Effectiveness of Buffered Propionic-Acid Preservatives for Large Hay Packages

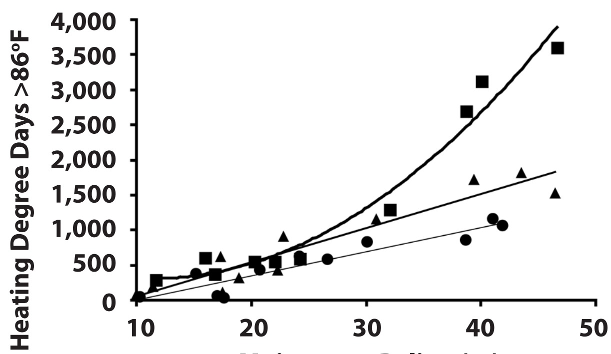
Wayne Coblentz, USDA-ARS and Michael Bertram, Marshfield (WI) Agricultural Research Station

Most hay producers realize that large-round or large-square bales are particularly sensitive to spontaneous heating, dry matter losses, and negative changes in forage quality. During the last two decades, this has become an important dilemma for producers because the cost and availability of labor has necessitated adoption of large-round or large-square hay packages on many farms. As a result, there often is a need for proactive action to reduce or eliminate spontaneous heating during bale storage, thereby preserving quality of valuable hay crops. Towards this end, various formulations of organic acids have been marketed as preservatives for moist hays. Currently, these preservatives are primarily propionic acid-based products, often buffered to limit oxidative damage to expensive farm equipment. While research has frequently shown benefits from using these products on moist hays packaged in small-rectangular bales (50-100 lb), considerably less is known about their effectiveness within larger packages. Recently, a buffered propionic-based product was evaluated extensively for moist alfalfa hays packaged in both large-square and large-round bales at the Marshfield Agricultural Research Station.

Sensitivity of Large Hay Packages to Spontaneous Heating

Most producers know that moist hays often heat spontaneously, and in severe cases, combustion is possible. This phenomenon occurs through microbial respiration, in which microorganisms associated with the hay convert plant sugars to carbon dioxide, water, and heat. In extreme cases, other (poorly defined) oxidative processes become involved in the heating process. Generally, the threshold moisture concentration for acceptable storage of small-rectangular bales is about 20%; however, this threshold should be reduced as the size of packages increase. The relationship between bale size and spontaneous heating is illustrated (see Figure) for alfalfa forages packaged in large-round bales at 3', 4', and 5' diameters without preservatives during 2006 and 2007. In the figure, spontaneous heating was measured as heating degree days >86°F (HDD), which is a single number that integrates the magnitude of the internal bale temperature over the time period when bale temperatures were elevated. It can be interpreted as a quantitative measure of heating. Regardless of bale diameter, heating increased with bale moisture; however, accumulations of HDD were primarily linear functions of bale moisture for 3' and 4' bales, but escalated far more rapidly in a curvilinear pattern for 5' bales. As packages become larger, they also become increasingly sensitive to spontaneous heating, which results in increased concentrations of fiber components, such as NDF and ADF, as well as decreased protein availability, and depressed estimates of energy density.

Figure. Relationships between moisture content at baling and heating degree days >86°F accumulated during storage for large-round bales of alfalfa-orchardgrass hay packaged in 5′ (■), 4′ (▲), and 3′ (●) diameter bales.



