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ALFALFA INSIGHTS

VIRENXIA'S NEWSLETTER ON ALFALFA, THE QUEEN OF FORAGES

ALFALFA QUALITY TERMS EXPLAINED

Understanding the basic terminology and meaning of alfalfa quality terms helps in the evaluation of a forage's ability to produce a desired level of animal performance when it is consumed. Interpretation of alfalfa forage quality laboratory results may seem complicated, but can be simplified by focusing on the items of primary interest: protein, fiber, and total digestible nutrients.

In continuation to our last issue about forage quality, this issue helps in understanding forage quality terms and feed analysis reports.

UNDERSTANDING ALFALFA FORAGE QUALITY TERMS

Forage Quality Terminology, Laboratory analysis, can be used to determine the nutritive value of forages and provide information needed to formulate animal rations. The maturity at harvest is important in determining alfalfa forage quality. Leaves are higher in quality and digestibility than stems, and the proportion of leaves in an alfalfa forage declines as the plant matures. When alfalfa is in vegetative growth, the proportion of leaves to stems is highest, which helps to maximize forage quality. **The yield of leaves will increase up until first flower and remain unchanged after that.** Stem yield continues to increase as alfalfa matures, decreasing forage digestibility and quality.

Not only will the stems make up a greater proportion of the total yield as alfalfa matures, the digestibility of the stem material also declines with advancing alfalfa maturity. **The fiber content of the stems increases, especially the lignin content which is the least digestible fraction of the fiber.** Harvesting and storage effects can also influence alfalfa forage quality. Leaf shatter, plant respiration, and leaching by rainfall during field drying of hay can reduce forage quality, even after cutting if not processed in a timely manner. Losses can also occur due to weathering and microbial activity during storage.

Important terms when interpreting alfalfa forage quality are as follows:

1 Dry Matter (DM)

The portion (weight) of the forage other than water is DM which is used in formulating rations. **Hay with moisture content less than 10% can be lower in palatability, but more than 15% may indicate a risk of mold.**

2 Crude Protein (CP)

An indicator of the protein content in the forage which is a mixture of true protein and non-protein nitrogen. CP content indicates the capacity of the feed to meet an animal's protein needs. Typical CP content in alfalfa is in the range of 18 to 25%. Alfalfa cut early or with a high percentage of leaves has a high CP content. Animals meet protein needs by breaking down plant and microbial (from the rumen) protein and reassembling as animal protein. Other terms include Rumen Digestible Protein (RDP) which is that portion of total protein that is degraded in the rumen, and Rumen Undergraded Protein (RUP) which is that portion of the protein not degraded in the rumen. NDFCP is neutral detergent fiber crude protein.

Typical CP content in alfalfa is in the range of 18 to 25%.

3 Acid Detergent Fiber (ADF)

The percentage of highly indigestible and slowly digestible material in a forage. This includes the cell wall portions of the forage which are made up of cellulose and lignin. Lower ADF indicates a more digestible forage, and **ADF values less than 35% are desirable for an alfalfa forage.** ADF can be an indicator of the energy content of a forage and is used in digestibility calculations. Acid Detergent Lignin (ADL) analysis can be performed sequentially on ADF residue. Lignin is the major factor influencing the digestibility of plant cell wall material.

As lignin increases, the digestibility, intake, and animal performance usually decreases. ADF values will be higher as lignin increases in a forage, or as alfalfa maturity increases.

4 Neutral Detergent Fiber (NDF)

The percentage of cell walls or fiber in a forage that is digested in a specified time, comprised of the ADF fraction plus hemicelluloses. NDF values reflect the amount of forage the animal can consume. They are inversely related to animal intake potential, with lower percentages indicating greater animal consumption. **NDF content less than 45% is generally desirable for an alfalfa forage.** Low NDF is better as long as there is a certain minimum fiber level in the ration to meet an animal's needs.

