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Quality Hay Production

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Hay is one of the most versatile of stored forages in that (1) it can be kept for long periods of time with little loss of nutrients if protected from weather; (2) a large number of crops can be successfully used for hay production; (3) it can be produced and fed in small or large amounts; (4) it can be harvested, stored and fed by hand or the production and feeding can be completely mechanized; and (5) hay can supply most nutrients needed by many classes of livestock. Hay is, therefore, the most commonly used stored feed on most farms.

Since hay is such a widely used feed, it is important to understand the factors that affect quality of hay and how to recognize quality of hay.

Importance of Hay Quality

The ultimate test of hay quality is animal performance. Quality can be considered satisfactory when animals consuming the hay give the desired performance. Three of the factors which influence animal performance are: (1) consumption—hay must be palatable if it is to be consumed in adequate quantities; (2) digestibility and nutrient content—once the hay is eaten, it must be digested to be converted to animal products; and (3) toxic factors—high-quality hay must be free of components which are harmful to animals consuming it.

Factors Affecting Hay Quality

Stage of maturity when harvested—Of all the factors affecting hay quality, stage of maturity when harvested is the most important and the one in which greatest progress can be made. As legumes and grasses advance from the vegetative to reproductive (seed) stage, they become higher in fiber and lignin content and lower in protein content, digestibility, and acceptability to livestock. The optimum stages of maturity to harvest for high quality and long stand life of many hay crops are listed in Table 1. Making the first hay cut early permits aftermath growth to begin at a time when temperature and soil moisture are favorable for plant growth and generally increases total yield per acre. The effects of stage of harvest on fescue hay quality and animal performance are shown in Table 2. Similar effects have been noted with alfalfa (Table 3). In both cases, early cut hay resulted in high-quality feed and superior animal performance.

Table 1. Recommended Stages to Harvest Various Forage Crops.

Plant Species	Time of Harvest
Alfalfa	Late bud to first flower for first cutting, first flower to 1/10 bloom for second and later cuttings.
Bluegrass, Orchardgrass, Tall Fescue, or Timothy	Boot[1] to early head stage for first cut, aftermath cuts at 4- to 6-week intervals.
Red Clover or Crimson Clover	First flower to 1/10 bloom.
Oats, Barley, or Wheat	Boot to early head stage.
Rye and Triticale	Boot stage or before.
Soybeans	Mid- to full-bloom and before bottom leaves begin to fall.
Annual Lespedeza	Early bloom and before bottom leaves begin to fall.
Ladino Clover or White Clover	Cut at correct stage for companion plant.
Sudangrass, Sorghum Hybrids, Pearl Millet, and Johnsongrass	40-inch height or early boot stage, whichever comes first.
Bermudagrass	Cut when height is 15 to 18 inches.
Caucasian Bluestem	Boot to early head stage.
Big Bluestem, Indiangrass, and Switchgrass	Early head stage.

[1] Boot is stage of growth of a grass just prior to seedhead emergence. This stage can be identified by the presence of an enlarged or swollen area near the top of the main stem.

Table 2. Effect of Stage of Harvest of Fescue Hay on Quality and Animal Gain.*

Stage of Harvest	Dry Matter Intake lb./day	Percent Digestibility	Percent Protein	lb. of Hay Fed per lb. Gain	lb. of Hay per Acre 1st Cutting	lb. of Gain per Day
Late boot to head, cut May 3	13.0	68	13.8	10.1	1334	1.39
Early bloom stage, May 14	11.7	66	10.2	13.5	1838	.97
Early milk stage—seed forming, May 25	8.6	56	7.6	22.5	2823	.42

**Holstein heifers were used, average weight: 500 pounds.*
SOURCE: Personal Communication, Monty Montgomery, University of Tennessee.

Table 3. The Effect of Alfalfa Hay Quality on Performance of Beef Steers.*

	Good	Fair	Poor
Crude Protein	18.7	15.9	13.7
Crude Fiber	29.4	35.4	46.7
Animal Performance			
Hay Consumed, lb/day	17.1	16.5	13.8
Gain, lb/day	1.85	1.49	-0.06

* 550 lb. beef steers

SOURCE: A.S. Mohammed et al., 1967. Tennessee Farm and Home Science Progress Report 61. Pages 10-13. University of Tennessee Agricultural Experiment Station, Knoxville.

