PARAMETERS FOR GOOD QUALITY ALFALFA HAY

Glenn E. Shewmaker, Mireille Chahine, and Rikki Wilson[1]

ABSTRACT

When alfalfa hay is tested in a laboratory analysis, several forage quality factors are considered. Several dynamics come into play when determining the quality of alfalfa, such as maturity, weather, soil conditions, dry matter concentration, temperature, time of cutting, density, exposure to weather, and variety. There are certain target value parameters that alfalfa must meet to ensure optimal forage production. Target values are considered on a dry matter basis with test results indicating percentages of protein, fiber content, energy values, digestibility, and minerals in the alfalfa. We recommend that forage be tested by labs certified by the National Forage Testing Association (NFTA) to minimize lab result error. Often the price and marketability of alfalfa is determined by the test results, therefore it is important that the producer and consumer have confidence in both the laboratory and the analysis. In the end, nutritional content and quality affect the bottom dollar of an operation and go hand in hand with animal production.

FORAGE SAMPLING AND TESTING ACCURACY

The proficiency of a laboratory depends on the methods used and the precision of laboratory techniques. Forage test values are not absolute! Several studies have documented sampling and lab errors. Results of a Utah State University study show that sampling is the largest source of error. Laboratory error is added to sampling error in the test analysis. Normally there is a +/-5% variation (error) in results, e.g. +/- 1.5% acid detergent fiber (ADF) or +/- 8 relative feed value (RFV). Usually a test of 31.5% ADF is not different than 30% ADF, and neither are tests of 172 RFV and 180 RFV. Proper training and conducting of sampling and laboratory analysis will minimize errors in predicting forage quality, but will not eliminate them.

CHOOSING A FORAGE TESTING LAB

Price and marketability of forage is often decided based on the laboratory test, which is why we highly recommend that you use labs certified by the NFTA. The NFTA is a volunteer group organized by hay growers to provide a system to certify forage testing proficiency of key nutrients. A NFTA certified lab must provide analysis on unknown samples, and must be within a certain variation of the mean. This certification provides the producer and consumer confidence that the laboratory is proficient at certain forage quality tests and has a quality control procedure (the lab knows their accuracy).

Variation of analysis from one lab to another is usually greater than variation within a lab. Therefore, it is recommended to choose a certified lab and stay with it to get consistent results. Forage quality is a multi-faceted system, the quality values are not absolute, and analysis is not adequately described

[1] G. Shewmaker, Univ. of Idaho Twin Falls R&E Center, P.O. Box 1827, Twin Falls, ID 83303-1827; M. Chahine, Univ. of Idaho Twin Falls R&E Center, P.O. Box 1827, Twin Falls, ID 83303-1827.; R. Wilson, Univ. of Idaho Gem County Extension, 2199 S. Johns Ave., Emmett, ID 83617. Published In Proceedings, Idaho Alfalfa and Forage Conference 3-4 February 2009, Twin Falls, ID, University of Idaho Cooperative Extension.

by any one variable. We should select a NFTA certified lab so that variability in analysis is minimized.

It is important to use the results of the forage and feed tests to formulate rations and adjust current management to the feedstuffs being fed. It is essential that the ration not only meets the nutritional requirements of the animals, but that it is balanced and not causing digestive upsets either.

If your laboratory analysis has values that are outside of the "normal" ranges, you should ask for more information from the laboratory and review how the sample was taken. The laboratory wants to do the best they can so communicate with them. They may re-analyze a sample for you. However, most of the error is the result of improper sampling prior to being sent to the laboratory (see chapter 8 in Bulletin 547, Idaho Forage Handbook). We recommend taking another sample, but this time take 3 sets of 7 cores per bag for a total of 21 cores from a single lot of hay. Analysis of three separate samples will give a better measure of variability in the stack. Many labs are willing to analyze 3 samples for the price of 2 to help you get more accurate results. Do not send a different sample to another lab and expect the results to be the same.

When a hay sample is tested at the forage lab, how does one determine if the results are reasonable? What are the optimal parameters for alfalfa hay?

