losses and prevent mold development.

EXPERIMENTAL RESULTS WITH PRESERVATIVES

Haylage and Silage. The most effective preservative for haylage and silage is propionic acid added at the level of 0.8-2.0% (16-40 lb/ton) of the forage. The effectiveness of propionic acid decreases as the level of application decreases. The effectiveness of additives recommended to be added at 1-10 pounds per ton appears extremely doubtful.

Propionic acid treatment has reduced dry matter loss and heating, and has increased dry matter and nitrogen digestibilities. Haylage usually gets hottest during the first 3 weeks of storage. Yu and Thomas noted lower average storage temperature for propionic acid and ammonium isobutyrate treated haylages than untreated controls (Table 1). Haylage temperature just beneath the surface during storage and feeding was also reduced by chemical treatment.

TABLE 1. Temperatures of treated haylages during storage and feeding

Dry matter	Treatment	Average temperature	Maximum surface temperature	
			Storage[a]	Feeding[b]
%			°F	
53	None	109	126	113
62	.4% Prop[c]	100	127	111
69	.8% Prop	100	100	102
60	.5% AIB[d]	97	115	104
55	1.0% AIB	104	113	102

[a]Weeks 3-7
[b]Weeks 1-6
[c]Propionic acid
[d]Ammonium isobutyrate
Source: Yu and Thomas, 1975, J. Anim. Sci. 41:1458.

Mold growth in haylage is inhibited by propionic acid. Wisconsin workers found haylage at 60% dry matter molded earlier than haylage at 40% dry matter. Haylage molded earlier in unsealed silos than sealed silos. This shows the value of having well sealed silos for preventing mold development and storage losses. Haylage treated with 1% propionic acid showed it to be the only treatment which prevented mold growth at either dry matter percentage and in either storage structure for 7 weeks and beyond.

Types of dry matter losses incurred during storage of propionic acid treated haylage are shown in Table 2. Haylage treated with .8% propionic acid had lowest total losses while untreated haylage had highest total losses. Cows consumed more of the haylage treated with .8% propionic acid treated haylage but milk production was unaffected by haylage source.

TABLE 2. Sources of dry matter losses from propionic treated haylage

Item	Untreated (50)[a]	.4% Prop (56)[a]	.8% Prop (60)[a]
	% DM ensiled		
Top spoilage	4.1	6.3	0
Other spoilage	2.8	2.9	2.6
Silage fed out	70.0	85.6	100.6
Gaseous[b]	23.1	5.2	-3.2

[a]% dry matter of ensiled haylage.
[b]Gaseous loss calculated by differences.
Source: Yu and Thomas, 1975, J. Anim. Sci. 41:1458.

Dry matter and nitrogen digestibility of haylages treated with propionic acid have been greater, equal and less than untreated haylages in many trials. The minimum effective level of propionic acid required to prevent storage losses in the silo appears to be 0.8 to 1.0%. Lower application rates usually do not prevent storage losses.

South Dakota workers added 10 lb/ton of a product containing enzymes from *Aspergillus oryzae* and combinations of lactic acid producing bacteria to alfalfa silage (25-40% DM). Silage pH after 1, 4 and 6 weeks of storage was 5.2, 5.0 and 5.1 for treated silage and 6.0, 5.6 and 5.2 for untreated silage. Maximum silage temperature was 122°F for untreated and 92°F for treated.

Yearling heifers fed treated silage gained 16% more weight than heifers fed untreated silage. Milk production and feed intakes from lactating cows were similar. When this experiment was repeated the following year, animal performance and silage characteristics were similar.

Benzoic acid and sorbic acid, common ingredients in many dry preservatives, were used in haylage (45% DM) to determine the effects of these compounds on prevention of mold growth. After 3 days of storage, benzoic acid treated haylage began to mold and by 7 days mold had completely covered the haylage. Haylage treated with 1% sorbic acid began to mold after 7 days of storage. Control haylage was covered with mold by 6 days but haylage treated with 1% propionic acid showed no evidence of mold growth after 40 days of storage.

Hay. Storing hay at moisture levels above 20-25% results in losses of readily available nutrients and mold growth greater than in hay stored at lower moisture levels. Hay stored at greater than 20-25% moisture undergoes heating and results in reduced digestibility and feeding value to animals.

Investigators from Purdue University added propionic acid at the rates of .02, .2, .5 and 1.0% to 32% moisture hay at baling. Visible mold was reduced in hay treated with .2, .5 and 1.0% propionic acid. No visible mold was present in hay treated with 1.0% propionic acid while the 0.5% propionic acid treated hay had only small, scattered areas of mold. After 5 days of storage, temperatures of hay treated with 0, .02, .2, .5 and 1.0% propionic acid were 124, 127, 115, 104 and 84°F.

Composition and digestibility of hay treated with 1.0% propionic acid were more like the fresh material than in any other treatment (Table 3). Digestible dry matter lost during storage was 8.3% for hay treated with 1.0% propionic acid but 17.9% for untreated hay.

