Hay Quality and Marketing in the Rocky Mountain Front Range and High Plains

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Introduction

Interregional hay trade has grown since the early 1990s, increasing the need for objective hay classification standards. Hay produced in the West is marketed to other regions on the basis of a forage quality analysis. Standardized evaluation methods establish the marketability and feed value of hay and other conserved forages. Hay buyers normally conduct business by visual appraisal and forage analysis on a dry matter basis. At minimum, a forage analysis should include moisture, dry matter (DM), crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF). A lab report for these variables usually includes the calculated values for relative feed value (RFV) and total digestible nutrients (TDN). High calcium (Ca) to phosphorus (P) ratios in legume hay can be a negative consideration to some individuals buying hay for horses.

Plant maturity at harvest is the primary factor in hay quality. Forage type, cultural practices, weather, and storage method also affect quality. For alfalfa hay, soil fertility generally influences yield more than quality; however, fertilization practices impact both yield and quality of improved grasses. Hay palatability and rate of intake by livestock relate to hay condition and fiber content. Hay condition relates to leaf capture, steminess, texture, heat damage due to baling at high moisture, and foreign material such as weeds, mold, or dust. Hay packaging and physical form (i.e., long-stemmed, baled, chopped, ground, cubed, or pelleted) affect feed intake and livestock performance. Animal performance expressed as milk production or average daily gain is the best index of forage quality. Digestion trials with cattle or sheep are the most accurate procedure for determining forage quality but are expensive and time-consuming. Therefore, chemical analysis and visual appraisal are valuable procedures for determining nutrient content and hay condition.

Forage analysis terminology in hay evaluation and marketing

Crude protein is composed of amino acids, nitrogen, and nonprotein nitrogen. Amino acids contain nitrogen (N) and are necessary for the synthesis of body protein in meat, wool, and milk. The CP content of forages is calculated by analyzing for total N content and multiplying by 6.25. This formula is based on an assumption that plant proteins contain about 16 percent N on average. Crude protein, a generally accepted measure of hay quality, does not indicate how efficiently the protein will be digested or utilized (Table 1). Digestible (available) protein is a more realistic measure of forage protein value. In fact, crude protein values for heat-stressed or fermented hay are not always a reliable indicator of available protein. The marketability of heat-stressed hay is impacted more by

Table 1. Crude protein ratings for legumes, legume-grass mixtures, and grasses.[1]

Standard	CP (percent)
Prime	>19
1	17-19
2	14-16
3	11-13
4	8-10
Fair	<8

[1]Expressed on a dry-matter basis as per the Hay Market Task Force of the American Forage and Grassland Council (1986).

excessive levels of mold and reduced values for TDN or digestible dry matter (DDM).

Neutral detergent fiber contains the total fiber content or cell wall fraction of a forage (Table 2). Chemical components of NDF include cellulose, hemicellulose, lignin, and heat-damaged proteins. The NDF fraction relates to feed intake and rumen fill in ruminants. As NDF decreases, potential forage intake (per unit time) increases. The best overall indicator of feed intake is considered to be NDF because of a relationship to both digestibility and density of a forage. The optimum dry matter intake (DMI) of a milk cow appears to occur at a daily NDF intake of about 1.2 percent of body weight, with about 75 percent coming from forages (Linn and Martin, 1991).

Acid detergent fiber (ADF) is considered to be a good predictor of digestibility (Table 2) and contains the same chemical components as NDF except for hemicellulose. A value for ADF can be used to calculate energy content or TDN. Potential digestibility of a forage increases as ADF decreases.

Total digestible nutrients and net energy (NE) are measures of a feed's energy value. The TDN values for legume and grass forages are considered equal to percentage digestible dry matter (DDM) which can be calculated from ADF (Table 2). NE is a more comprehensive measure of energy. For a discussion of NE calculations, consult nutrient requirements for beef and dairy cattle (National Research Council, 1984 and 1989).

Relative feed value is an index that combines potential intake and digestibility (Table 2) into a rapid method for determining feed value.