5 Neutral Detergent Fiber Digestibility (NDFD)

A newer term which is the percentage of the NDF that is digested by animals at a specified level of feed intake. NDFD is inversely related to animal intake and the energy that an animal can derive from a forage. This value can be used to rank alfalfa forages on potential fiber digestibility and in energy calculations.

6 Total Digestible Nutrients (TDN)

This can be an estimate of the digestible energy of a forage, representing the digestible fiber, protein, lipid and carbohydrate components. TDN in conjunction with protein and ADF can be instrumental in determining the overall quality and rations of the forage material when making feeding recommendations. Typical TDN values for alfalfa can be in the range of 60 to 70%.

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Other net energy values often calculated from TDN values are:

1. **Net Energy of Maintenance (NEM)** - an estimate of the energy value of a forage used to keep an animal in equilibrium (neither gaining or losing weight).
2. **Net Energy of Lactation (NEL)** - an estimate of the energy value of a forage used for maintenance plus milk production during lactation.
3. **Net Energy for Gain (NEG)** - an estimate of the energy value of a forage used for body weight gain above that required for maintenance.

7 Relative Feed Value (RFV)

An index for ranking forages based on combining digestibility and intake potential, calculated from ADF and NDF values. An index representing forage quality and one of the systems used by forage testing laboratories for many years. **RFV uses NDF and ADF as predictors of forage quality.** The NDF content is correlated with intake, and ADF is correlated with digestibility. RFV values are relative to a value of 100 which is the indicator of quality that can be equated to alfalfa at full bloom. For example, **when alfalfa is at pre-bloom, it would have higher nutritive value with an RFV greater than 100. Values less than 100 indicate mature alfalfa at post bloom.** Some growers raising or buying alfalfa will use RFV to evaluate or compare alfalfa quality when buying or selling the hay. It provides the producer or buyer with a simple means of comparing the performance potential any given forage has with other available like forages.

The NDF content is correlated with intake, and ADF is correlated with digestibility.

8 Relative Forage Quality (RFQ)

Another index used to rank forages by potential intake of digestible matter where 150 is considered milking dairy quality feed and lower indices are needed for other categories of animals. RFQ can be a better predictor of animal performance than RFV.

Value above 14% for legumes usually indicate soil contamination of forage.

9 Total Ash

Total ash is determined analytically by ashing the feed at 500-600 °C for 3-5 h. It is a measure of the total mineral content; the residue remaining after burning the sample. Value above 14% for legumes usually indicate soil contamination of forage. Sometimes the ash value can provide an indication of contamination of feeds with supplemental minerals or soil. Energy values can be estimated most accurately when ash is measured and taken into account.

10 Crude Fiber

Traditionally, fiber was defined as the undigested ballast or bulk in a feed. Crude fiber includes most of the cellulose but only a portion of the lignin and no ash. More recently it has been defined for ruminants as the indigestible or slowly digesting fraction of the feed that occupies space in the gastrointestinal tract. Historically, fiber was measured as crude fiber. Currently fiber is measured routinely as either ADF or NDF.

