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Making and Storing Quality Hay

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The most important factors affecting the quality of hay are 1) moisture content at baling and time of storage, 2) stage of maturity at baling, 3) storage conditions, and 4) the forage species, of course. This guide has information on the first three factors as well as on hay preservatives. It does not deal with forage species.

Some forages, such as alfalfa, orchardgrass, red clover, and so forth, have higher feeding values than some other forages. If you have questions on forage species, call your county University of Missouri Extension Center.

Moisture Content

When forage plants are cut, the plant continues to breathe until the moisture content of the plants falls below 40 percent. Dry matter is lost during this process, and in some cases the loss may be as high as 15 percent. However, respiration losses are usually about 5 or 6 percent of the total dry matter. In normal hay curing, you cannot eliminate these losses.

When the moisture content of hay drying in the field reaches about 40 percent, further dry matter losses are due to raking and baling. Losses from these operations range from 10 to 25 percent, with most losses averaging about 15 percent. Dry matter losses from raking and baling are especially severe because most of these losses come from the most valuable part of the hay—the leaves.

Using hay crimpers and crushers can greatly reduce dry matter loss. Their use reduces curing time in the swath, exposure to the weather, leaf shattering, and respiration losses. All serious hay producers use crimpers and/or crushers.

The key to keeping dry matter losses of hay to a minimum are (1) bale at a moisture level low enough to prevent excessive heating and (2) prevent infiltration of moisture into the hay after it has been baled.

When hay is baled, it should not be higher than 20 to 22 percent moisture. When it contains more than this, there is danger of excessive heating, molding, and in severe cases, spontaneous combustion.

Although there is no danger of burning buildings when large hay bales are stored in the field, excessive heating and molding can still occur. Therefore, hay to be stored outside also should not be baled until the moisture level reaches 20 to 22 percent range. See Table 1.

During storage, hay will usually lose an additional 5 to 10 percent dry matter, even if it is originally baled and stored below 20 percent moisture. However, hay that is baled too wet reaches high temperatures and losses can become phenomenal. See Figure 1.

Table 1. Dry matter losses of alfalfa-grass in big bales under different storage conditions.

Type Hay	Moisture at baling	Storage	Dry Matter Loss
1st cutting	36%	Inside	17.8%
		Outside	26.6%
2nd cutting	24%	Inside	12.2%
		Outside	15.2%

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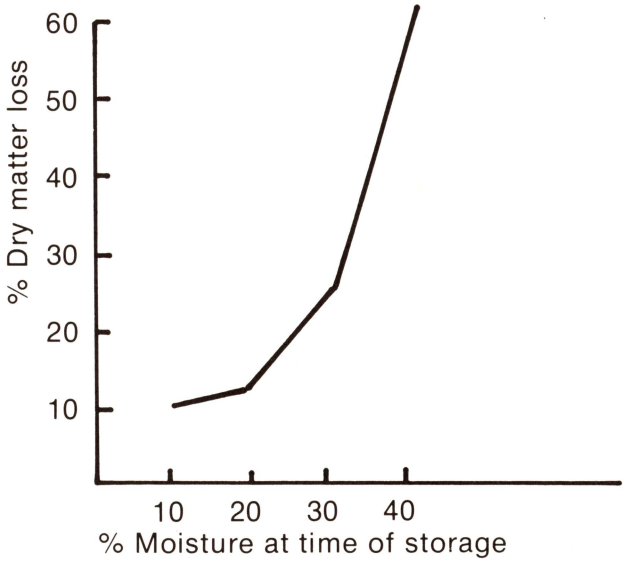
Figure 1. Spoilage loss in bales made from alfalfa-grass at different moisture levels.



When hay begins to heat, molds develop. When molds begin to form, heat generated by the activity of the organisms further increases the temperature of the hay. Molds usually develop between 113 and 149°F. If temperatures increase to above 150°F, there is danger of spontaneous combustion.

Molds and heating consume hay dry matter. Storage

losses during heating and mold development are proportional to the moisture content above 20 percent.

The feeding value of hay is greatly reduced if it heats to 110 to 150°F or more for as long as 12 hours. There is some deterioration of hay quality and direct dry matter loss if temperature within the hay exceeds 105°F. If the hay contains more than 20 to 22 percent moisture at baling time, temperature will usually exceed 105°F.

