DIVISION OF AGRICULTURE
RESEARCH & EXTENSION
University of Arkansas System

Agriculture and Natural Resources

FSA3051

Baled Silage for Livestock

John Jennings
Professor -
Forages

Ken Coffey
Professor -
Animal Science

Introduction

Baled silage, commonly referred to as "baleage," originated in northern Europe, where drying conditions are not conducive to the production of high-quality hay. This dilemma is common in Arkansas as well as most of the southeast United States. In this region, high-quality cool-season grasses are difficult to harvest as hay in the spring because drying conditions are often poor. Producers typically wait for good drying weather, which occurs later in the spring or summer, but forage quality has usually deteriorated by that time.

There is increased interest in baleage techniques because they offer the potential for storing high-quality forages without prolonged periods of field-drying. This approach may also allow a regular second harvest of cool-season grass crops before the summer dormancy period begins.

Warm-season grasses, such as bermudagrass, have also been successfully ensiled by this method. In addition, this system generally requires a much smaller investment in equipment and labor than is necessary for storing precision-chopped silages, which makes it more attractive to small-scale producers.

In this system, forages are wilted in the field to 45 to 65 percent moisture, baled in large round packages and then wrapped in plastic to limit air access.

Plastics for baleage can take several forms. Generally, these include the following:

- individual bale bags
- stretch wraps that are applied to individual bales in several layers
- long tubes that may accommodate several bales stacked end-to-end within one sealed unit

In most cases, regular hay-making equipment can be used to produce good baleage. Equipment needs include:

- a mower or mower-conditioner
- a large round baler
- bale-moving equipment that will not puncture plastic wrap or bags
- raking/tedding equipment
- a bale wrapper or tubing machine

Individual silage bags can be applied manually or bales can be placed in long tubes or wrapped with stretch film plastic. Oftentimes, this means that quality silage can be made with only one additional piece of equipment (the bale wrapper or tuber). Most producers in Arkansas already own large round balers and other hay-making equipment.

Other Advantages

Another advantage of silage bales is the increased flexibility they offer with respect to management of forage inventories. Individual bales can be labeled, inventoried and stored so that forage quality can be matched with the nutrient demands of different cattle classes.

Reduced storage losses are also likely to be observed when forages are stored as baleage. Research in Louisiana and other southern states has shown that dry matter losses in hay stored outdoors often range between 20 and 50 percent. In contrast, these losses in baleage usually do not exceed 5 percent, provided moisture levels at baling are correct and the plastic bag or wrap is applied and maintained correctly. Other potential advantages this system has over hay and conventional silage systems include the following:

- The baler can be used for both hay and silage production; separate sets of equipment are not necessary.
- Field losses due to rain damage and leaf shatter are reduced relative to harvest as hay.
- The system can be expanded to accommodate as much forage as necessary with little extra investment.
- Small quantities of excess forage can be stored as silage. This is much more difficult to accomplish with larger silo types and also provides a means of storing silage when large tower or trench silos are full.

Disadvantages

All forage storage systems have disadvantages. In making baleage, the most prominent disadvantages are related to the plastic covering that creates an acceptable environment for fermentation of the forage. The primary disadvantage is cost. Plastic costs associated with bale wrapping can range up to $8 per bale. Preformed bale bags may cost slightly more.

Secondly, the plastics used in making baled silage are susceptible to puncture and animal damage, and maintaining a good seal has sometimes been a problem. Plastics must be closely observed for tears and holes during the storage period.

Thirdly, plastics used in the preservation of baled silage cannot be reused. This has created a disposal problem for many producers. Recycling options are being evaluated; however, these options are currently limited because the plastic is often contaminated with dirt and must be cleaned before it can be reprocessed. In addition, these polyethylene plastics have a low weight-to-volume ratio that makes compaction a necessary part of any transport process. Furthermore, the cost of producing virgin polyethylene has generally been low, which decreases the demand for recycled material. Most of these plastics are currently disposed of in landfills, but this could potentially become more difficult as environmental regulations evolve.

