Managing Fermentation with Baled Silage

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Production of baled silage is attractive to many dairy and beef farmers. There are clear advantages over dry hay: 1) less risk of rain damage; 2) better potential to harvest at an earlier or appropriate maturity – shorter window of suitable weather is required to wilt, bale, and wrap; 3) better retention of leaves, especially from legume forages; and 4) greater potential for outside storage since it is wrapped in plastic film. In many cases, existing hay equipment can be used, reducing some of the start-up costs.

General Management Goals

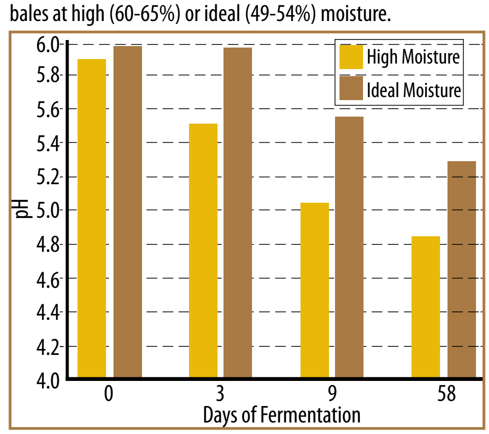
In general, management principles for conventional chopped silage apply to baled silage. The first goal is to start with high-, or appropriate-quality forage for your livestock; however, baled silage is not a corrective measure for storage of poorly managed forage. Once baled, the most important goal is to create an anaerobic (without oxygen) environment where plant sugars convert into fermentation acids (lactic acid is most desirable) by microorganisms adhering to plants at time of ensiling. Production of fermentation acids lowers pH of the forage mass, ideally creating stable fermented silage as long as anaerobic conditions are maintained.

Rapid establishment and continued maintenance of anaerobic conditions are critical because: 1) respiration by active plant cells convert sugars (in presence of oxygen) into carbon dioxide, water, and heat, and must be terminated quickly to prevent sugar losses necessary for fermentation; 2) anaerobic conditions support efficient growth of lactic acid producing bacteria; 3) yeasts and molds cause aerobic deterioration (spoilage) when plastic integrity is compromised; and 4) aerobic deterioration results in dry matter (DM) loss, increased concentrations of fiber components, and decreased energy density. Recommendations for sealing bales are to apply 6-8 layers of plastic within 2-4 hours of baling, if possible.

Moisture Management

Baled silage should be packaged at 45-55% moisture (Shinners, 2003); the average for the whole field, or a group of bales should be ~50%. This recommendation contrasts sharply with normal targets (<70%) for most precision-chopped silages. One reason is related to equipment, particularly safety issues with bale weight and limitations of some balers to package excessively wet forages. Another reason for the reduced moisture recommendation is the potential of clostridial fermentations, depressing voluntary livestock intake and producing undesirable end products (i.e., butyric acid, ammonia). Recent work at the University of Wisconsin Marshfield Agricultural Research Station detected elevated concentrations of undesirable fermentation products when moisture of wrapped alfalfa bales approached 60%. On this basis, 60% should be considered the upper moisture alfalfa threshold, since it is sensitive to clostridial fermentations. Production of silage fermentation acids is positively associated with moisture concentration. As a result, fermentation within baled silages of lower moisture is inherently restricted, resulting in a slower fermentation and a greater (less acidic) final pH (Figure 1).

Figure 1. Fermentation rate for alfalfa ensiled in large-round bales at high (60-65%) or ideal (49-54%) moisture.



Plant Factors Affecting Fermentation

All forages are not created equally – this also applies to relative suitability as silage crops. Sugar (referred to as water-soluble carbohydrates, or WSC) is required during silage fermentation to produce lactic acid. Concentrations of WSC in forage plants vary with many factors, including plant species, cultivar within species, growth stage, time of day, climate, drought, frost events, N fertilization, rain damage, and poor/extended wilting conditions. Plant species has a profound effect on WSC concentrations (Table 1), explaining why highly-sugared crops, such as

Table 1. Concentrations of WSC for selected forage crops expressed as a percentage of DM.

Crop/Species	WSC % of DM
Corn silage	10-20
Forage sorghum	10-20
Sudan, sorghum-sudan, millet	10-15
Rye, oat, wheat, triticale	8-12
Ryegrass	8-12
Alfalfa	4-7
Bermudagrass, stargrass	2-4
Bahiagrass	<5
Limpograss	<5
Perennial peanut	1-4

Source: Adesogan and Newman, 2013

Table 2. Buffering capacities of selected forage crops.