Calcium and phosphorus content are important to some hay buyers. The National Research Council suggests that dietary Ca:P ratios between 1:1 and 7:1 result in normal performance provided phosphorus consumption meets livestock requirements. However, sensitivity to Ca:P ratios in ra-

Table 2. Forage quality standards for legumes, grasses, and legume-grass mixtures.[a]

Standard[a]	RFV[b]	ADF %[c]	NDF %[c]	DDM %[d]	DMI[e]
Prime	>151	<31	<40	>65	>3.0
1	151-125	31-35	40-46	62-65	3.0-2.6
2	124-103	36-40	47-53	58-61	2.5-2.3
3	102-87	41-42	54-60	56-57	2.2-2.0
4	86-75	43-45	61-65	53-55	19.-1.8
5	<75	>45	>65	<53	<1.8

[a]All values are based on forage dry matter as per standards of the Hay Market Task Force of the American Forage and Grassland Council (1986).

[b]Relative feed value (RFV) = (DDM x DMI)/1.29. A reference RFV of 100 = 41% ADF and 53% NDF is roughly equivalent to alfalfa in full bloom.

[c]ADF = acid detergent fiber and NDF = neutral detergent fiber.

[d]Dry matter digestibility (DDM%) = 88.9 - (0.779 x ADF%).

[e]Dry matter intake (DMI) as % of body weight = 120/Forage NDF.

tions may vary with nutritional requirements and livestock class. Alfalfa hay with high Ca:P ratios can be fed safely if rations are adjusted to ensure consumption of adequate phosphorus levels. Occasionally, some harvest lots of alfalfa hay produced on high pH soils in the western United States have been observed to have Ca:P ratios as high as 18:1.

Forage quality characteristics and standards

In 1986, the Hay Market Task Force of the American Forage and Grassland Council (AFGC) developed forage quality standards for legumes, grasses, and legume-grass mixtures. The AFGC standards for crude protein (Table 1) were developed independently from ADF and NDF (Table 2) as explained below. In 1998, the USDA Hay Market News Task Force improved uniformity of hay pricing information by adopting a modified version of the AFGC standards (Table 3). A description of the visual characteristics associated with each market class appears below. The USDA Market News Hay Quality Designations use only RFV and ADF to quantify standards for legume and legume-grass mixtures, and only crude protein is used for grass hay.

Table 3. USDA Market News Hay Quality Designations.[a]

Legume or legume-grass hay mix		
Standard	**RFV**	**ADF %**
Supreme	>180	<27
Premium	150-180	27-30
Good	125-150	30-32
Fair	100-125	32-35
Grass hay		
Standard	**CP %**	
Premium	>13	
Good	9-13	
Fair	5-9	
Low	<5	

[a]Values based on forage dry matter standards of USDA Hay Market News Task Force (1998).

USDA market visual descriptions of hay quality:

Supreme = Very early maturity, pre-bloom, soft, fine-stemmed, extra leafy. Factors indicative of very high nutritive and protein content. Hay is excellent in color and free of damage. *Premium* = Early maturity, meaning pre-bloom in legumes and pre-seedhead in grass hays, extra leafy, and fine-stemmed. Factors indicative of a high nutritive content. Hay is green and free of damage. *Good* = Early to average maturity, meaning early to mid-bloom in legumes and early seedhead in grass hay, leafy, fine- to medium-stemmed, free of damage other than slight discoloration. *Fair* = Late maturity, meaning mid- to late-bloom in legumes, seedheads in grass hay, moderate or low leaf content, and generally coarse-stemmed. Hay may show slight damage. *Low* = Hay in very late maturity, such as mature seed pods in legumes or mature seedheads in grass hay, coarse-stemmed. This category should include hay discounted due to excessive damage, weed content, or mold. Defects will be identified in market reports when using this category.

The nutritional quality of hay is aptly characterized by CP, TDN, ADF, NDF, and RFV. Dairymen are particularly interested in analyzing hay for ADF and NDF to estimate digestibility and potential dry matter intake, respectively. Decreasing digestibility and intake of forages are associated with increasing values of ADF and NDF (Table 2). Forage RFV, a numerical index calculated from ADF and NDF, allows hay buyers to quickly rank different harvest lots on the basis of fiber content. Prime quality hay (Table 2) has less fiber and more digestible energy than lower quality hay.