Summary

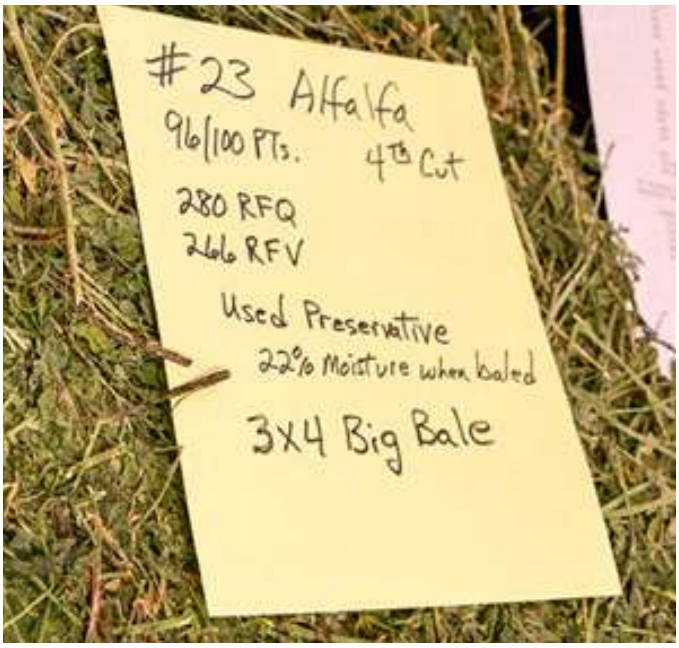
Factors having the greatest impact on alfalfa forage quality are stage of maturity at harvest and the harvesting and storage techniques. Alfalfa leaves are higher in quality than stems, and young stems are higher in quality than old stems. The more mature and fibrous an alfalfa forage, the longer it can take to be digested and the less an animal may consume. The ultimate measure of forage quality is animal performance.
Good animal performance results when animals consume forage that is high in nutrients and low in fiber.
The numbers provided on a forage test report are valuable but not absolute. Sampling technique and good laboratory procedures are important for obtaining useful forage quality results.

Source: Undersander, D., Cosgrove, D., Cullen, E., Grau, C., Rice, M., Renz, M., Sheaffer, C., Shewmaker, G., and Sulc, M. 2011. Alfalfa management guide. ASA/CSSA/SSSA publication

DETERMINING FORAGE QUALITY

UNDERSTANDING FEED ANALYSIS

A goal for any feeding program is to achieve an appropriate balance among available feed ingredients where total ration nutrient composition meets daily nutritional needs of the animal or animals. To accomplish such a feat on a day-to-day basis, one needs to have some information as to the nutrient content of feed ingredients. Tremendous variation exists in nutrient composition between different feeds. Even within a feed ingredient there is potential for significant variation in composition. This is especially true for forages. Forages harvested off the same field within the same year can have very different composition as influenced by environmental conditions and cutting time. In a previous column, the concept of forage quality was defined and its affect on a feeding program described. Low quality forages have less available nutrients, thus require larger amounts of supplements to be added. Unsupplemented low quality forages may predispose pregnant or lactating females to hepatic lipidosis or slow rate of gain in growing animals. Supplemental feeds are often cereal grain based and their over consumption may increase risk of digestive upsets and acidosis. Below mentioned are forage testing practices as they relate to evaluating quality of your forage.



Supplemental feeds are often cereal grain based and their over consumption may increase risk of digestive upsets and acidosis.

A variety of biologic, chemical, enzymatic, and other sophisticated analytical methods are used to evaluate nutrient content and availability of feeds. Chemical methods can directly measure quantities of compounds associated with an essential nutrient; however, they tell us nothing about availability. Biologic, enzymatic, and other sophisticated methods provide a more nutritional perspective to feed analysis; thus helping us to better understand just how the animal will interact with its feed.

Newer technologic advances have brought a rapid, lower cost analytical technique termed near infrared reflectance (NIR) spectroscopy. In general, NIR analysis has high accuracy in measuring crude protein and fiber fractions compared to wet chemistry, but is less accurate in measuring feed mineral content. Many certified feed analysis laboratories are capable of completing wet chemistry, NIR analyses, or both.

Figure 1. Comparison of essential nutrients, feed chemical composition, and analytical testing procedures.

Essential Nutrients		Chemical Components	Analytical Procedures	
Fatty acids, Fat-solvable vitamins		Lipids, pigments, sterols	Ether Extract	
Protein, amino acids		Nitrogen-containing compounds - Protein, Nonprotein nitrogen	Kjeldahl Procedure (Crude Protein)	
Inorganic minerals		Ash	Ashing (complete combustion)	
Carbohydrates	Glucose	Sugars	Nonstructural Carbohydrates**	Nonfiber Carbohydrates+
		Starches		
	Dietary fibre	Soluble Fiber		
		Hemicellulose		Neutral Detergent Fiber
		Cellulose	Acid Fiber / Detergent	
		Lignin*		

*Lignin is not truly a carbohydrate compound but is so intimately associated with cell wall carbohydrates that it is often included as such.
**Newer methods are being used to measure starch content.