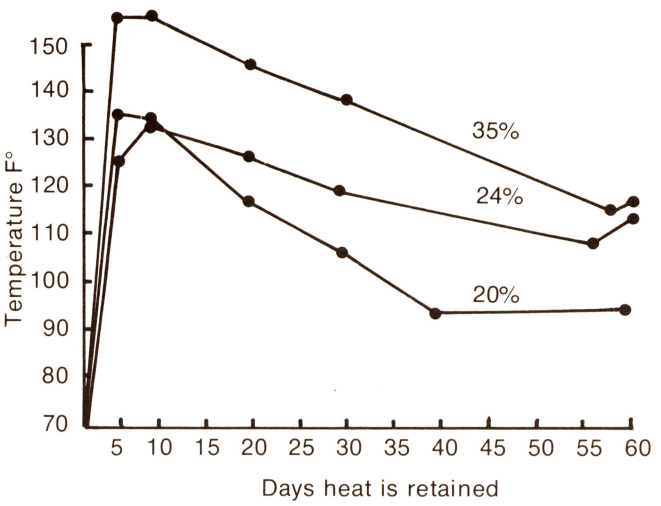
Farmers often report dark brown hay with a caramel-candy smell that cattle consume readily. When excessive heat is present in hay, the protein and carbohydrates combine to form an undigestible compound. This phenomenon is called the *browning reaction* and creates the caramel smell. Hays that have undergone these changes are extremely low in digestibility, and in particular, very low in digestible protein.

Large bales tend to retain internal heat much longer than conventional size bales. The implications of this are far reaching. Hay bales that remain above 120°F for 20 days or longer definitely lose excessive amounts of dry matter and suffer extreme losses in digestibility of protein and energy. These bales often will lose more than half of the original digestible protein. This is a serious loss, especially with grass hays that are borderline in protein content at cutting time.

If you are storing or sheltering some of your big bales, this long-term heat retention affects the proper time to move big bales into storage. See Figure 2. Hay baled with more than 22 percent moisture should probably not be put into storage for at least 30 days. This is especially true if bales are to be stacked several layers deep.

With the threat of barn fires removed by outside hay storage, many operators of large round balers try to bale hay with too much moisture. But excessive heating and molding can cause the loss of as much as one-third of the feeding value of hay baled at 28 percent moisture.

Figure 2. Effect of moisture at baling time on heat retention in big bales.



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Stage of Maturity

The stage of maturity at time of harvest is one of the most important factors affecting forage quality.

Most forages will have a 20 percent loss in TDN (total digestible nutrients) and a 40 percent loss in protein by a delay of only 10 days past the most desirable stage of harvest. For instance, alfalfa-grass mixtures cut when the alfalfa is in the late bud to early bloom stage will often contain 65 percent TDN and 18 percent protein. Contrast this to cutting at the 1/2 bloom stage or later, with 48 to 50 percent TDN and 12 percent protein. This is a 20 percent loss in the value of the hay.

Grasses, which are somewhat lower in feed potential than legumes to start with, follow the same decreasing pattern in feeding value as they mature. Grasses such as fescue and orchardgrass will often be as low as six percent crude protein after blooming when the seeds are beginning to form.

Legume-grass mixtures should be harvested when the legume reaches the desired stage of maturity regardless of the growth stage of the grass.

If the plants are not under stress conditions, the recommended stages of maturity for harvesting common forage plants in Missouri are:

- Alfalfa: bud to 1/10 bloom
- Red clover: 1/4 to 1/2 bloom
- Timothy: late boot
- Bromegrass: heads emerged
- Orchardgrass: bloom
- Reed canarygrass: heads emerged
- Tall fescue: boot stage

Overall losses due to late hay making can reach staggering proportions. Shattering and wilting losses are always proportionately higher with late-cut than with early-cut forages. Such an economic loss affects the profit of livestock farms.

The four major contributors to feed value losses in hay are:

- Late cutting losses in digestibility: 20%
- Wilting losses in the swath: 5%
- Shattering of leaves: 20%
- Too high moisture at time of baling: 15 to 25%

Storage Losses

If hay is baled with a moisture content of 20 to 22 percent, loft or mow-stored hay should not lose more than five percent of its original dry matter during the first year of storage. It will lose very little of its digestible nutrients during that time or in succeeding years. One exception: the hay will suffer some loss of carotene, the precursor of vitamin A, following one year of storage.

Large bales stored outside will suffer extremely variable losses, depending upon a combination of factors. These factors are: moisture of the hay at baling time, amount of rain and snow during the storage period, internal drainage of the soil on which bales are stored, amount of space between the bales, type of hay (grass or grass-legume), and the skill of the operator making the bales.

There are two types of storage losses suffered during outside storage. The easiest to see and the one that has been measured in many experiments is the total dry matter loss. This represents the weight loss between the beginning of storage and the time the hay is fed. While this loss is quite variable between experiments, it is usually in the range of 6 to 15 percent of the total hay stored, with the norm much closer to 15 percent than to 6 percent. See Table 2.

The second type of loss in outside storage is the loss in digestibility of the weathered portion of the hay. Just because the cattle eat most of this portion does not mean that it is as high in feeding value as the unweathered part. In fact, the loss of feeding value in the weathered portion of the hay usually is a greater source of loss than that from total dry matter loss. When these two types of losses are added together, the loss of total feed during storage will usually approach 25 percent.

