TOPIC

16

Fundamentals of Hay Quality

OBJECTIVES

- To identify the types of hay and hay quality.
- To outline the process of harvesting.

Hay is the most important harvested forage for U.S. dairy cattle. The proportion of concentrates to roughage is largely determined by economics. When buying forage, this means it is important to consider the cost of energy and protein units per dollar. However, forages will always remain the foundation of the dairy ration.

Drying, or making hay, is the most common method of preserving forage for storage primarily because it is relatively easy to handle. It can be stored or transported long, chopped, pelleted, cubed, or baled into various types and sizes of bales. Modern equipment, including conditioners, hasten drying time; automated systems facilitate handling.

TYPES OF HAYS

Hays are made from legumes, grasses, and cereal crops (Table 16.1). In terms of total tonnage produced annually, alfalfa accounts for well over half of the U.S. hay crop (Figure 16.1). Many different kinds of hay make up the remainder of the nation's hay supply: among them, the clovers, lespedeza, soybeans, and cowpeas; the cereal hays made from oats, barley, wheat, or rye; and grass hays made from Bermuda grass, prairie grass, redtop, johnsongrass, orchard grass, fescue, and timothy.

Whenever feasible, it is recommended that legumes be grown for hay. In comparison with grasses, legumes are higher in protein, vitamins, and minerals; they provide higher yields; and they are nitrogen-fixing when inoculated: the bacteria (rhizobia) on their roots take free atmospheric nitrogen from the air. However, a mixture of grasses and legumes is often preferred for reasons of palatability, ease in curing, erosion control, and lessening the risk of bloat.

Legume hays are higher in protein, calcium, and carotene than grass hays, and they are usually more palatable. Alfalfa yields the highest tonnage per acre and has the highest protein content of the legume hays. Of course, poor-quality legume hays, those cut at a late stage of maturity (Figure 16.2) and exposed to weathering, are not as good as high-quality grass hays. Lespedeza is an excellent hay for dairy cattle, provided it is cured without weather damage, it is fine stemmed, and free of foreign material.

Grass hays include prairie grass, redtop, johnsongrass, orchard grass, and timothy. Grass hays grow under a wider range of conditions than alfalfa does, but they yield less dry matter per acre. When cut at the usual stage of maturity, grass hays are less palatable than legume hays and lower in protein and mineral content. However, when grass hays are heavily fertilized and cut at an early stage of maturity, they are very palatable and about equal to alfalfa in protein content.

Clover (Figure 16.3) is usually grown with timothy, as a grass-legume mixture. In comparison with alfalfa, clover-timothy mixed hays are lower in protein and not as high in quality. The lower quality is due to the fact that at cutting time the timothy is at the right stage of maturity whereas the clover is overly mature.

Soybeans, cowpeas, and vetch are often made into hays and fed to dairy cattle. They are not as valuable as alfalfa; generally, they are stemmy and difficult to cure. If they are cut at the proper stage and cured without loss of leaves, however, they make good feed.

Cereal hays are made from oats, barley, wheat, and rye. When cut sufficiently early in the flower stage and before the milk stage, they retain much of their feeding value. They are low in protein; hence, they must be fed with legume hay, grass silage, or a protein supplement. If cereal hays are cut too early, yield is reduced; if cut too late, they become fibrous and are of low feeding value.

TABLE 16.1 Nutrient Content of Several Common Forages, as a Percentage of Dry Matter

Forage	*Maturity*	*CP*	*NDF*	*ADF*	*Ca*	*P*	*Mg*	*K*
Alfalfa	Bud storage	21	40	30	1.4	0.30	0.34	2.5
	Early bloom	19	44	34	1.2	0.28	0.32	2.4
Bromegrass	Vegetative	19	51	31	0.6	0.30	0.26	2.0
	Early head	15	56	38	0.5	0.26	0.25	2.0
Corn Silage	Dough	8	50	27	0.3	0.20	0.20	1.0
	Black layer	8	46	26	0.3	0.20	0.20	1.0
Small Grain Hay	Heading	11	60	40	0.5	0.25	0.23	1.0
	Dough	10	65	43	0.5	0.25	0.23	1.0

Source: Adapted from Undersander, Howard and Shaver. U.W. Extension Bulletin No. A3325.