Table 4. The Effect of Handling Conditions on Alfalfa Hay Losses.

		Losses			
	Raked and Baled Correctly	Raked Too Dry	Baled Too Dry	Raked and Baled Too Dry	Total
	lb/A	lb/A	lb/A	lb/A	Percent
Dry Hay	2900	700	100	1000	34
Crude Protein	660	210	60	290	44
T.D.N.	1710	480	90	690	40

SOURCE: Alfalfa Hay Quality. D. Ball, T. Johnson, G. Lacefield, and H. White. Special Publication. Certified Alfalfa Seed Council. Davis, CA.

Table 5. The Effect of Hay Preservative Type on Post-storage Moisture Concentrations, Storage Losses, and Visual Characteristics of Alfalfa Hay.

Treatment	Initial Moisture (%)	Final Moisture (%)	Peak Temperature (degrees F)	Dry Matter Intake (% of body weight*)	Dust** Rating
Wet Control	21.6	13.0 b***	88	2.11 a	4.72 a
Buffered Propionic Acid	21.0	14.8 a	80	2.20 b	3.32 b
Inoculant	22.0	12.1 c	90	2.11 a	4.79 a
Dry Control	12.2	12.4 c	75	2.32 c	1.96 c

**Dry matter intake = 110/neutral detergent fiber*

***Dust ratings are on a 1 to 10 scale, with 1 being dust-free and 10 being extremely dusty*

****Values within a column followed by different letters are statistically different.*

Curing and handling conditions—After mowing, poor weather and handling conditions can lower hay quality. Rain can cause leaf loss and can leach nutrients from plants during curing. Sunlight can lower hay quality through bleaching and lowering Vitamin A content. Raking and/or tedding dry, brittle hay can cause excessive leaf loss.

Hay plants with an 80 percent moisture content must lose approximately 6,000 pounds of water to produce a ton of hay at 20 percent moisture. Crushing stems (conditioning) at time of mowing will cause stems to dry at more nearly the same rate as leaves. Conditioning will usually decrease the drying time of large-stemmed plants by approximately one day and can result in leaf and nutrient savings. Chemical conditioners which contain potassium carbonate and/or sodium carbonate (when properly sprayed on alfalfa at cutting) may be expected to reduce drying time as much as one day when drying conditions are favorable. Under poor drying conditions, they may give no advantage. Raking and/or tedding while hay is moist (about 40 percent moisture) and baling before hay is too dry (below 15 percent moisture) will help reduce leaf losses (Table 4).

Hay preservatives—Hay may be safely baled at greater than 20 percent moisture (small bales) and 18 percent moisture (large packages) only when effective preservatives are properly applied at baling. Effective hay preservatives will prevent excessive heating and mold growth when applied uniformly and at the correct rate on moist hay.

The most proven form of hay preservative currently marketed in Kentucky is the propionic acid types. Early propionic acid products were either propionic acid or a mixture of propionic acid and acetic acids. Though effective, these products were not well accepted nor widely adopted for many reasons, including their tendency to remove paint from balers, their offensive and penetrating odor, and the irritation of exposed skin which came in contact with the material.

Today the primary form of propionic acid hay preservatives on the market are 'buffered' products that are less volatile, less harmful to paint, and less offensive to nasal passages and exposed skin. The buffered materials are effective in reducing hay heating and molding in storage when applied uniformly and at the proper rates for the moisture of the hay (Table 5). In a UK study, alfalfa hay treated with a buffered propionic acid heated less and was less dusty than both untreated wet hay and hay treated with a hay inoculant. In contrast, the inoculant product did not decrease heating or dustiness compared to the moist control.

Hay handled in a rough manner before it gets to the animal can lose an excessive amount of leaves. For the average bale (14 inches x 18 inches x 30 inches), about 29 percent of its total volume is contained in a 1-inch depth all around the bale. For large round bales, the outer 4 inches contains roughly 25 percent to 30 percent of its total volume. This means a large portion of the bale is exposed, and care in handling and storage should be practiced to minimize loss.