University of Maryland investigators found no difference in the preservative qualities of propionic acid and ammonium isobutyrate added at rates of 1.0 to 2.0% to hay at 31 or 40% moisture. Dry matter digestibility (in vitro) was similar between preservatives and both were greater than controls. These preservatives reduced temperature during storage. Wetter hay required high levels of preservatives.

TABLE 3. Dry matter losses and digestibilities of alfalfa hay baled at 32.4% moisture with various levels of propionic acid

Treatment	Dry matter loss	Digestible dry matter loss	In vitro dry matter disappearance
Original sample	----	----	70.5
Control	15.1	17.9	60.5
Propionic acid			
0.02%	16.7	19.3	61.8
0.2%	13.2	15.4	62.2
0.5%	11.7	14.0	61.0
1.0%	7.6	8.3	65.0

Source: Knapp, W. R. et al., Agronomy Journal 68:120.

Georgia workers found no benefits of a preservative (Hay Savor[1]) when added at the rate of 5 pounds per ton to 16 and 24% moisture bermudagrass hay. The dry matter lost in storage was 3.8% and 1.8% for treated and untreated 24% moisture hay. For 16% moisture hay these losses were 0.8 and 1.0% for treated and untreated hay. Intakes were similar between treated and untreated hay (both moisture levels and combined) but rates of gain were greater for untreated hay.

SHOULD A PRESERVATIVE BE USED?

A review of scientific data indicates varying degrees of successful use of preservatives. Some reports show positive effects from preservatives while others show no effect. The most important consideration is whether the improved quantity and quality of forage from the use of a preservative will offset the cost of preservative and its application.

Information from Purdue University directs itself to this question (Table 4). Four systems of harvesting baled hay are in this example: I baled dry (no rain); II baled dry (1 in. rain); III baled wet (70% DM untreated); IV baled wet (70% DM treated with an effective preservative). Values used are actual measurements and represent the average for each system.

Results show that the ideal harvesting system is one where no rain damage occurs and hay is harvested by normal procedures as dry hay. Hays damaged by rain or baled too wet are about equal in value but using a preservative improved both amount and quality of harvested forage (IV compared to II and III). From this analysis, application of a preservative improved the value of "wet" hay by $3.00 to $5.45 depending on the method of expression (per ton or per acre of harvested hay). Expressing the difference on a per acre basis takes into account both quantity and quality of the harvested hay whereas expressing the difference on a per ton basis accounts for only improved quality. A change in yield, amount of rain damage, field loss or value of hay will change the difference between systems II and IV.

TABLE 4. Comparison of haying systems

	I Baled dry (no rain)	II Baled dry (1 in. rain)	III Baled wet (untreated)	IV Baled wet (treated)
Original yield (lb/acre)	2000	2000	2000	2000
Original digestibility (%)	70	70	70	70
Original TDN	1400	1400	1400	1400
Respiratory loss(%)	5	5	5	5
Mechanical loss (%)	10	15	5	5
Total field loss	15	20	10	10
Harvested yield (lb/A)	1700	1600	1800	1800
Storage loss (%)	5	5	18	10
Total dry matter loss (%)	20	25	28	20
Final yield (lb/A)	1600	1500	1440	1600
Final digestibility (%)	66	61	59	64
Final TDN (lb/A)	1056	915	850	1024
Original TDN loss (%)	26	35	39	27
Value of one acre at $0.05/lb TDN ($)	52.80	45.75	42.40	51.20
TDN/remaining ton (lb/A)	1320	1220	1180	1280
Value/retaining ton ($)	66.00	61.00	59.00	64.00

Source: Hold and Lectenberg, 1975, Proc. 6th Ann. Alfalfa Symposium.

You must plan a system (preservative or none) before actual application, so you are somewhat inflexible after you have purchased preservative. You can either try to avoid rain (if possible) or bale early using a preservative. If weather conditions at the time of baling are favorable, application of a preservative would not be needed (Table 4, System I vs. IV).

SUMMARY

Effective preservatives can reduce storage losses in silage and haying systems. Field losses are reduced in haying systems by decreasing the time hay is left lying in the field. Available data indicate propionic acid is the preservative of choice in reducing storage losses and must be added at about 1% (20 lb/ton) of the forage wet weight to be effective. The usefulness of products added at rates less than 0.8% (16 lb/ton) as preservatives appears extremely doubtful. Preventing rain damage to hay results in the highest dollar return per acre for baled hay. Cutting early is essential to make high quality hay.

[1] *Hay Savor is a trade name of Kemin Industries, Inc., Des Moines, Iowa 50301. Ingredients listed in this liquid are: propionic acid (not less than 10%); phosphoric acid, fumaric acid, benzoic acid, ctric acid, lactic acid, isopropyl alcohol, oil of orange, oil of lemon, oil of wintergreen, anise oil, propyl gallate and butylated hydroxyanisol. "Hay Savor promotes digestibility of all hay, color retention, preserves more nutrients and improves palatability" was on the label.*

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