Lastly, silage bales must be tied with net wrap, plastic twine or untreated sisal twine. Regular sisal twine contains a rodenticide that can cause the premature deterioration of plastic bale wrappers.

Wilting the Forage Crop

One of the major factors affecting the fermentation process is the moisture content of the forage at baling. Generally, the optimum moisture content for large round bale silage is about 55 percent. Baling forages at moisture contents greater than 70 percent is not recommended. High moisture levels favor undesirable (clostridial) fermentations that produce silages that are less acidic and have high concentrations of butyric acid and ammonia nitrogen. Silages dominated by this type of fermentation have a strong, rancid odor and are poorly consumed by cattle. This is an especially important consideration when the silage crop also has 1) high nitrogen or crude protein content, 2) high buffering capacity (is resistant to pH changes) and/or 3) low sugar content.

In the U.S., unwilted alfalfa is probably the forage crop that best meets these conditions and is most likely to undergo a clostridial fermentation. In northern Europe, where drying conditions are often poor, clostridial fermentations in perennial ryegrass silages are commonly reported when the forage is direct-cut or extremely wet at harvest. Wilting perennial ryegrass forage from 80 to 70 percent moisture substantially improved fermentation characteristics of round bale silage under these conditions in South Wales (Table 1).

Generally, grasses have higher concentrations of plant sugars and lower buffering capacities than most legumes. These traits favor the production of lactic acid and the subsequent rapid and extensive reduction of silage pH during fermentation, which creates an unfavorable environment for clostridial bacteria. If careful attention is given to harvesting grasses at the proper moisture content, the risk of clostridial fermentations in Arkansas forages should be relatively low. When it is necessary to ensile (by any method) excessively wet forages, producers should consider using appropriate silage additives (see Table 2) and be careful to avoid contamination of the forage by the soil. Soil contamination of the forage during mechanical field operations increases both the number of clostridial spores in the forage mass and the subsequent likelihood that this undesirable type of fermentation will occur.

Table 1. Effect of Moisture Content on Perennial Ryegrass Baled Silage Quality in South Wales.
Ammonia nitrogen, butyric acid and acetic acid concentrations were substantially reduced in response to wilting the forage from 80% to 70% moisture prior to baling.

Item	Moisture Content (%)	
	80	70
Crude protein, %	16.1	16.1
Ammonia nitrogen, % of total nitrogen	20.7	10.9
Lactic acid, %	3.2	3.0
Acetic acid, %	2.3	1.5
Butyric acid, %	1.9	0.7

Source: P.M. Haigh. 1990. *Grassland Forage Sci.* 45:29.

In contrast, low forage moisture content at baling (< 50 percent) can restrict fermentation, producing a less stable silage that has a lower lactic acid content and is less acidic (higher pH). In these silages, maintaining the integrity of the plastic wrap is absolutely critical to the long-term preservation of the silage. Evidence of mold and spontaneous heating are more common in these silages. Excessively dry forage stems are also more likely to puncture silage plastics from the inside, particularly during handling.

Table 2. Effect of Microbial Inoculant Treatment on the Fermentation of Bermudagrass Round Bale Silage Packaged at 70% Moisture.

Day of Fermentation	pH		Lactic Acid (%)	
	Control	Inoculated	Control	Inoculated
0	5.9	6.1	0	0
1	6.0	5.7	0.3	0.3
4	6.1	4.9	0.4	0.6
14	5.2	4.7	0.5	1.3
100	5.1	4.6	0.8	1.4

Source: M. E. McCormick, 1994. *Proceedings of the Louisiana Forage and Grassland Council*. November 1, 1994, Alexandria, Louisiana.