Acid Treatment of Alfalfa-Orchardgrass in Large-Square Bales

During 2010, alfalfa-orchardgrass hay was baled in 3' x 3' x 6' large-square bales, and then stacked individually on wooden pallets under roof during a 71-day storage period. Bales were made at three moisture concentrations (19.6, 23.8, or 27.4%) and treated with a buffered propionic-acid preservative at rates of 0 (no acid), 0.6, and 1.0% of wet bale weight (see Table). For the driest hay (19.6%), there was little evidence of heating in acid-treated hays, regardless of application rate; however, spontaneous heating clearly occurred within control (no-acid) bales. Maximum internal bale temperatures (MAX) and accumulated HDD for control bales made at this moisture concentration were 116°F and 463 HDD, which were approximately 21°F and 428 HDD greater than observed for acid-treated hays, respectively. It should be noted that this moisture concentration (19.6%) was within the traditional threshold for safe storage for small-rectangular bales, further illustrating the sensitivity of larger hay packages to spontaneous heating. Excellent mediation of heating also occurred within acid-treated bales when the initial bale moisture was elevated to 23.8%; as observed for 19.6% moisture hays, there was little additional benefit to the greater (1.0%) application rate relative to the lower (0.6%) rate. For hays made at both 19.6 and 23.8% moisture, there also were measureable improvements in forage quality as a result of acid treatment relative to untreated hays. For the wettest hay (27.4%), there was a clear response to acid-application rate. Untreated hay exhibited a MAX of 129°F, but this response was reduced to 117°F, and then to 108°F, when preservative was applied at the 0.6 and 1.0% rates, respectively.

Table. Storage and quality characteristics of alfalfa-orchardgrass hays baled in large-square bales at 3 moisture concentrations and treated with buffered propionic-acid preserve at 0 (no-acid), 0.6, or 1.0% of wet bale weight.

Bale Moisture	Treatment	MAX[1]	HDD[2]	DM Recovery[3]	NDF[4]	ADICP[5]	TDN[6]
%		°F	>86°F	%	---------% of DM---------		
27.4	Acid, 1.0%	108	288	93.6	59.2	2.21	51.9
	Acid, 0.6%	117	596	91.1	60.8	2.63	51.0
	No Acid	129	783	93.1	62.7	2.71	49.5
23.8	Acid, 1.0%	100	146	96.7	57.7	2.15	52.8
	Acid, 0.6%	99	167	97.3	56.8	1.88	53.8
	No Acid	123	549	93.6	61.7	2.75	50.1
19.6	Acid, 1.0%	98	36	99.2	58.5	2.47	52.3
	Acid, 0.6%	96	34	99.8	57.5	2.32	53.4
	No Acid	116	463	98.3	59.2	2.50	51.7

[1]Maximum internal bale temperature during a 71-day storage period. [2]Heating degree days >86°F. [3]Recovery of DM following a 71-day storage period. [4]NDF, neutral detergent fiber. [5]ADICP, acid detergent insoluble crude protein. [6]TDN, total digestible nutrients.

Acid Treatment of Alfalfa in Large-Round Bales

During 2009 and 2010, 87 large-round (5' x 5') bales of alfalfa hay were made at moisture concentrations ranging from 10.2-40.4%. Of these, 42 bales were treated with a propionic-acid based preservative; the remaining 45 served as untreated control hays. A single application rate (0.5 ± 0.14%) was used on all treated hays. All bales were placed on individual wooden pallets without contact from adjacent bales, and monitored for temperature responses until there was no evidence of active heating (as long as 5 months). While responses to acid treatment were easy to interpret for large-square bales, they were far more complicated for large-round bales. There were clear and measurable reductions in heating in response to acid-treatment during the first 28 days of storage, even when the initial bale moisture exceeded 35%. Unfortunately, this relationship did not persist. Considered over the entire storage period; acid-treated bales actually accumulated greater numbers of HDD than controls whenever the initial bale moisture exceeded 30%. Generally, this occurred because acid-treated bales tended to retain water longer than control bales, and then maintained elevated temperatures that often persisted for months after baling. Improvements in forage quality as a result of acid treatment were fairly minimal throughout the study.

It should be noted that all bales described in these studies were stacked individually, which allowed for the easiest dissipation of water and heat. Caution should be exercised in applying these results to bales packed tightly in hay storage structures.

Conclusions

Propionic-acid based preservatives were very effective with large-square bales, but responses only were marginal, and difficult to interpret, for 5' x 5' large-round bales. Although normal heating characteristics were altered by acid treatment for large-round bales, overall positive effects on poststorage forage quality were very limited. This could be related to the greater size of the bale packages, differences in application methodologies between round and square (plunger-type) balers, acid application rates, or other factors. For large-round bales, potential to improve quality relative to cost of application was not especially favorable, and producers may find that diligence to achieve adequate field desiccation prior to baling, or use of oxygen-exclusion methods, such as wrapping in plastic, may be better alternatives for preserving moist hays.