For high-producing cows, Minnesota dairy operators prefer hay containing at least 18 percent CP, 28 to 35 percent ADF, and 35 to 45 percent NDF on a DM basis (Linn and Martin, 1991). Dairymen recognize that forage RFV, as calculated from ADF and NDF, is a much better predictor of potential animal performance than is CP. Furthermore, Minnesota and Wisconsin forage specialists have advised dairymen and forage producers that optimum forage quality of alfalfa is 20 percent CP, 30 percent ADF, and 40 percent NDF so that stand persistence and yield are not sacrificed for forage quality (Undersander and Martin, 1991). While milk producers can usually adjust dairy rations for alfalfa hay with an RFV as low as 124, they generally prefer to feed a higher quality hay. Bonuses paid for dairy quality hay in the Western High Plains Region from 1990 to 2000 appear in Table 4.

Table 4. Grower receipts reported for alfalfa hay in the Western High Plains[1].

Date	RFV	$/T
11-20-90	≥170	100
3-25-91	≥150	85-95
11-11-91	≥150	80-90
11-11-91	≥190	100-105[2]
10-12-92	≥150	90
10-12-92	≥165	100
8-30-93	150	90
8-30-93	127	75
11-22-93	150-160	115
11-22-93	120-150	90-100
1-24-94	212-213	125[3]
1-20-97	150-175	100-110
1-20-97	175-200	110-135
5-1-00	≥181	80-85
5-8-00	150-180	60-80

[1] Source: *High Plains Journal.*

[2] $15-25/T bonus for superior dairy quality hay in various areas of Nebraska; indicates equal to or greater than the stated RFV.

[3] Delivered freight on board to Colorado dairies from northeast Nebraska.

Can hay quality be too high? If extremely immature (low fiber content) alfalfa is the primary source of roughage in a dairy diet, optimal milk production may not be achieved because the supply of undegraded protein (bypass protein) could be insufficient, unless the diet is supplemented with a protein source resistant to ruminal degradation (Combs, 1990). However, high-quality immature forages are valuable when a dairy's primary source of roughage has a higher than desirable ADF content. In some instances, when alfalfa hay with an extremely low fiber content (early bud) is substituted for hay with a high fiber content (full bloom), the amount of concentrates fed in a dairy diet might be reduced by nearly 50 percent (Table 7).

Sometimes hay is prime for either CP or RFV, but not both. Therefore, CP standards (Table 1) have been developed separately from ADF, NDF, and RFV. As stated previously, dairy hay buyers will pay a bonus for prime quality hay because the low fiber content increases the digestibility and rate of intake by high producing milk cows. When available, alfalfa hay with ADF values of 30 or lower is preferred by dairymen. As a general rule of thumb, alfalfa

Table 5. Variations in relative feed value indexes of Wyoming alfalfa hay that exceeded 19 percent crude protein.

Harvest	Entry[a]	CP%	RFV	TDN%[b]	ADF%	NDF%
1st cutting	1	24.0	126[c]	61.4	30.4	48.0
	2	21.8	132	64.0	33.0	44.4
	3	21.1	219	71.5	21.1	30.8
2nd cutting	1	25.6	168	68.0	26.4	37.9
	2	20.2	165	66.0	29.5	37.1
	3	20.1	101	52.8	37.9	54.6
3rd cutting	1	21.7	261	74.4	16.7	27.1
	2	20.8	199	70.6	22.4	33.3
	3	19.2	273	73.3	18.3	25.4

[a]Data from selected entries in competitive hay exhibitions, 1987-89.

[b]Calculated TDN = 88.9 - (.779 x ADF%).

[c]This entry was immature, rain-damaged hay.

hay with an RFV greater than 150 will normally have ADF and NDF values lower than 30 and 40, respectively. Nutritive value of hay is not adequately reflected by crude protein alone (Table 5). Values greater than 150 for RFV generally reflect alfalfa stands harvested prior to reaching a stage of advanced maturity. When an RFV index is high, the associated CP percentage is almost always impressively high because a high RFV relates to plant immaturity (low fiber content). The correlation between plant immaturity and a high CP content is strong because an immature plant tends to have a high leaf to stem ratio. This ratio diminishes with increasing plant maturity. However, in some instances, a high CP content may occur in alfalfa hay with a rather low RFV. For example, alfalfa cut in a stage of advanced maturity may have a high CP value if leaves are not lost in the process of curing or baling the hay. An example of alfalfa cut near full-bloom and baled without loss of leaves appears in Table 5 as Entry 3, second cutting.