Wide differences in silage moisture content can also create potential feeding problems, particularly for high-producing dairy cows. As described, moisture content can profoundly affect the fermentation characteristics of any silage. This is also true within the context of acceptable fermentations. Changes in the dietary components of these high-producing animals usually result in a noticeable period of adjustment. This can be observed whenever the forage base of a dairy diet is changed. Conventional precision-chopped silages are generally a more blended product than silage bales. The combined processes of chopping around the field, unloading into a silo, equilibration of the moisture within the silo, unloading the silo and feeding blended rations all generally help to avoid abrupt changes in the forage base of the diet. This is not true with silage bales. When these silages are fed, day-to-day variation with respect to fermentation characteristics and quality can be substantial. This generally has a negative effect on forage intake and animal performance.

To limit the potential problems that variations in moisture content can create, some adjustments in management styles may be necessary to produce a more consistent product. Hay producers will often mow large acreages when the weather appears favorable. With grasses, overdrying is not usually a major concern. **This approach will not work for baled silage**. Grass forages can easily become too dry to ferment properly if they reach the optimum moisture level (55 percent) at 11 a.m. but can't be baled until 3 p.m.

The window of opportunity for making well-fermented silage can pass quickly, particularly for grasses which normally dry faster than legumes and other forage crops. Don't wait until the forage moisture content is optimum (55 percent) to start baling. Ideally, the average moisture content of all the bales produced should be about 55 percent; therefore, a substantial amount of the mowed forage should already be rolled into bales when that level of dehydration is reached. At the same time, the overall range of moisture content for the bales produced probably should be confined between 45 and 65 percent. If producers find they can't harvest forages fast enough to stay within these guidelines, they should consider mowing less forage at one time and mowing more often.

Also, remember that most forages can be sufficiently wilted for silage in less than 24 hours and that baling hours are not necessarily limited to those when the sun is shining. If forages become too dry, consider baling the crop as hay. Producers making baled silage for the first time should experiment with small acreages until they determine the best management style to keep moisture contents at baling within these general guidelines.

Baling

Although most new balers that make high-density round bales are likely to make good silage, some units cannot handle the wet forage necessary for successful baled silage production. Regular hay balers may require modifications, such as scrapers to prevent gum buildup on belt rollers or shields to prevent the crop from wrapping. Kits can be purchased for some models to alleviate these problems.

Some new models are sold specifically as silage units. Basically, these units are designed for producers who intend to make large quantities of round bale silage. In addition to the features described above, these units often have heavier roller shafts, bearings, tires, etc., that make them more durable under the heavy weight loads associated with packaging wet hay. Some specialized silage balers are also equipped with additional features for the pick-up head, others may have slicers, which reduce stem length and allow for easier handling and feeding of the fermented forage. Generally, special silage balers make bales that are 4 feet wide and 5 feet in diameter (63 cubic feet); these bales may weigh up to 1,750 pounds, depending on the forage species and moisture content. Specialized silage balers typically cost $2,000 to $4,000 more than regular round balers that make packages that are similar in size.

Bales should be packaged as tightly and evenly as possible. Tightly wrapped, dense bales are desirable because they incorporate less air (oxygen) into the bale package and are less susceptible to infiltration of air into the silage mass. For the best results, silage bales should contain about 10 pounds of forage dry matter per cubic foot. Be sure that all bale-handling equipment can handle the additional weight of the silage bales. If packaged between 50 and 60 percent moisture, silage bales may weigh twice as much as regular field-cured hay bales. It is absolutely imperative that these weight factors be considered before the field is full of wet bales that can't be handled or sealed.

Silage Inoculants

Silage inoculants that stimulate the production of lactic acid during the fermentation process are available and can be used in baled silage. Although acceptable silage fermentation can clearly be obtained without additives, several studies have shown that inoculants can promote the fermentation of plant sugars into lactic acid (Table 2). Many manufacturers of silage plastics that store multiple silage bales within a single tube or wrap routinely recommend inoculating silage bales stored in their system. Ammonia treatment may reduce surface mold on baled silages, but this approach is not generally recommended because of the possibility of inducing "crazy cow syndrome," a nervous condition sometimes observed when cows are fed high-quality hays that have been ammoniated.