As previously described, forage quality reflects the ability of a given forage to meet the nutrient needs of the consuming animal. Forage fiber content is the primary detractor to high intake and nutrient availability. Relative to assessing forage quality, fiber tests are our single best method, though additional tests for protein and moisture can help to further characterize the forage. The following are brief descriptions of forage analysis tests and their interpretation relative to forage quality.

Forage fiber content is the primary detractor to high intake and nutrient availability.

Dry Matter (DM)

Dry matter is defined as the non-moisture portion of a feed ingredient or diet. The sum of moisture and dry matter content of a feed on a percent of total will always equal 100. Dry matter contains the essential nutrients within a given feed ingredient or forage. Feeds, and thereby diets, vary widely in their moisture content. Pastures and liquid feeds have moisture content between 75 and 90% (10-25% DM). Dried feeds usually have less than 15% moisture (>85% DM). Moisture or dry matter content of a feed is determined by heating a weighed sample of feed in a convection drying oven until a constant weight is reached (24-48 hours). Dry weight is expressed as a ratio to original sample weight (moisture + DM) or converted to a percent. For example, a feed sample weighs 150 g wet and 50 g dry. The DM ratio would be 0.33 (50/150) and percent DM 33.3% (50/150 x 100). The moisture content of this feed would be 66.7% (100-33.3 or [150-50]/150 x 100).

Why is knowing moisture content important? One important aspect is our ability to compare nutrient content of different feeds on an equal basis.

Nutrient content of a feed can be determined on an "As Fed" (AF; moisture included), or dry matter (moisture excluded) basis. Intuitively, nutrient content will always be higher on a DM compared to AF basis for any feed. Feeds having more water content (i.e., pastures) will have much lower nutrient content than dry hay when compared on an as fed basis. From Table 1, it can be seen the pasture has much lower nutrient content on an AF basis; however, when corrected for water content, both pasture and hay have equal nutrient content. To appropriately compare these two feeds equally, nutrient content needs to be converted to a DM basis. Feed moisture determinations also facilitate calculations and monitoring of animal DM intake. Finally, DM determinations can be used to evaluate whether or not feed moisture content is within expected ranges.

For hay or any dry feed, moisture content should not exceed 15%, as this amount of moisture is necessary to promote mold growth.

Table 1. Comparison of nutrient content expressed on As Fed (AF) or Dry Matter (DM) basis for generic grass pasture and hay.

	Nutrient Density	%Nutrient Content				
	Basis*	DM	Protein	NDF	ADF	Calcium
Grass Pasture	AF	20	2.2	11.0	8.0	0.12
	DM	100	11.0	55.0	40.0	0.60
Grass Hay	AF	90	9.9	49.5	36.0	0.54
	DM	100	11.0	55.0	40.0	0.60

*Conversion formula: As Fed nutrient content = DM nutrient content x DM ratio or DM nutrient content = As Fed nutrient content/DM ratio. DM ratio is 0.2 for pasture and 0.9 for hay in this example.

The detergent feed analysis system is used to characterize fiber or total cell wall content of a forage or feed. That portion of a forage or feed sample insoluble in neutral detergent is termed neutral detergent fiber (NDF), which contains the primary components of the plant cell wall, namely, hemicellulose, cellulose, and lignin. As cell wall production increases, as occurs in advancing plant maturity, NDF content will increase. As NDF content of a feed increases, dry matter intake will decrease and chewing activity will increase. Within a given feed, NDF is a good measure of feed quality and plant maturity. t For grass forages, NDF < 50% would be considered high quality and > 60% as low quality.

Another measure of fiber is acid detergent fiber (ADF), a subset of NDF.