In Wyoming, third-cutting alfalfa (Table 5) growing from mid-August until frost, may not bloom and tends to be low in fiber and high in TDN and RFV due to decreasing temperatures and day length. Third-harvest alfalfa is frequently dairy quality. First and second harvest alfalfa also may have a prime RFV if cut by late-bud stage. Hay baled with excessive stem moisture is unstable and can become heat-stressed or fermented inside the bale. Heat-stressed hay may retain a relatively high CP content due to a proportionally greater loss of carbohydrates (digestible energy) than CP during spoilage. If leaf loss is minimal, rain-damaged hay usually will retain relatively high CP values because most leaf proteins are not as water soluble as nonstructural carbohydrates. However, rain- or heat-damaged hay tends to have lower digestible energy, TDN, and RFV values because some of the water soluble carbohydrates (sugars) are either leached by precipitation or consumed during fermentation. An example of hay harvested in a stage of immaturity and then leached by rain while in the windrow appears in Table 5 as Entry 1, first-cutting. The CP of this rain-damaged entry remained high because leaf losses during baling were minimized.

Degree of decline in hay's nutritive value depends on severity of heat or rain damage. Leaf shatter can be substantial due to heavy rain showers on a windrow or excessively dry conditions during raking or baling. When leaves are lost, values for both digestible protein and energy will be lower. On the other hand, a very light rain shower may result in only a slight leaching of water soluble carbohydrates from cured leaves and stems of hay in the windrow. If leaf loss is minimal, only a small decrease in digestible energy may occur. If severe fermentation results from baling hay at a high moisture content, extreme digestible energy losses may occur along with mold development.

Visual appraisal of physical characteristics and hay marketability

Prior to sale, hay should be visually appraised because numerous physical characteristics provide clues to quality. Hay always should be evaluated on a "harvest lot" basis. A harvest lot is considered to be one cutting from one field. Quality differences between alfalfa harvests (first, second, and third cuttings) in the western United States are somewhat predictable with traditional hay-making practices. Nevertheless, a skilled producer can make premium quality hay from any of these harvests.

Stage of maturity: A simple rule of thumb applies to all forages. Protein content and RFV are much greater for young, rapidly growing stems and leaves than for mature, senescent tissue (Table 6). In other words, plant tissue digestibility and forage intake by livestock usually decrease with increasing plant maturity. Stems are less nutrient-dense and less digestible than leaves, and differences become more pronounced as plants mature. The quality of alfalfa leaves diminishes only slightly with increasing plant maturity, but the quality of grass leaves, on the other hand, may decline sharply with maturity.

Stems are leaf support structures that contain more fiber and structural tissue than leaves. Constituents responsible for the rigidity of stems range from slowly digestible to totally indigestible. Mature forage's protein content, digestibility, and RFV levels are lower than those of immature forage due to dilution of nutrients by increasing amounts of structural tissue.

Lower, older leaves are lost as stems elongate and increase in maturity. Younger stems tend to have a greater proportion of leaves than mature stems. Plants in advanced stages of maturity are usually flowering or seed bearing. Leaf losses due to shading from the lower parts of older stems are sometimes compounded by water stress and fungal and bacterial diseases. The declining ratio of leaves to stems with plant aging will lower the digestibility of a forage crop.

Baled hay can be visually inspected to determine maturity at harvest, but an analysis for ADF and NDF is more conclusive evidence of forage quality. Excessive leaf shatter will lower the RFV of immature hay if

Table 6. Influence of harvest date on quality and yield of first cutting alfalfa, Riverton, Wyoming.[1]

Date	Stage of maturity	Tons/A DM yield	Relative feed value	% Crude protein			Plant part components:	
				Whole plant	Leaves	Stems	% Leaves	% Stems
5-16	pre-bud	0.96	309	27.1	31	16	67.5	32.5
5-23	early bud	1.30	255	26.1	32	18	57.9	42.1
5-27	bud	1.41	215	23.7	30	16	54.9	45.1
6-03	late bud	1.76	196	21.7	31	14	45.4	54.6
6-09	early bloom	1.80	134	19.2	29	12	41.9	58.1
6-17	bloom	2.40	124	17.6	28	11	36.5	61.5
7-01	late bloom	2.30	104	15.3	26	9	37.0	63.0