Storage Site

Bales should be stored in well-drained sites that do not have metal, rocks or other trash that could puncture the plastic surrounding each bale. Grass and weeds should be mowed regularly or controlled by herbicide treatment. Clean storage sites ultimately will reduce the incidence of damage by rodents and other pests.

Shady areas are preferred for baled silage. Storage space under a roof is ideal, but good results have also been obtained by storing silage bales on north-facing slopes.

Bales also can be stored in stacks (pyramid fashion) up to three layers high, provided the moisture content of the forage is less than 65 percent. These considerations are important for several reasons. Research conducted at the University of Florida in 1992 showed that the stability of plastic bale wraps varied widely under the high ambient temperatures common to the southern U.S. In that study, the range of time that individual plastic wraps remained stable following direct exposure to the sun varied from 28 to 375 days. While it is clear that there are wide variations in the durability of available plastic wraps, these differences are not necessarily associated with proportional differences in cost. Much of this variability is related to the relative amount or effectiveness of ultraviolet (UV) light inhibitors in the plastic. Ultraviolet light is known to degrade plastic wraps. Producers should seek advice from experienced producers or custom operators in their area and carefully consider their options prior to purchasing plastic products.

Stacking systems for silage bales that avoid or limit exposure to direct sunlight will aid the long-term stability of silage plastics, particularly in southern states. Direct solar radiation and extreme fluctuations of diurnal temperatures have also been observed to cause the migration of moisture within the bales, oftentimes from top to bottom and south to north directions.

Sealing the Bales

In actuality, plastic wraps are not completely airtight; however, they do restrict air exchange sufficiently to promote a good fermentation environment. Plastic wraps for silage bales are normally one mil (0.001 inch) thick and contain a tackiness agent, which is critical to proper sealing. The relative amount and effectiveness of these tackiness agents may vary. Normally, these plastics are guaranteed for at least one year and are available on 50- to 60-pound rolls that are 5,000 to 6,000 feet long and about 30 inches wide. This should be enough plastic to cover 25 to 30 silage bales with roughly 2 pounds of plastic per bale.

Plastic wraps should be applied with a 50 percent overlap and then wrapped twice for a total of four layers of plastic. Some producers and custom operators will wrap the bales an additional time, resulting in a total of six layers of plastic. This provides additional insurance against air infiltration, puncture and other potential problems but will increase costs on a per-bale basis.

Plastic wraps should be stretched by about 55 percent to provide the correct tension and promote sealing. Some studies have shown that two men can reasonably expect to wrap 25 to 30 bales per hour; however, these estimates may be dramatically affected by associated transport and stacking requirements. Bale-wrapping machines that apply plastic stretch wrap range in price from about $7,000 to $15,000, depending on the style and accessories. Some models mount on a tractor with a three-point hitch while others are pull types. Machines that apply plastic wrap to a group of bales arranged end-to-end (a tube or sausage-stuffer approach) can be purchased for about $17,000. A variation of this style also exists in which round bales are fed into preformed plastic tubes rather than wrapped. With these approaches, every possible effort should be made to keep the air gap between bales to an absolute minimum.

A recent study in Louisiana has suggested that greater surface spoilage may be observed with this storage style, but the overall silage quality and silage intake by 1,100-pound Holstein heifers was similar to that of individually wrapped bales.

Individual silage bags are more difficult to use, but they do not require the purchase of an additional piece of equipment. Check the first bales made in the field to ensure they fit in the bags correctly. Bales should fit snugly inside the bag in order to minimize air space but loosely enough that the bag can be applied without any tearing or puncture. If your silage bags do not fit properly, deal with the problem before the field is full of wet bales.

Once the bag is over the bale, the air trapped in the bag should be pushed out before sealing. To seal a bag, the end of the bag should be pulled, twisted and tied with good-quality twine. This "tail" can then be doubled over and tied again. After sealing, bags frequently swell (wrapped bales may do this as well) as fermentation gases are produced. This is a sign of good sealing. Bags that do not swell should be closely inspected for holes and taped if necessary. Most polyethylene plastics are more permeable to carbon dioxide than oxygen. This restricts oxygen from infiltrating the silage bale but does allow some venting of carbon dioxide formed during respiration.

