

ALFALFA HAY QUALITY: TERMS AND DEFINITIONS

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At the 22nd Kentucky Alfalfa Conference we discussed the relationship among Alfalfa - Yield-Quality-Persistence. In our presentation, we indicated that all three components must be considered for best management of alfalfa stands. Over the past week, I have looked through the past twenty-two years of Alfalfa Conference Proceedings. It's interesting, but not surprising that we have focused far more attention on yield than on quality and/or persistence.

Alfalfa yield (quantity) and quality are both important; however, it is easier for producers to recognize problems associated with quantity than quality because quantity can be easily assessed visually. Thus, forage quantity often receives far more emphasis than alfalfa quality and the result is that animal performance is often penalized.

Alfalfa hay quality has been defined in many ways, including protein, fiber, lignin content, total digestible nutrients, energy content, color, smell, texture, leafiness, fineness of stems, relative feed value, relative forage quality and other physical and/or chemical components (Figure 1). Each of these have merit and some are much better than others, but all fall short of clearly defining alfalfa quality. Factors such as average daily gain, conception rates, milk production, wool production, etc. are reliable indicators of alfalfa hay quality.

To accurately define forage quality, we must "link" it to animal performance. With the wide variation in animal performance expectation, it is easy to understand why no single definition will fit all animal species and production levels. Perhaps the best concise definition of alfalfa hay quality is: extent to which the hay has the potential to produce a desired animal response. With this working definition, one can quickly see a need for different levels of quality based on animal species, age, and production desired. Alfalfa hay quality required to sustain weight on a dry pregnant beef cow is considerably lower than needed by a stocker gaining 2.5 pounds per day. Likewise, quality required by a dairy replacement heifer or dry cow is considerably lower than required by the highest milk producing cow in the herd.

Our challenge is to have an understanding and appreciation for alfalfa hay quality, terms used to measure, and management factors affecting quality. Couple the above with an understanding of the quality needs of our animals permits us to economically and efficiently match our alfalfa hay based on quality to our animals based on nutritional needs.

Other speakers to follow will discuss many aspects relating to alfalfa quality. For more detailed information on making-testing-marketing alfalfa hay, I encourage you to attend the breakout sessions this afternoon. I also recommend you get a copy of the publication "Understanding Forage Quality" available at the KFGC display in the exhibit hall.

Figure 1. Glossary of Forage Quality Terms and Definitions.

Acid detergent fiber (ADF) – The residue remaining after boiling a forage sample in acid detergent solution. ADF contains cellulose, lignin and silica, but not hemicellulose. Often used to calculate digestibility, TDN and/or NEI. Contrast with *crude fiber* and *neutral detergent fiber*.

Acid detergent insoluble crude protein (ADICP) – The same feed fraction as ADIN that has been converted to crude protein equivalent by multiplying ADIN * 6.25.

Acid detergent insoluble nitrogen (ADIN) – Nitrogen in acid detergent fiber residue. ADIN greater than 15% of nitrogen is an indicator of heat damage. Formation of ADIN is also called non-enzymatic browning (because the hay or silage turns brown) or the Maillard reaction. Should be expressed as a percent of the dry matter (preferred) or of the nitrogen, not of ADF.

Acid insoluble lignin – Lignin measured using sulfuric acid. See *lignin*.

Adjusted crude protein (ACP) – A calculated value adjusting total crude protein for heat-damaged protein. Adjusted crude protein estimates the protein available for animal use and should be used for formulating rations when ADIN is greater than 15% of the total nitrogen.

Ash (also called total ash) – A measure of the total mineral content; the residue remaining after burning a sample. Values above 10% for grasses or 14% for legumes usually indicate soil contamination of forage. Ash, ADF-ash, and NDF-ash will be different values because ADF and NDF procedures remove some minerals.

As fed (As is) – Values expressed based on moisture content of forage when it was received in the laboratory.

Cellulose – A structural carbohydrate; a long-chain polymer of glucose that is the main constituent of plant cell walls. It is the most abundant carbohydrate in nature and is slowly and partially digestible by ruminants.

Crude fat – An estimate of the fat content of feeds that is measured by ether extraction. Crude fat contains true fat (triglycerides) as well as alcohols, waxes, terpenes, steroids, pigments, ester, aldehydes, and other lipids. See *ether extract* and *fat*.