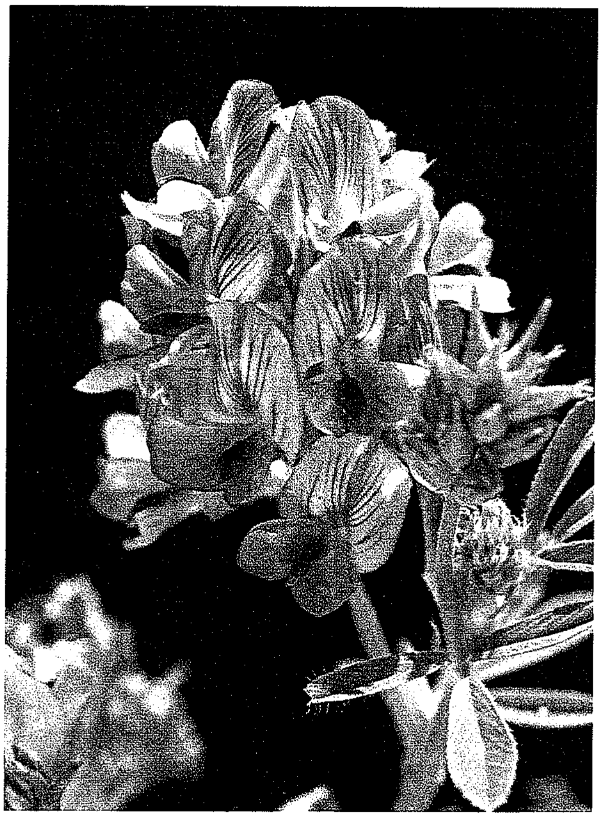

Figure 16.1 An alfalfa plant in full bloom. *(Courtesy of USDA-ARS)*

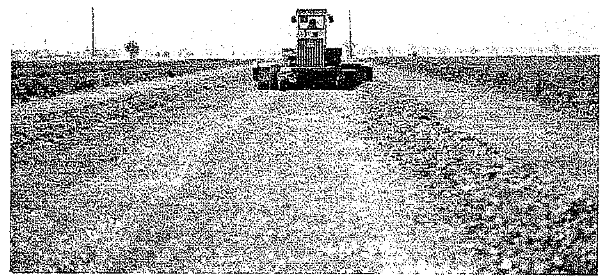

Figure 16.2 Cutting at the optimal stage of plant development dramatically improves the feeding value of forage. *(Courtesy of Iowa State University)*

Figure 16.3 A field of red clover. *(Courtesy of USDA-ARS)*

HAY QUALITY

The quality of hay greatly affects its consumption. High-quality forage is more digestible and passes through the digestive tract more rapidly than does low-quality forage; hence, animals will consume more of it (Figure 16.4).

Fortunately, hay quality and value can be estimated by certain characteristics. Hay of high feeding value is made from plants cut at an early stage of maturity, thus ensuring the maximum content of protein, minerals, and vitamins and the highest digestibility. It is leafy, thus giving assurance of high protein content. It is bright green in color, thus indicating proper curing, a high carotene or provitamin A content, and palatability. It is free from foreign material, such as weeds, and it is free from must or mold or dust. It is fine stemmed and pliable, not coarse, stiff, and woody, and has a pleasing, fragrant aroma; it smells good enough to eat. During the curing process, the quality and feeding value of hay is decreased rapidly by rain, sun, bleaching, raking, handling when too dry, and storing with too much moisture.