Table 1. Target values for alfalfa hay
(On a dry matter basis)

Nutrient	**Optimal Range**	**Definition**[2]	**Reasoning**
Dry Matter (DM)	82-90%	The percentage of the sample that is not water (100 – moisture = DM).	Excessive moisture can cause spoilage and heat damage that decreases the quality of the hay. Large, dense bales should be >85% DM (<15% moisture).
Protein Terms			
Crude Protein (CP)	18-24%	The most common and dependable test of protein. 6.25 times the nitrogen content for forage, or 5.7 times the nitrogen content for grain.	High protein is desirable and can be obtained by harvesting at an early growth stage. Low protein may be caused by nitrogen losses due to rain, leaf loss during harvest, grass and weed competition, and heat damage.
Available Protein	As close as possible to CP	A calculated value adjusting total CP for heat damaged protein using Acid Detergent Insoluble CP (ADICP).	Unavailable protein may pass through the animal without absorption or benefit to the animal.
Acid Detergent Insoluble CP (ADICP)	1.1-1.7%	This determines the indigestible protein. 6.25 times nitrogen in acid detergent fiber (ADF) residue.	This is CP that is not available for digestion-higher levels (>1.5) indicate heat damage.
Soluble Protein as % of CP	35-47%	Quickly, almost instantly degraded protein in the rumen. 200-300% per hour.	This is the amount of the CP that is quickly degraded.
Degradable Protein	65-73%	Protein that is broken down at a	Amount of CP that has potential

[2] Source: Undersander, Dan. 2008. Glossary of Forage Quality Terms. National Forage Testing Association.

as % of CP		slower rate in the rumen.	to be degraded in the rumen.
Neutral Detergent Insoluble CP (NDICP)	2.4-4.3%	It has been suggested that the NDICP represents the portion of the undegradable protein that is available to the animal.	Amount of CP insoluble in neutral detergent solution and thus associated with cell wall. It is slowly degradable in the rumen and a big portion of it might escape ruminal degradation and get digested in the small intestine
Fiber Terms			
Neutral Detergent Fiber (NDF)	33-44%	Residue left after boiling sample in neutral detergent solution. If amylase and sodium sulfite are used during the extraction (this is recommended procedure), the fiber fraction should be called amylase-treated NDF (aNDF) to distinguish from original method. The NDF in forages represents the indigestible and slowly digestible components in plant cell walls (cellulose, hemicellulose, lignin, and ash). Contrast with *acid detergent fiber*.	NDF values will generally increase with maturity or with increasing grass composition. High NDF values are related to decline in animal intake. NDF is a different value than given by the older crude fiber method.
Acid Detergent Fiber (ADF)	26-34%	The least soluble constituents of the cell wall remaining after boiling forage sample in acid detergent solution. ADF contains cellulose, lignin, and silica, but not hemicellulose. This is a good indicator of digestibility.	Fibrous, least digestible portion of roughage. It consists of cellulose, lignin, insoluble ash (silica), cutin, and pectin. High ADF content is undesirable for same reasons as high NDF content.
Lignin	6.5-8.4%	Indigestible plant component, giving the plant cell wall its strength and water impermeability. Technically, a chain of phenyl propane units.	It increases as plant matures and reduces NDF digestibility. Higher temperatures during the growing season tend to increase lignin.
Energy Terms			
Non-structural Carbohydrates (NSC)	8-13%	NSC is from an enzymatic method to estimate the sugars, starch, organic acids, and other reserve carbohydrates such as fructans. It is a lower value than nonfibrous carbohydrates because NFC contains compounds other than starch and sugars.	Similar to total nonstructural carbohydrates, except all constituents for NSC are analyzed.
Non-fibrous Carbohydrates (NFC)	27-34%	An estimate of the rapidly available carbohydrates (primarily starch and sugars) in forage. This value is calculated from one of the following equations: NFC = 100% - (CP% +	Since NFC is calculated by subtraction, the result includes the additive errors of each component and depends on the NDF procedure, mostly.