[1]Source: Alan Gray, Wyoming Honor Farm, 1988. All values reported on dry matter basis with samples oven dried at 140° F (60° C) for 48 hr. To convert tons/A yield to 12% moisture hay, multiply by 1.102.

dry conditions prevail during raking and baling. Hay mowed in bud to late bud stage usually has few or no blooms. Hay with numerous blooms or seed pods indicates an advanced stage of maturity or water stress prior to harvest.

Leaf capture and retention: Leafy hay tends to be nutrient dense. Leaves can make up 50 percent of the total dry matter of good quality hay. In mature alfalfa hay, leaves may have almost three times the protein content of stems (Table 6). For example, the CP content of alfalfa harvested at a stage of one-tenth bloom[1] can be 18 to 19 percent before harvest losses. Leaves and stems analyzed separately for CP may test around 29 percent and 12 percent, respectively. Any practice during mowing, raking, curing, baling, storing, or feeding that results in leaf loss or reduction in leaf quality will lead to a reduction in feed value.

Leafiness can be characterized as degree of capture and retention. *Leaf capture* is maximized when hay is baled without substantial leaf loss, which may be increased by baling dry hay in very low humidity. Leaf capture is determined by examining individual flakes of a bale. *Leaf retention*, on the other hand, relates to the degree that leaves remain attached to stems when flakes are removed from a bale. Sometimes leaves are observed to be well-captured in the bale but detached from the stems. Excellent capture and retention of leaves in the flake are most desirable. Hay with excellent capture but poor retention of leaves can be bunk fed to minimize nutrient losses.

Fall-harvested alfalfa frequently exhibits excellent capture and retention of leaves because hay in the windrow takes longer to cure due to shorter days, cooler nights, and heavier dew. Consequently, third-cutting alfalfa is usually baled at a higher moisture content and with better leaf retention than first or second cutting. "Stemmy" hay usually results from leaf loss

1 (of 100 random stems, 10 have at least one open flower)

due to raking or baling during excessively dry conditions. Stemmy hay also may result from harvesting stands in advanced stages of maturity when leaf to stem ratios are poor or when windrows have been turned to allow additional drying due to rain.

Rain damage: Hay exposed to heavy or repeated light showers will be lower in digestible energy (Table 5, first cutting, Entry 1). Crude protein content of rain damaged hay will depend on the presence or absence of leaves. Highly soluble and digestible sugars are protected in the live plant cells. When plants are harvested, cellular membranes shrink and rupture as tissues dry during the curing process. Cellular contents are about 98 percent digestible and well-retained if cured hay remains dry. However, once hay is cured, the water soluble content of plant cells can be leached by precipitation. The effect is similar to placing a tea bag in a cup of water. However, plant proteins are somewhat insoluble in water and, consequently, CP losses usually are due to leaf shatter rather than precipitation.

Generalized statements that estimate rain damage are questionable without a forage analysis. Degree of rain damage to hay varies so that general rules are not particularly reliable. Losses in dry matter yields of up to 5 percent have been observed for each inch of rainfall while hay is curing. However, nutrient analysis is the best procedure to address potential quality losses due to rain, spoilage, or leaf shatter.

Hay color: Although hay color is a strong clue to environmental conditions during harvest, it is not a reliable measure of either nutrient content or potential hay intake by livestock. Bright green hay usually indicates a rapid cure, no precipitation, and minimal exposure to sunlight. Sunlight bleaches hay and accelerates the normal decline in carotenoids (Vitamin A precursors). Vitamin A content of hay stored in ideal conditions will decline, but this is relatively unimportant because most livestock receive vitamin A supplements. Exposure to sunlight will not lower hay's digestible protein or energy. Hay that has been streak-bleached in the windrow by a heavy dew usually retains quality. Reliance on color as a sole indicator of quality is unwise. Sometimes a bright green, well-cured, mature hay is lower in feed value than a less mature, slightly weathered, or fermented hay. However, quality of hay weathered and browned excessively by precipitation is significantly diminished.