WRONG way to store hay, with bales against each other, is shown by author Howell Wheaton.

RIGHT way to place hay allows plenty of room for air to circulate and dry hay.

Table 2. Total feed loss in big bales stored outside.

	Dry matter in bale	% Digestible	Total nutrients available
At harvest	1,000 lbs	56%	560 lbs
At feeding	930 lbs	48%*	446 lbs
	70 lbs (7% loss)		Lbs loss: 114
			TOTAL % LOSS: 20.2

*Loss due to weather-damaged outside portion of bale that was lower in feeding value but that cattle ate anyway.

A loss of 20.2 percent of the original feeding value of the hay was lost during storage, but the original dry matter loss was only seven percent. If the original dry matter loss during storage had been 15 percent (an average loss that occurred in several recent experiments), then the total feed nutrient loss would have been 27 percent. This is a high price to pay for outside storage, especially if hay is high quality.

Select your storage area carefully. Store bales on well drained areas. Some farmers place them on poles or crushed rock to minimize losses on the bottom of bales. Some research has shown that these techniques reduce storage losses by 15 percent. Always place bale rows in the same direction as the prevailing winds.

There does not seem to be much difference in storage losses of bales set side-by-side versus those set end-to-end. One note of caution: Bales placed end-to-end should be the same size. Cone-shaped bales or bales of different diameters placed end-to-end will often cause excessive spoilage on the ends of bales.

Some general guidelines can help reduce outside storage losses:

- Always store bales on a well drained area.
- Use a minimum of three feet between bale rows for air circulation. The more space, the better.
- If bales are stored side by side, leave at least 24 inches between bales.
- Avoid storing bales under trees and in the shade of buildings.
- If space is available, store some of the bales inside, especially the higher quality hays that should be used near the end of the feeding period.

Hay Preservatives

Farmers in the past often applied salt to hay as it was stored in the barn to prevent mold and heating. This practice had some merit. But the amount of salt needed for hay of very high moisture content would be so great that the salt would be extremely expensive and in many cases would lower the palatability of the hay.

Most recent research to prevent storage losses of hay has involved organic acids. The ones receiving the most attention have been propionic and acetic acid and formaldehyde. In general, these have been successful as far as the keeping and feeding values of the hay are concerned. The major drawbacks have been cost and application problems. The organic acids probably operate as fungicides to prevent molds from

forming in the hay. Formaldehyde kills bacteria and binds protein in a manner that prevents a decline in hay feeding value.

The preservative is usually applied to the hay as it enters the baler. Some farmers have had difficulty obtaining accurate application rates of the acids because of differences in windrow size and baling techniques. The acids are also corrosive to equipment.

About 20 pounds of actual acid should be applied per ton of hay if the moisture content of the hay ranges between 25 and 30 percent moisture. Hay between 30 and 35 percent moisture will need at least 40 pounds of acid per ton to prevent heating and mold formation.

If hay is baled at 25 percent moisture or slightly lower, about 10 pounds of actual acid per ton should control heating and dry matter losses. Higher application rates may be needed to prevent heating in large bales. Ohio State reported that stacks that contained more than 25 percent moisture at stacking time heated excessively, regardless of how much acid was used.

Anhydrous ammonia has recently been used experimentally as a hay preservative. When anhydrous gas equivalent to one percent of the weight of the hay was diffused into hay baled at 30 to 35 percent moisture, it effectively prevented mold and losses in digestibility. Since much of the ammonia is retained in the hay, it will also increase the crude protein percentage to some extent. In addition, the ammonia treatment seems to increase the digestibility of the cell wall fiber portion of the hay.

Anhydrous ammonia may have a much greater potential value as a preservative than the organic acids because it costs less and it actually improves the product by increasing crude protein and the digestibility of fiber. *However, practical methods of application must first be devised before the use of anhydrous ammonia as a hay preservative can become widespread.*

Bales treated with preservatives are extremely heavy and in most instances need to be handled mechanically. When the bales dry, the strings and wires become loose, making them difficult to handle. Re-baling may be necessary if hay is sold and needs to be rehandled and transported.

Should you use preservatives? There is no firm yes or no answer. First, consider the value of the final product. Adding $5 to $10 per ton in preservatives' cost to a ton of high quality alfalfa hay worth $65 on the market is much more economically feasible than adding the same amount to fescue hay worth about $25 to $30 per ton on the market.

Preservatives will reduce the time needed for hay to cure in the field and, thus, will reduce the risk of rain damage to the hay. And if properly used, preservatives substantially reduce storage losses of high moisture hay.

Weigh these benefits against the original cost of the preservative, the extra labor required to apply it and to handle the heavier hay, and the value of the end product before making a decision to use or not to use a hay preservative.

Another factor to consider is preservative's potential damage to haying equipment. The acids are corrosive to equipment, and you must take care to wash balers, bale wagons, etc., to prevent permanent damage.

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