Soil fertility—Adequate amounts of lime, nitrogen, phosphate, potash, and minor elements are needed to produce high yields of hay per acre and to maintain stands of desirable plants for a long period of time. A soil test should be used as a guide in determining the amount of fertilizer and lime needed for economical hay production.

High yields of hay remove large amounts of nutrients (Table 6). Since properly inoculated legume plants are capable of fixing atmospheric nitrogen, mixtures containing more than 25 percent legumes usually do not give economical responses to nitrogen fertilization. With pure grass stands, nitrogen must be added for high levels of production.

Plant species—Legumes are normally higher in quality than grasses, but within each group there can be a wide range of quality. When both grasses and legumes are harvested at the proper stage of plant growth, legumes are usually higher in total digestibility, rate of digestion, protein, and many minerals and vitamins. A mixture consisting of an adapted grass and legume is usually of high quality when properly managed. In addition, grasses can improve the drying rates of mixed stands compared to pure legume stands. Perennials, such as alfalfa, orchardgrass, timothy, fescue, bermudagrass, etc., are usually more economical for hay crops than annuals, although annuals, such as sorghum-sudangrass hybrids, pearl millets, small grain, lespedeza, and ryegrass, can be used effectively.

Variety—Plant certified seed of adapted varieties tested and proved under local conditions. For example, stands seeded with common medium red clover are visibly shorter and thinner than those from certified, improved varieties even in the seeding year. Over three years, improved varieties of red clover averaged 2.89 tons more dry matter yield per acre than common medium red clover. The maximum difference in total yield over three growing seasons between the best improved and worst common clover seed lot was 4.93 tons of dry matter per acre. The largest differences came in the third growing season when stands from common clover seed lots were essentially non-productive.

Weeds generally lower hay quality by adding material lower in palatability and digestibility. Some may be harmful or toxic. Therefore, clean seed (which is free of weed seed) is especially important when planting perennial hay crops.

Seeding rates and dates—Seed high-quality, certified seed at recommended rates and dates (see AGR-18 for specific dates and rates for most Kentucky forage crops). Fall seedings should be made early enough for establishment before cold weather stops or slows growth. Late winter and early spring seedings should be made early enough to provide a vigorous stand to survive summer drought and weed competition.

Table 6. Nutrients Removed by Hay Crops.

		Approximate lbs per Acre Removed		
Crop	**Yield/Acre**	**N**	**P_2O_5**	**K_2O**
	(Tons)			
Alfalfa	5	255	68	245
Red Clover—Orchardgrass	4	136	47	204
Tall Fescue, Orchardgrass, Timothy	3	87	29	144

SOURCE: K.L. Wells and W.O. Thom, 1994. Estimated nutrient and uptake by Kentucky's Crops. Soil Science News and Views Vol. 15, No. 4.

Evaluating Hay Quality

Forage testing—The most practical way to determine the nutrient content of hay is through forage nutritive analysis. Forage nutritional results can be used to assess quality and to determine amount and type of supplementation needed for the desired level of animal production if hay is stored so a representative sample can be taken and the analysis is done by a reputable laboratory. The use of an instrument to obtain a core sample of hay has been one of the most reliable methods of getting a representative sample for nutritional analysis. Matching hay to different classes of livestock based on nutriental content of the forage and the requirements of the animal can lead to a more efficient forage-livestock program.

Visual estimate *(judging your own hay)*—Although not as reliable as forage testing, a visual estimate can be helpful in determining forage quality. Guidelines for sensory evaluation are given in Table 7. Hay that is early cut, green, leafy, soft, free of foreign material, and has a pleasant odor will be of high quality. However, color and visual appearance are not always good indicators of hay nutritive quality.

Making and Storing in Big Packages

The availability of hay stackers and large round balers has brought about changes in methods of packaging hay. The principles of packaging are essentially the same for all methods, i.e., compressing the loose hay into a package which can be handled and stored conveniently.

Storage method has a large impact on DM and quality loss of round bales. Unprotected, outside storage of twine-tied round bales can result in losses exceeding one-third of the original crop. Plastic mesh wrap (netwrap) and solid, self-adhesive plastic wrap are recent developments in round bale storage that can provide some protection against weathering losses during outside storage. A

Table 7. Score Card for Hay Quality Evaluation.