Bright green, mold-free, leafy hay is attractive and in high demand by the horse hay market. Generally, horse hay buyers are more concerned with hay condition and color than with nutrient content.

Heat stress damage: Hay packaged in conventional, small square bales above 18 percent moisture may undergo fermentation, produce heat, and tend to brown. Hay stressed by mild fermentation and resulting heat may be diminished somewhat in digestible energy but enhanced in palatability due to sugar caramelization. Heat stress and damage can be magnified by increasing either bale density or moisture content of high-moisture hay. In 1 ton bales, fermentation may begin at moisture contents of 15 percent or greater. Brown hay with an odor similar to tobacco or silage usually indicates fermentation and heat stress. Excessive heat stress might reduce both digestible energy and protein.

Whether or not some of the protein in hay binds to plant carbohydrates (making it unavailable) is debatable. The degree of bound protein would depend on how high interior bale temperatures become and for what duration. Wyoming research tends to show that the quantity of bound protein in hay baled at high moisture is less important than the degree of mold produced.

In extreme cases, hay will combust spontaneously if baled and stored at 30 to 40 percent moisture. Extreme heat stress produces hay that is black to brown, moldy, and very pungent with a low feed value. Bale temperatures of 130 to 140 degrees Fahrenheit are the result of digestible plant sugar fermentation by microbes. Temperatures that do not exceed 120 degrees Fahrenheit may recede rapidly with little negative impact on hay quality. Temperatures of 150 degrees Fahrenheit or greater are due to chemical reactions that lead to spontaneous combustion.

On the other hand, hay baled in small rectangular bales at a moisture content of 20 to 22 percent may undergo a mild "sweat" (fermentation) with a slight caramelization and discoloration but little impact on quality. Such hay varies widely in appearance from a dark, olive-green to a golden brown with a tobacco-like aroma. In some instances, hay packaged in small, rectangular, moderately dense bales at 20 percent moisture content might not mold or heat significantly if field-dried at low humidity prior to being stacked or transported to a humid region. The stability of hay baled at 20 to 22 percent moisture depends on air temperature, humidity, soil moisture, and bale density.

Mold: The aroma of recently mowed, properly-cured hay is a quality standard recognized by most hay buyers and sellers. Musty, moldy, or otherwise foul-smelling hay can decrease palatability and consumption. Hay molded by exposure in the stack or by baling at a high moisture content may not be readily acceptable to livestock. "Dusty" hay is more frequently due to a very fine mold rather than from soil particles. When dusty hay causes sneezing or a nose-burning sensation, mold is probable. A laboratory analysis of hay for mold content is costly and sometimes inconclusive because the spectrum of hay mold types is broad. Hay mold, quantity, type, and toxicity vary with conditions. Horse hay buyers generally avoid moldy, dusty, or off-colored hay.

Texture: Hay texture ranges from soft and pliable to hard and coarse. Texture varies widely among harvest lots. Soft, pliable, leafy hay might be more acceptable and readily consumed with less waste than a hard, stemmy, coarse hay. Hay with superior leaf capture and retention tends to be soft and pliable. Hay texture can be influenced by plant maturity and moisture content at baling. Some types of hay, whether stemmy, weedy, or fermented, may have a distinctly hard, coarse texture when compared to a softer, more pliable, well-cured, leafy hay. Stem size, fiber content, and maturity at harvest, while somewhat important, do not influence hay texture as much as environmental conditions during curing or baling. Soft, pliable, leafy hay is more attractive to horse hay buyers than is coarse, stemmy hay.

Weeds: Broadleaf and/or grassy weeds are considered foreign materials that lower the quality of alfalfa, prairie hay, or improved grasses. Thick-stemmed and/or succulent weeds tend to cure poorly, mold, and spoil

Table 7. Milk yield of cows in early lactation when fed three maturities of alfalfa.

	Early bud	Late bud	Full bloom
Ratio of forage to concentrates	66:34	49:51	40:60
Milk yield lbs/day	73.9	72.8	74.4

Kaiser and Combs, Univ. of Wis., 1989.

when baled. Spiny weeds may injure livestock, as well as reduce nutritive value and palatability of hay. Native and improved pasture grasses usually cure well and are better in quality than broadleaf or grassy weeds but lower in quality than good alfalfa hay. Premium quality hay generally has a minimum of foreign material.