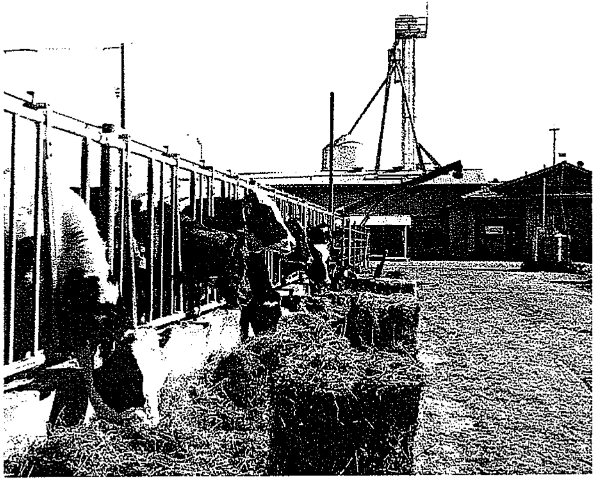

Figure 16.4 At some stages of production, high-quality forage can meet most of the nutrient needs of the cow, thus minimizing feed costs. *(Courtesy of Iowa State University)*

Figure 16.5 Visual appraisal is the initial approach to determining hay quality. *(Courtesy of Iowa State University)*

Visual estimates of hay quality are valuable and should be used (Figure 16.5), but the most precise way to determine the nutrient value of hay is through chemical analysis. Analyses are not infallible, however; a Pennsylvania study revealed errors of as much as 5 percent in crude protein and 9 percent in Total Digestible Nutrients (TDN) (energy) content of forages, with evaluations made by trained individuals. Fortunately, there is a high relationship between the chemical composition, especially the protein and fiber, of hay and its feeding value for animals. As hay matures, protein decreases and fiber increases. Likewise, weathering lowers the protein and raises the fiber content because soluble nutrients are washed out by rain and leaves are lost during harvest.

By using detergents, hay samples are chemically separated into two fibrous fractions: a neutral detergent fibrous (NDF) fraction and an acid detergent fibrous (ADF) fraction. In comparison with traditional proximate analysis, NDF provides a better estimate of dry matter intake (consumption) by animals, and ADF provides a better estimate of the in vivo (inside the animal) dry matter digestibility.

No forage test is any better than the sample taken. Thus, the most important single step in determining the chemical composition of hay is sampling. No matter how accurate the chemical analysis, a poor sampling technique can easily invalidate the results and lead to an erroneous conclusion. It is difficult to obtain a representative, meaningful sample of forage because of its bulky nature and variability within a given lot of hay as compared to most other crops. For the sample to be representative of a given lot of hay, it should have been produced under the same cultural conditions, be from the same cutting, and be at the same stage of maturity, and all of it should have been baled within a forty-eight hour period using only one harvesting method. With conventional, rectangular bales, at least twenty bales should be sampled at random, by probing every third bale, for example. The probe, or core sampler, should be at least ⅜ inch in diameter. The center of either end of a rectangular bale may be probed by inserting the probe at a right angle to the face of the bale and to a depth of 12 to 18 inches. Hay samples should be placed in a plastic bag or freezer carton; otherwise, the moisture content will not be meaningful.

Certainly, poor-quality hay can be fed, and under certain circumstances, it may even be economical. When buying poor hay, however, the purchase price should be lowered accordingly, and the feed analysis should also be used as a basis of balancing the ration. By the same token, it is usually good business to pay a premium for high-quality hay. Some dairy producers very wisely apply an escalator principle to hay purchases. They may pay a premium per ton for each 1 percent of protein above an agreed-upon figure, or they may dock the price by a corresponding amount if the content is lower. For example, if a vendor guarantees to deliver alfalfa with 15 percent crude protein and it is agreed that a $1.50 per ton premium will be paid for each 1 percent protein in excess of this figure, a $4.50 per ton premium would be added for alfalfa containing 18 percent crude protein.

HARVESTING

Whether the crop is a grass or a legume or a combination of the two, the stage of maturity of the plants at the time of harvest affects digestibility, yield, and feeding value. Young, immature plants are high in protein and low in fiber or lignin. As hay crops mature, feeding value goes down, and fiber content increases. Digestibility of the forage (TDN) declines about 0.5 percent each day that cutting is delayed beyond the early bloom stage, and the intake of forage decreases during this same period at more than 0.5 percent each day. Thus, in total, the feeding value of forage drops more than 1 percent for each day's delay after early bloom. With increasing maturity of the hay, the crude protein, digestible dry matter decreases, as do the dry matter intake and milk production of the cows fed the hay. Maturity also increases the NDF and ADF fractions. The increase in NDF and ADF with maturity is expected because NDF is inversely correlated with intake, whereas ADF is highly correlated with digestibility.