Acid detergent fiber contains the poorly digestible cell wall components, namely, cellulose, lignin, and other very resistant substances. Due to its nature, ADF is often used to predict energy content of feeds. Like NDF, ADF is a good indicator of feed quality; higher values within a feed suggest lower-quality feed. A goal would be to have < 35% ADF in either legume or grass forages.

For legume forages, NDF content below 40% would be considered good quality, while above 50% would be considered poor.

Crude Protein (CP)

Feed protein content is often considered a good determinant of quality. In actuality protein cannot be directly measured, it is estimated from feed sample nitrogen (N) content. On average all biological proteins contain 16% N, therefore protein content is estimated by multiplying N% by 6.25 (6.25 = 1) 0.16). Thus, crude protein does not differentiate between N in feed samples coming from true protein or other nonprotein nitrogen (NPN) compounds, nor does it differentiate between available and unavailable protein.

Although issues have been raised concerning application of crude protein as a feed measure, it continues to be a commonly used measure of feed quality. Crude protein content is very different across feeds, but within a feed, higher protein is usually associated with higher quality. This certainly is true in forages. As forages mature, their crude protein is diluted with increasing fiber content. Forage fertilization practices can alter this relationship, suggesting crude protein should not be solely used as a quality criterion without evaluating fiber content.

Energy

Energy content is often used to compare feeds and evaluate quality. Feed energy content is not directly measured like other nutrients but derived through regression equations. Traditionally ADF alone or with CP were used to predict energy value of various feeds. Most laboratories report feed energy values based on cattle equations, reporting total digestible nutrients (TDN) and net energy (NE) values.

NFC values >20 and >30%, respectively, would be considered higher quality

More recently some laboratories have offered an enzymatic analysis for feed starch content; helping to further define the more digestible portion of NFC, termed nonstructural carbohydrates (NSC). Higher values for NFC and NSC would reflect higher quality forages. For grasses and legume forages, NFC values >20 and >30%, respectively, would be considered higher quality, especially if associated with lower fiber values.

Other Feed Fractions

Additional analyses may be completed on a feed sample, including fat content (ether extract) and mineral analysis. Ether extract is a chemical method by which all lipid (fat) soluble compounds are extracted by being dissolved in ether.

Total feed mineral content can be measured by a procedure where the feed sample is completely combusted into ash. Mineral analysis is not always done since it is the most expensive test. Feed mineral content has no bearing on feed quality evaluation, but can provide insight as to the type of mineral supplement required.

Visual Assessment of Forage Quality

One can use their various senses to evaluate small amounts of forages, though sensory evaluation does not provide any sense of nutrient content. The table on the next page summarizes visual and chemical analysis of forages with guidelines for assessing quality.

Table 2. Visual Assessment of Forage Quality

Testing Method	Description/Comment
Sensory Evaluation	
Visual	
Stage of maturity	Look for the presence of seed heads (grass forages) or flowers or seed pods (legumes), indicating more mature forages
Leaf to Stem ratio	Look at forage and determine whether the stems or leaves are more obvious; good-quality legume forages will have a high proportion of leaves, and stems will be less obvious and fine
Color	Color is not a good indicator of nutrient content, but bright green color suggests minimal oxidation; yellow hay indicates oxidation and bleaching from sun, and hay will have lower vitamins A and E content
Foreign	Look for presence and amount of inanimate objects (twine, wire, cans, etc.), weeds, mold, or poisonous plants
Touch	Feel stiffness or coarseness of leaves and stems; see if alfalfa stems wrap around your finger without breaking; good-quality hay will feel soft and have fine, pliable stems
Smell	Good quality hay will have a fresh mowed grass odor; no musty or moldy odors
Chemical Testing	
Moisture/Dry Matter	Measures amount of moisture in forage; moisture content will determine how well the forage will store without molding; Goal for any hay <15% moisture (>85% dry matter)t
Neutral Detergent Fiber	Measures total cell wall content of plant and indicates maturity; the higher the value, the more mature and lower quality the forage; Goal < 40% Alfalfat
Acid Detergent Fiber	Measures the more indigestible portion of cell wall and reflects degree of lignification; Higher values indicate more mature, lower quality forages; Goal: < 35% Alfalfa
Crude Protein	Crude protein content reflects maturity of forage as well as fertilization amount; Good-quality forages generally will have higher protein content; Goal >15% for Alfalfat