		NDF% + EE% + Ash%) or, if corrected for NDFCP, NFC% = 100% - [CP% + (NDF% - NDFCP%) + EE% + Ash%]	
Crude Fat or Ether Extract (EE)	2-2.8%	Crude fat contains true fat (triglycerides), as well as alcohols, waxes, terpenes, steroids, pigments, ester, aldehydes, and other lipids.	An energy source with 2.25 times more energy than carbohydrates per unit.
Total Digestible Nutrients (TDN)	57-63%	The sum of digestible crude protein, digestible fat (multiplied by 2.25), digestible non-fibrous carbohydrates, and digestible NDF. For dairy cows at maintenance level: TDN_{1X} = [(NFC * .98) + (CP * .93) + (FA * .97 * 2.25) + (NDF * NDFD)] – 7 Where: FA = fatty acids = EE - 1	Amount of nutrients that are digestible. Can be used to express the energy value of the hay. TDN is often estimated by calculation from ADF, but with much greater error. Many different formulas are used for calculating TDN from ADF.
Net Energy for Maintenance (NEm)	0.53-0.62 Mcal/Lb	An estimate of the energy value of a feed used to keep an animal in energy equilibrium, i.e., neither gaining nor losing weight.	Mega calories of energy for maintenance.
Net Energy for Gain (NEg)	0.27-0.36 Mcal/Lb	An estimate of the energy value of a feed used for body weight gain above that required for maintenance.	Mega calories of energy for gain.
Relative Feed Value (RFV)	120-190	An index for ranking cool season grasses and legume forages based on intake of digestible energy. RFV is calculated from ADF and NDF as follows: RFV = [(120 / NDF) * (0.889 - (0. 779 * ADF))] / 1.29 It is used to compare varieties, match hay/silage inventories to animals, and to market hay.	A RFV of 100 represents full-bloom alfalfa hay containing 41% ADF and 53% NDF. The higher the RFV, the better the quality. Feeder quality hay is <160 and dairy quality hay is >160. Hay with RFV >180 should be fed with a total mixed ration or blended with lower quality hay.
Relative Forage Quality (RFQ) Index	100-200	An index for ranking all forages based on intake of TDN calculated by estimating digestible portions of protein, fatty acids, fiber (NDF), and non-fibrous carbohydrates. Formulas: RFQ = dIntake potential * dTDN / 1.23 Where:	RFQ is based on a more comprehensive analysis than RFV and it should be more reflective of the feeding value of the forage, especially grasses. RFQ is based on the same scoring system as RFV. The higher the RFQ, the better the quality. Same recommendations as above RFV.

		dTDN = TDN (defined above) with NDFD. dIntake potential for legumes = (120 / NDF) + (NDFD- 45) * 0.374 * 1350 / 100 dIntake potential for grasses = -2.318 + 0.442 * CP -0.0100 * CP^2 - 0.0638 * TDN + 0.000922 * TDN^2 + 0.180 * ADF – 0.00196 * ADF^2 - 0.00529 * CP * ADF Digestible fiber should be based on a 48-hr *in vitro* estimate. It is used to compare varieties, match hay/silage inventories to animals, and to market hay.	
Digestibility Terms			
In Vitro True Digestibility (IVTD) IVTD @ 30 hours IVTD @ 48 hours	 70-80% 75-83%	Determined by incubation of ground forage sample with rumen fluid in beaker or test tube for 24 to 48 hours. Followed either by addition of acid and pepsin and further incubation for 24 hours (IVDM or IVDMD), or boiling in NDF solution (IVTD).	An anaerobic fermentation performed in the laboratory to simulate digestion as it occurs in the rumen and small intestine resulting in a measure of digestibility that can be used to estimate energy.
Neutral Detergent Fiber Digestibility (NDFD) NDFD @ 30 hours NDFD @ 48 hours	 33-45% 41-53%	*In vitro* NDF digestibility of forages are evaluated by incubating forage in buffers and live rumen fluid, at body temperature, under anaerobic (no air) conditions. NDFD = (IVTDMD) / NDF) * 100 NDFD is expressed as a percentage of the NDF. The NDFD can be used to rank forages on potential fiber digestibility and in energy.	Higher values indicate higher intake and animal performance. Grass values are usually higher than values for alfalfa. Many lab reports list NDFd which is the proportion of IVTD to total dry matter, and as a result is a lower number than NDFD.
Mineral Terms			
Ash	<12%	An estimate of the total mineral content. The residue remaining after burning a sample.	Plant content is 6 to 8% and higher levels of ash indicate contamination by soil, which is not digestible.

REFERENCES

Dougherty, Dennis. Ph.D. 2006. Alfalfa Hay Quality Considerations. Dairy Biz.
Undersander, Dan. 2008. Glossary of Forage Quality Terms. National Forage Testing Association.