Forage dry weight yields increase until midbloom to late-bloom stages. Timothy and bromegrass fully headed and red clover and alfalfa at full bloom give maximum yield of dry matter. However, the maximum feeding value of first cutting forage is reached at least ten days before the time of maximum dry weight yield; this usually corresponds to less than 10 percent bloom for alfalfa hay.

Stage of maturity also affects the vitamin content of hay. Levels of carotene (precursor of vitamin A) and the B vitamins decrease as plants mature. Vitamin D content is the one exception: it increases as the forage is sun-cured. Everything considered, there is a loss of about 1 percent in nutrient value for each day that the hay harvest is delayed beyond the late vegetative stage of growth.

Cutting (Figure 16.6), followed by curing in the swath or windrow (Figures 16.7 and 16.8), are the first two steps in haymaking, regardless of the subsequent method or type of equipment employed. Any one of several types of mowers may be used because all of them are designed to get the hay down. The most important thing is that the hay be cut at the proper stage of maturity.

After the hay has wilted sufficiently in the swath but while it is still tough and the leaves will not shatter, it should be windrowed. For this assignment, the side-delivery rake is preferred to the dump rake. The side-delivery rake rolls hay into fluffy, cylindrical windrows, which allow for good circulation of air. Dump rakes, on the other hand, produce large windrows that are apt to remain damp underneath and bleach excessively on top. Where the hay crop is exceedingly heavy, windrow size can be kept small by limiting the width of each windrow.

If considerable shattering appears probable, it may be desirable to do the raking early in the morning, when the dew makes the hay a bit tougher. When windrowed hay is rained on, wait until the top half dries out and then turn it upside down with the side-delivery rake. The use of the tedder for windrowing again is not recommended because of excessive leaf shattering.

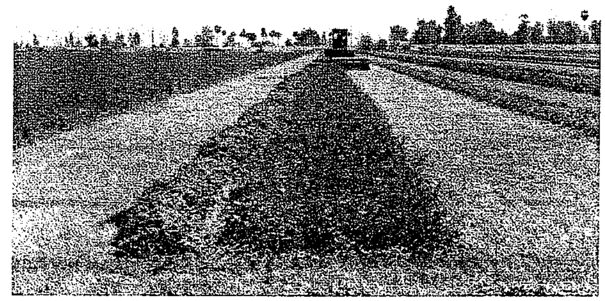

Figure 16.6 Freshly cut hay is typically 75 to 80 percent water and must be field-dried prior to harvest. *(Courtesy of Iowa State University)*

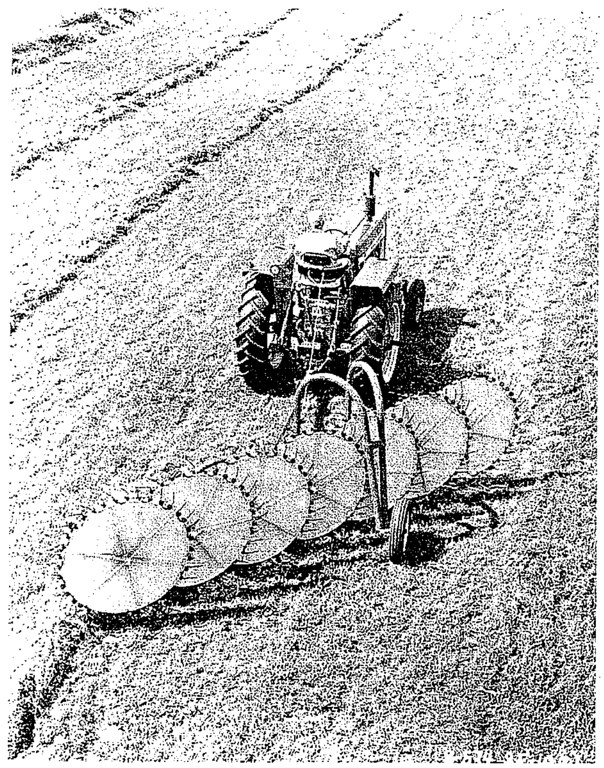

Figure 16.7 Hay is raked into windrows by a wheel rake. *(Courtesy of Iowa State University)*