Silage bags generally are not reused. Minor pinholes that can easily go undetected may permit air access into the bale and result in spoilage and silage losses. Some reports indicate that used silage bags have been reused as a part of a double-bagging system that provides additional protection for the silage and better return on plastic costs. In general, the industry seems to be moving away from using individual silage bags because of problems associated with maintaining a good fermentation environment; however, these plastics are still available and can produce good-quality silage with good management.

Regardless of the method used to seal the silage bales, plastics should be inspected regularly (weekly if possible) for holes, tears and animal damage. While this is critical for all systems, bags containing individual silage bales will billow in the wind and exchange more than plastic wraps when they are damaged. Generally, it is best to seal the bales in plastic at the storage site so there is less chance of damaging the plastic during transport. Special tractor attachments are available that allow sealed bales to be handled without tearing or puncturing the plastic. Bales should be sealed as quickly as possible after the baling is completed (within two hours if possible) to limit the effects of respiration and spontaneous heating.

Effect of Delayed Wrapping on Baled Silage Quality

Recommendations generally suggest wrapping all silage bales on the day of baling to limit oxygen and to improve fermentation and stability of the silage. However, delays can happen. A study was conducted at the University of Arkansas and the USDA Dairy Forage Research Center in Marshfield, WI to evaluate effect of delayed wrapping had on forage quality and fermentation of silage bales.

Alfalfa (WI) and ryegrass (AR) forages were baled, then wrapped either the day of baling or 1, 2, or 3 days after baling. The alfalfa was baled at approximately 54% moisture and was wrapped with either standard baleage plastic wrap or with a wrap that included an oxygen-limiting barrier. The ryegrass was baled at either 30 or 74% moisture.

Digestible intake was greatest from the alfalfa wrapped the day following baling, but both intake and digestibility declined rapidly when wrapping was delayed beyond 1 day after baling (Table 3). Fermentation measurements such as lactic acid and pH were related well with digestible forage intake. Lactic acid was highest and pH was lowest with no delay of wrapping indicating good fermentation of the forage. Lactic acid decreased and pH increased with each day wrapping was delayed indicating lower fermentation and likely lower storage stability.

Ryegrass silage intake and digestibility were generally greater from the lower-moisture silage and from silage wrapped the day it was baled. Waiting to wrap the ryegrass bales until the following day resulted in a substantial reduction in preference and digestible forage intake (Table 4). Although digestible forage intake was greater from the ryegrass silage baled at lower moisture, fermentation profiles were greater from silages baled at higher moisture. Storage stability of the drier wrapped ryegrass would likely be low due to low lactic acid, high pH, and high mold and yeast counts. Wet ryegrass silage contained mold along the outer 2-3" of the bales but were free of visible mold once the outer layer was removed. Dry ryegrass silage bales contained small "specks" of mold throughout the bales due to more air throughout bales of the dryer forage.

Baled Silage Summary

Over the past decade, Louisiana State University has conducted extensive research on baled silage production, primarily with annual ryegrass, at the Southeast Research Center, Franklinton, Louisiana. Their research[1] can be summarized as follows:

- Forage should be harvested and ensiled when the nutritive value is high.
- Forages should be wilted to moisture contents between 40 and 65 percent to optimize silage fermentation and minimize plastic costs. (Other sources suggest that 55 percent moisture is optimum.)
- Bale with a high-density baler using plastic or untreated sisal twine. Net wraps are also acceptable.

- Wrap or seal bales within 12 to 24 hours of baling.
- Stored bales should be handled carefully to minimize tears. Any damaged bales should be immediately patched with the appropriate plastic tape or fed.
- Use stretch plastics, if possible, to exclude air and seal the bales.
- Consider using silage inoculants to improve fermentation characteristics of the silage.
- Use high-quality plastics with high resistance to ultraviolet light.
- Baled silage storage losses under good management should be comparable to barn-stored hay (< 5 percent of forage dry matter).
- Using baled silage in animal feeding programs can improve profit by reducing concentrate costs, minimizing forage loss from rain and enhancing nutritive value relative to poor quality hays.