Hay storage: Good storage practices help retain hay quality. Digestible energy may decline rapidly in a few months if hay is left unprotected from precipitation. Exposure to sunlight alone has little impact on either energy or protein content. If hay is not invaded by insects or rodents and is protected from moisture, quality may remain well preserved for years. Stacks covered with plastic need to be properly ventilated to prevent moisture condensation. Hay buyers should determine the dry matter (DM) content of hay purchased directly from the field or a stack to ensure hay has stabilized and is unlikely to spoil.

Nutrient content and animal performance

The ability to predict animal performance is the primary reason to analyze forages for nutrient content. This concept is best demonstrated with dairy cows that consume different qualities of alfalfa hay. Table 7 shows that milk yields can be maintained by adjusting forage to concentrate ratios when feeding alfalfa hays of different maturities. Studies in California and Idaho (Mayland et al., 1998 and Putnam et al., 1998) suggest that cows prefer alfalfa hay harvested in the afternoon and evening to hay harvested in the morning. Enhanced palatability and increased nutrient content of the afternoon/evening harvested hay resulted in increased feed consumption, body weight gains, and milk production of dairy cattle. Both forage grasses and alfalfa accumulate soluble sugars [total nonstructural carbohydrates (TNC)] during the day. Sugars are utilized by the plant during night respiration, causing a diurnal cycling of soluble sugars. The factors influencing the preference of cattle for afternoon harvested hay also are measurable with forage quality tests. In other words, afternoon harvested hay would have a lower fiber (ADF) content than morning harvested hay.

Grass Hay

Grass hay frequently ranges from 6 to13 percent CP, depending on species, stage of maturity at harvest, and nitrogen fertility. The hay of perennial or annual grasses may exceed 12 percent CP when harvested in an immature stage. Grasses are generally higher in NDF than legumes and therefore have a lower potential for dry matter intake by livestock. The presence of a legume in grass hay will elevate CP, TDN, and RFV. As a rule, the greater the proportion of a legume in a grass-legume mix, the greater the nutrient content of the hay. Grass hay or legume-grass hay is favored by some horse hay buyers.

Hay marketing tools and strategies

A harvest lot is usually considered to be "one cutting from one field, swathed within a 24-hour period." A universal truth is that even with prime-quality hay, the level of each nutritional parameter can vary from one harvest lot to another regardless of forage type or the producer's management style. Different harvest lots (i.e., first, second, and third cuttings) from a highly productive, uniform stand of weed-free alfalfa always will have different nutritional compositions, so a separate forage analysis must be conducted for each harvest lot. If a cash bonus is expected for superior-quality hay, documentation of quality with a forage analysis is necessary for each harvest lot. For details on coring and sampling hay on a harvest lot basis, see UW MP-63. Refer also to *A Standardized Visual Appraisal for Marketing Wyoming Hay*, UW B-947. Six western states and various federal agencies have forage-restricted areas where hay products must meet regional forage certification standards. This regional niche market presents unique opportunities to hay growers who have hay certified as noxious weed-seed free. The program is conducted by local weed and pest districts in Colorado, Idaho, Montana, Nebraska, Utah, and Wyoming.

Marketing hay products can be a challenge. Compared to grain, hay products are low value, bulky, difficult to transport, and impractical to blend prior to shipping. Even the most accomplished hay grower cannot avoid producing some harvests that fall short of dairy and/or horse hay market standards. One marketing strategy is to build a reputation for producing high-quality hay. The first step is to document quality with a forage analysis and then gain exposure to potential buyers by listing forage-tested products with hay and commodity listing services conducted by the Cooperative Extension Service, the State Department of Agriculture, or various private listing services. Another means of building a reputation and gaining exposure is participation in hay shows at county and state fairs. And finally, national and international reputations can be developed by participating in the National Hay Show, sponsored annually by the American Forage and Grassland Council (*www.afgc.org*), and the international competition at the Forage Analysis Superbowl, conducted at the World Dairy Exposition in early October (*www.agsource.com/sbentry.htm*).

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