Figure 16.8 Windrows of alfalfa in an irrigated California hay field. *(Courtesy of USDA-ARS)*

Proper curing ensures that the hay can be stored safely without overheating or becoming moldy, and the maximum leafiness, green color, aroma, nutrient value, and palatability will be retained. Freshly cut forage contains 75 to 80 percent moisture, whereas the maximum moisture content for safe hay storage is as follows:

For loose hay, 25 percent moisture.

For baled hay, 20 to 22 percent moisture (the lower figure is for larger bales).

For chopped hay, 18 to 20 percent moisture.

For cubes, 16 to 17 percent moisture.

Hay of a higher moisture content than indicated should not be stored because its value may be greatly lowered due to mold or to nutrient losses accompanying fermentation and because of the danger of spontaneous combustion and a costly fire.

Legume forages contain a larger proportion of leaves than do grasses, but the fine, thin legume leaves dry out more rapidly than do the coarse stems to which they are attached. This results in considerable shattering losses unless great care is taken. In alfalfa, for example, 50 percent of the total weight of the plant is contained in the leaves, but the leaves contain 70 percent of the protein and 90 percent of the carotene content of the entire plant. In field-curing hay, losses from leaf shattering range from 2 to 5 percent for grass hay and 3 to 39 percent for legume hays, with as much as 15 to 20 percent for legume hays field-cured under the most favorable conditions (Figure 16.9).

In general, the carotene or provitamin A content of freshly cured hay is proportional to the greenness. With severe bleaching, more than 90 percent of the vitamin A potency may be destroyed. Even under the best of conditions, unavoidable loss, especially losses in sugars, starch, and carotene, occurs through fermentation. With good weather and proper curing methods, however, these losses are not excessive. The leaching losses from rain are less severe soon after mowing, but they increase in severity as curing progresses. Also, repeated showers are more damaging than is one heavy rain. Damaging rains may lower the feeding value of hay by one-fourth to one-third or even more with severe exposure. Losses from weather damage may be reduced by using haymaking equipment that reduces the field drying time and by using proven chemical conditioning and preserving agents.

Chemical hay-drying agents and preservatives assist haymakers in decreasing haymaking losses and improving hay quality. These products speed up the haymaking process and reduce exposure to weather

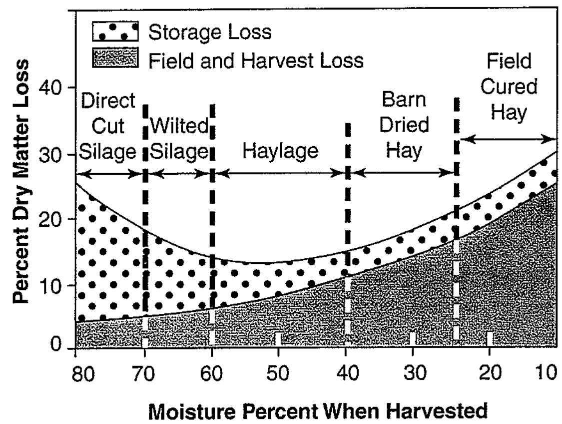

Figure 16.9 Estimated forage losses for hay and silage harvested at various moisture stages. *(Courtesy of M. E. Ensminger)*

damage. In comparison with no treatment, the use of a desiccant, or drying agent, along with mechanical conditioning can reduce the moisture content by an additional 2 to 10 percent during a twenty-four hour period. Adding a preservative to hay that is in the 25 to 35 percent moisture range allows it to be baled and stored without undue heating.

Chemical drying agents, which are sprayed on the crop at mowing time, break down the waxy cutin layer on the wall of the stem and allow moisture to escape, thereby promoting faster drying time. The drying rate of the stems approaches that of the leaves. Several chemicals are used for conditioning, including potassium carbonate, sodium carbonate, and sodium silicate. Also, methyl esters of fats, vegetable oils, or animal fats have been mixed with potassium carbonate in an attempt to increase the effectiveness of chemical conditioning.