Crop/Species	Range	Mean
	-------mEq/kg DM-------	
Corn silage	149-225	185
Timothy	188-342	265
Fall oat (headed)	300-349	323
Orchardgrass	247-424	335
Red clover	---	350
Fall oat (boot)	360-371	366
Italian ryegrass	265-589	366
Alfalfa (mid-bloom)	313-482	370
Perennial ryegrass	257-558	380
Alfalfa (1/10th bloom)	367-508	438
White clover	---	512

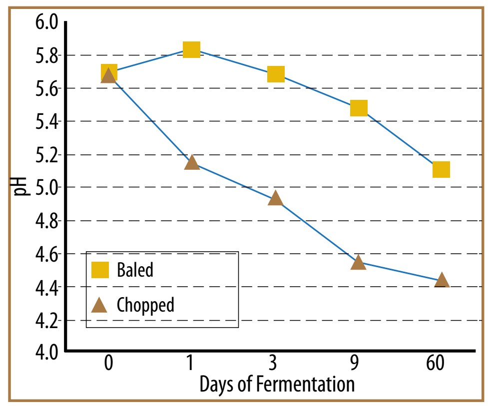
corn (10-20% of DM), are easier to ensile than alfalfa, which typically has moderately low sugar content (4-7% of DM). Common factors depressing WSC concentrations include N fertilization, rain damage, and poor wilting conditions.

Buffering capacity is another plant factor affecting fermentation ease. It can be defined as inherent resistance to pH change within any forage; therefore, highly-buffered forages are naturally more difficult to ensile than less buffered. Specifically, corn is not highly buffered (185 mEq/kg DM; Table 2), but alfalfa and other legumes are. Furthermore, buffering capacity of alfalfa is closely associated with proportions of leaf tissue. As a result, alfalfa ensiled at 1/10 bloom is more heavily buffered (438 mEq/kg DM) than alfalfa harvested at the mid-bloom stage of growth (370 mEq/kg DM), or alfalfa that has been damaged by rainfall events (Coblentz and Muck, 2012).

Other Differences between Baled and Chopped Silages

First, chopped silages have greatly reduced particle length, but baled silage usually is ensiled as long-stem forage. This lack of chopping action within baled silages forces sugars to move, largely by diffusion, from inside the plant to reach lactic acid producing bacteria adhered to the outside of plants. This normally limits the rate and extent of fermentation (Figure 2). In addition, baled silages often are less dense than chopped silages, which may restrict availability of sugars to lactic acid producing bacteria, and further slow fermentation rate. To combat this, farmers should adopt a 10 lbs DM/ft^3 target density threshold when baling. Although operator experience is important in creating dense bales, other management practices, such as reducing tractor/baler ground speed, increasing power take-off (PTO) speed, and creating thinner windrows, also help maintain bale density.

Figure 2. Fermentation rate for baled compared to precision-chopped alfalfa/grass forages ensiled at 61% moisture.



Figures 1 and 2 adapted from Nicholson, et. al., 1991.

Questions about Inoculants

Research studies evaluating baled silage inoculants are very limited relative to chopped silages; it is difficult to support recommendations with good data. However, for ensiling baled alfalfa, there may be three circumstances especially warranting inoculation with lactic acid producing bacteria. These include alfalfa forages that have: 1) suffered damage from rainfall events during wilting; 2) received dairy slurry or other manures during current growth cycle (Coblentz et al., 2014); or 3) been packaged at 60% moisture threshold at which production of butyric acid may become problematic.

References: Adesogan, A. T., and Y. C. Newman. 2013. Silage harvesting, storing, and feeding. University of Florida/IFAS Extension Service, Gainesville, FL; Coblentz, W.K., and R.E. Muck. 2012. Effects of natural and simulated rainfall on indicators of ensilability and nutritive value for wilting alfalfa forages sampled before preservation as silage. J. Dairy Sci. 95:6635-6653; Coblentz, W.K., R.E. Muck, M.A. Borchardt, S.K. Spencer, W.E. Jokela, M.G. Bertram, and K.P. Coffey. 2014. Effects of dairy slurry on silage fermentation characteristics and nutritive value of alfalfa. J. Dairy Sci. 97:7197-7211; Nicholson, J.W.G., R.E. McQueen, E. Charmley, and R.S. Bush. 1991. Forage conservation in round bales or silage: effect on ensiling characteristics and animal performance. Can. J. Anim. Sci. 71:1167-1180; Shinners, K.J. 2003. Engineering principles of silage harvesting management. p. 361-404. *In* D.R. Buxton, R.E. Muck, and J.H. Harrison (ed.) Silage Science and Technology. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, Madison, WI.