Many factors influence forage quality, the most critical being plant maturity. Feeding programs consisting of low quality forage and limited variety of feedstuffs can potentially result in protein- energy malnutrition, failure to thrive and hepatic lipidosis disease problems. When hay is the primary forage in a feeding program, critical assessment of nutrient content via laboratory analysis is highly recommended.

Source: Robert J. Van Saun, Extension Veterinarian, Penn State Extension

ALFALFA: INNOVATIONS

NEW BALE MARKER TO IDENTIFY ALFALFA QUALITY

Hay producers and cattle feeders now can visually identify the relative feed value (RFV) of every alfalfa hay bale. A new feature of Harvest Tec's RFV Calculator is a bale-marking device that applies food grade dye striping to the side of the bale as it is being made. The striping identifies the level of RFV quality of the hay in that specific bale.

Harvest Tec recently introduced its RFV Calculator system, currently available from all large square baler brands. This "first of its kind" technology accurately determines the RFV of each bale, and enters that value into its record keeping software. Best of all, it can assign the value to each bale either with optional tagging equipment or with the dye striping. These colored stripes indicate a certain range of RFV. For example, **three stripes identify alfalfa bales that exceed 180 RFV, two stripes for bales 160 to 180 RFV, one stripe for bales 140 to 160 RFV, and no stripes for bales under 140 RFV.**

The RFV Calculator system has been tested at locations across the USA and found to be as accurate as the historical core sampling process. In many cases, it is more accurate than the traditional lab analysis method because it measures the value of the entire bale rather than the value of a single core taken from just one part of the bale.

Harvest Tec is once again bringing precision technology to the hay making industry. By sorting alfalfa bales according to their relative feed value, dairy producers can more accurately determine the proper ration for high producing cows, dry cows or heifers. In a recent study conducted by Utah State University under the guidance of **Dr. Allen Young, he determined that cows would produce four pounds more milk per head per day by feeding sorted hay compared to feeding the same hay taken randomly out of a mixed stack.** For hay sellers, this technology helps them establish a fair price based on their hay's actual quality.

To calculate each bale's RFV, Harvest Tec's system uses a precise moisture monitor, on-board computer and the baler's scale kit. To establish a base value, a field sample is sent to a lab when the field is cut. The lab's value is entered into the system's computer and the Harvest Tec software measures the RFV as the baler operates. It eliminates the tedious task of individual bale core sampling. And now it offers a two-way option for identifying the bale's feed value.

Source: Harvest Tec, Inc., USA

MARKET INSIGHTS

ALFALFA HAY

Alfalfa Hay market prices in US markets *(As of 30 July, 2019)*

Alfalfa hay prices reported to USDA from selected states.			
	Forage Quality Grade		
Location	Premium+	Good	Fair
	$ per ton		
California	160-280	170-210	160-170
Colorado	N/A	215-290	N/A
Idaho	170-208	140-155	135-140
Iowa	320	115-250	75-155
Kansas	170-235	160-175	90-165
Minnesota	175-280	120-190	115-180
Missouri	170-225	120-160	100-125
Montana	160-180	130	80-125
Nebraska	175-180	110-160	95-100
New Mexico	200-320	150(d)-220(d)	130(d)-150(d)
Oklahoma	257(d)-263(d)	127-210(d)	N/A
Oregon	200-230	150-180	N/A
Pennsylvania	385	225	N/A
South Dakota	200-220	100-160	90-125
Texas	240-330(d)	210-245	N/A
Utah	N/A	N/A	N/A
Washington	192-225	180-215(d)	170
Wisconsin	275	220-250	N/A
Wyoming	270	145-180	100

Source: USDA Hay market prices

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