		Possible Score	Your Score
I. Stage of Harvest	1. Before blossom or heading	26-30	_____
	2. Early blossom or early heading	21-25	_____
	3. Mid- to late-bloom or head	16-20	_____
	4. Seed stage (stemmy)	11-15	_____
II. Leafiness	1. Very leafy	26-30	_____
	2. Leafy	21-25	_____
	3. Slightly stemmy	16-20	_____
	4. Stemmy	0-6	_____
III. Color	1. Natural green color of crop	13-15	_____
	2. Light green	10-12	_____
	3. Yellow to slightly brownish	7-9	_____
	4. Brown or black	0-6	_____
IV. Odor	1. Clean - "crop odor"	13-15	_____
	2. Dusty	10-12	_____
	3. Moldy - mousey or musty	7-9	_____
	4. Burnt	0-6	_____
V. Softness	1. Very soft and pliable	9-10	_____
	2. Soft	7-8	_____
	3. Slightly harsh	5-6	_____
	4. Harsh, brittle	0-4	_____
		Sub-total	_____
VI. Penalties	1. Trash, weeds, dirt, etc.	Subtract 0-35	_____
Scoring: 90 and above—Excellent; 80-89—Good hay; 65-79—Fair hay; Below 65—Poor hay		**TOTAL**	_____

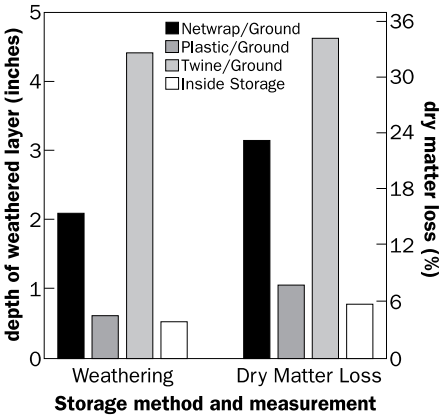
University of Kentucky trial showed that very little weathering occurred on solid-plastic-wrapped round bales but that an average depth of 4.4 inches was weathered on twine-tied bales stored outside for about one year (Figure 1). Weathered hay, discolored by the effects of moisture, soil contact, and microbial activity, suffers greatly in feeding value due to large increases in fiber levels and post-storage digestibility values as low as 30 percent.

Assuming all of the weathered hay on round bales is lost due to poor palatability as whole bales are fed, losses of dry matter range from only about 6 percent for bales stored inside to as much as 34 percent for twine-tied bales stored on the ground. Solid plastic wrapped bales may lose no more than inside-stored bales. Netwrap also saves large amounts of DM compared with twine-tied bales but does not match inside storage or solid plastic in minimizing losses.

Points to consider when making and storing hay in big packages:

1. Harvest at proper stage of plant maturity.
2. Legumes alone usually have higher rates of spoilage from outside storage than grasses. This loss can be excessive.
3. Make a tight uniform package at 18 percent to 20 percent moisture content or below.
4. Store on a well-drained site.
5. Break direct contact between damp soil and hay using rock, tires, poles, or pallets.
6. Top stacks properly to shed water.
7. Store hay of similar quality together.
8. Leave at least two feet between stacks; round bales can be stored end to end in rows with about two feet between rows.
9. Multiple storage lots will minimize risk of fire loss and excessive mud.

Figure 1. *Weathering and DM losses during storage of tall fescue round bales bound using twine, plastic mesh netting or solid plastic wrap.*



10. High-quality hay should be stored inside or should be protected from the weather and raised off the ground on old tires, poles, or crushed rock.

Hay Feeding Systems

For more information concerning hay feeding systems, see "Hay Feeding Systems" (AGR-61).

Other Information

More detailed information on many of the recommendations discussed in this publication is available from the UK College of Agriculture Cooperative Extension Service. The following list may be helpful:

AGR-16 Taking Soil Test Samples
AGR-18 Grain and Forage Crop Guide for Kentucky
AGR-19 Liming Acid Soils
AGR-33 Growing Red Clover in Kentucky
AGR-64 Establishing Forage Crops
AGR-76 Alfalfa, the Queen of Forage Crops
AGR-107 Alfalfa Quality Means Profits
AGR-137 Alfalfa Hay Quality Makes the Difference
ID-46 Hay Preservatives
ID-101 Interpreting Forage Quality Results

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