[1]Adapted from M. E. McCormick in the *Proceedings of the Louisiana Forage and Grassland Council*, November 1, 1994, Alexandria, Louisiana.

Table 3. Intake, digestion, and selected fermentation profiles of alfalfa silage bales wrapped with plastic with and without an oxygen limiting barrier either the day of baling or after delays of 1, 2, or 3 days after baling. USDA Dairy Forage Research Center in Marshfield, WI.

	OXYGEN-LIMITING BARRIER				NO OXYGEN-LIMITING BARRIER			
Wrapping delay after baling (days) ➔	0	1	2	3	0	1	2	3
DMI, % BW	2.4	**2.4**	**2.2**	**2.1**	2.2	**2.5**	**2.3**	**2.2**
DM digest, %	66.9	67.3	64.2	65.6	64.1	66.7	64.9	64.2
pH	5.5	5.5	5.5	5.4	5.4	5.6	5.5	5.5
Lactic acid	2.4	**1.9**	**1**	**0.5**	2.1	**1.9**	**0.7**	**0.7**

DMI, % BW = dry matter intake as % of animal body weight

Key points:
- Alfalfa forage was wrapped at an optimum 54% moisture.
- Oxygen-limiting plastic wrap treatments showed higher DM intake, digestibility, and lactic acid production for wrapping the day of baling, but differences were small when wrapping was delayed beyond the first day after baling.
- Dry matter intake and digestibility were slightly higher by delaying wrapping until the day following baling.
- Delays of more than 1 day reduced dry matter intake and digestibility.
- Delays past the day of baling reduced lactic acid production which indicates lower fermentation and possibly less stable silage for long-term storage.

Table 4. Intake, digestion, and selected fermentation profiles from ryegrass silages baled at 30 or 74% moisture, then wrapped either the day of baling or 1, 2, or 3 days after baling. University of Arkansas.

	DRY (30% MOISTURE)				WET (74% MOISTURE)			
Wrapping delay after baling (days) ➔	0	1	2	3	0	1	2	3
DMI, % BW	2.3	2.0	2.2	2.2	1.8	1.6	1.8	1.5
DM digest, %	55.7^{ab}	57.6^{a}	56.1^{ab}	54.8^{ab}	55.7^{ab}	53.0^{bc}	49.5^{cd}	46.7^{d}
pH	5.7	6.1	6.0	5.8	4.4	4.5	4.7	4.8
Lactic acid	**2.0**	**0.5**	**0.5**	**0.6**	**4.6**	**3.6**	**2.1**	**1.4**

Key points:
- Both ryegrass treatments were baled at moisture contents too dry or too wet compared to the recommended range (45% to 65%) for baleage.
- For either the dry forage (wrapped at 30% moisture) or the wet forage (wrapped at 74% moisture) dry matter intake was not reduced by delay of wrapping.
- In general, forage intake was higher for the drier wrapped forage than for the wet wrapped forage.
- Delaying wrapping past the day of baling reduced digestibility of the wet wrapped forage.
- Higher lactic acid and lower pH for the wet wrapped forage indicated better fermentation than for the drier wrapped forage although lactic acid declined with more delay.
- Lactic acid was low and the pH was high for the dry wrapped forage indicating poor fermentation. Mold and yeast counts were also high for the drier forage. These factors suggest much less storage stability of the drier silage even though animal preference was greater.

DR. JOHN JENNINGS is professor - forages with University of Arkansas System Division of Agriculture, Department of Animal Science, Little Rock. **KEN COFFEY** is professor - animal science with University of Arkansas System Division of Agriculture, Department of Animal Science, Fayetteville.

FSA3051-PD-5-20RV