Chemical conditioners are effective on legumes such as alfalfa, birdsfoot trefoil, and red clover, but generally they are not effective on grasses. Although they reduce drying time on all cuttings of legumes, they are most effective on second and third cuttings and are least effective on first and late autumn cuttings. This situation is attributed to the fact that conditioners work best when drying conditions are best (in the summer) and that first cutting has heavier yields and heavier swaths than later cuttings, conditions that hamper drying because moisture movement inside the swath is inhibited. Drying agents are more effective as an addition to and not as a substitute for mechanical conditioners. The chemical of choice is applied at the time of cutting by either a spray boom mounted ahead of the reel or spray nozzles mounted behind the reel but in front of the conditioning rollers so that the rollers help distribute the spray.

Under normal conditions and for safe baling, moisture content of 20 percent or less is a must. If properly treated with an adequate amount of the right preservative, however, alfalfa hay can be baled at 25 to 30 percent moisture, thereby speeding harvesting and decreasing losses significantly. Preservatives act as fungicides and inhibit the growth and reproduction of microorganisms that cause heating and molding in wet hay.

Propionic acid is the organic acid of choice. It is sometimes mixed with acetic acid, inorganic acids, formaldehyde, water, flavoring ingredients, and/or antioxidants. But to be most effective, organic acid formulations should have at least 60 percent propionic acid; should be applied at the proper rate, depending on the moisture content of the hay; and must be uniformly distributed throughout the hay mass.

When properly applied, anhydrous ammonia stops bacteria and mold growth; when applied to poor-quality hay, it has the added advantage of increasing protein and digestibility. As a preservative, however, it is not as effective as propionic acid. Also, unless large round bales are covered and/or contain less than 28 percent moisture, too much ammonia escapes. For high-quality alfalfa hay, which is already high in protein and digestibility, it is doubtful that the added expense of ammonia use can be justified.

Some claim that most bacterial inoculants on the market produce lactic acid, which acts as a fungicide and inhibits mold growth. More experimental work is needed to substantiate the effectiveness of bacterial inoculants as hay preservatives.

In many areas, there is a decided preference among livestock producers in favor of a certain cutting of alfalfa hay. Generally, first-cut alfalfa hay is coarser stemmed and less leafy than later cuttings and therefore of somewhat lower feeding value when the different cuttings are equally well cured. Also, the weather is often less favorable for curing the first cutting. On average, each successive cutting is lower in crude fiber and higher in crude protein.

SUMMARY

- Hay is the most important harvested forage for U.S. dairy cattle.
- It is recommended that legumes be grown for hay because they are higher in protein, calcium, carotene, vitamins, and minerals; they provide higher yields; they are more palatable; and they are nitrogen-fixing.
- High-quality forage is more digestible and passes through the digestive tract more rapidly than does low-quality forage.
- Hay of high feeding value is made from plants cut at an early stage of maturity, which ensures maximum content of protein, minerals, and vitamins and the highest digestibility.
- As hay matures, protein, DDM, DMI, and milk production decrease, while fiber, NDF, and ADF fractions increase.
- The stage of maturity of the plants at the time of harvest affects digestibility, yield, and feeding value.
- Chemical hay-drying agents and preservatives assist haymakers in decreasing haymaking losses and improving hay quality.
- Each successive cutting of alfalfa is lower in crude fiber and higher in crude protein.

QUESTIONS

1. What forages and cereals are hays made from?
2. Give some examples of grass hays and cereal hays.
3. When using detergents to analyze hay samples chemically, which fraction provides a better estimate of dry-matter intake by animals?
4. How deep should a probe be inserted into the end of a rectangular bale when taking a representative sample?
5. Which vitamin increases as the forage is sun-cured?
6. What is the first step in haymaking?
7. What is the advantage of using a side-delivery rake compared to a dump rake?
8. Why should a producer avoid storing loose hay at a moisture greater than 25 percent?
9. What is the purpose of adding a preservative?