Crude fiber (CF) – The original fiber method using sequential acid and alkali extraction (developed by Henneberg and Stohmann in 1865). Crude fiber includes most of the cellulose, but only a portion of the lignin and no ash. Therefore it underestimates true fiber and is less than ADF. It is seldom used for forage analysis. Contrast with *acid detergent fiber* and *neutral detergent fiber*.

Crude protein (CP) – This value is 6.25 times the nitrogen content for forage or 5.7 times the nitrogen content for grain.

Digestible cell wall – See *digestible neutral detergent fiber* (preferred term).

Digestible neutral detergent fiber (dNDF) – The portion of the neutral detergent fiber digested by animals at a specified level of feed intake. The dNDF of feeds may be determined by *in vivo* feeding trials or estimated by lignin analysis, *in vitro* or *in situ* digestibility, or by near infrared reflectance analysis.

Digestible energy (DE) – The energy in a forage or feedstuff that is not excreted in feces.

Dry matter (DM) – The percentage of the sample that is not water.

Dry matter digestibility (DMD) – The portion of the dry matter in a feed that is digested by animals at a specified level of feed intake. Called *in vivo* DMD if determined by feeding animals in a digestion trial. There is no laboratory method for measuring DMD directly; it is often estimated by measuring *in vitro* digestibility, *in situ* digestibility, near infrared reflectance analysis, or calculated from acid detergent fiber (the least accurate method of determination).

Ether extract (EE) – Portion of dry matter extracted with ether. Used to measure crude fat. See *crude fat* and *fat*.

Fat – Triglycerides of fatty acids that are a high density source of energy for animals. Fat is measured by determining content of fatty acids or is estimated in forages as ether extract minus one. Fats and fatty acids contain 2.25 times the energy found in carbohydrates and are highly digestible by animals. See *ether extract* and *crude fat*.

Forage quality – The ability of a forage to support desired levels of animal performance (e.g., daily gain or milk production). It is a function of voluntary intake and nutritive value.

Hemicellulose – Long chains of sugar compounds associated with plant cell walls.

***In vitro* dry matter digestibility (IVDMD)** – Digestibility determined by incubation of a 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 by boiling in neutral detergent fiber solution. See *dry matter digestibility*.

In situ digestibility – Digestibility determined by incubation of a ground forage sample in a porous nylon bag within rumen of an animal for a fixed time period.

Lignin – Undigestible plant component, giving the plant cell wall its strength and water impermeability. Lignin also reduces digestibility.

Metabolizable energy (ME) – The energy in a forage that is not lost in feces, urine, or rumen gases.

Metabolizable protein (MP) – The rumen undegraded protein and microbial protein that passes into the intestine and can be broken down into amino acids.

Modified crude fiber (MCF) – A modification of the crude fiber in which the ashing step is deleted. Modified crude fiber is crude fiber plus ash.

Moisture – The percent of the sample that is water.

Net energy for gain (NEg) – An estimate of the energy value of a feed used for body weight gain above that required for maintenance.

Net energy for lactation (NEl) – An estimate of the energy value of a feed used for maintenance plus milk production during lactation and for maintenance plus the last two months of gestation for dry, pregnant cows.

Net energy for maintenance (NE_m) – An estimate of the energy value of a feed used to keep an animal at a stable weight.

Neutral detergent fiber (NDF) – Residue left after boiling a sample in neutral detergent solution. Called aNDF if amylase and sodium sulfite are used during the extraction (this is recommended procedure). The NDF in forages represents the indigestible and slowly digestible components in plant cell walls (cellulose, hemicellulose, lignin, and ash). Contrast with *crude fiber* and *acid detergent fiber*.

Neutral detergent insoluble crude protein (NDICP) – Nitrogen in neutral detergent fiber residue. Estimates the portion of the undegradable protein that is available to the animal.

Neutral detergent soluble carbohydrates (NDSC) – See *nonfibrous carbohydrates*.

Neutral detergent solubles (NDS) – The portion of the forage that is soluble in neutral detergent solution and therefore is not neutral detergent fiber. Usually assumed to be 98% digestible.

Neutral detergent soluble fiber (NDSF) – Neutral detergent soluble material undigestible by animal enzymes.

Nonfibrous carbohydrate (NFC) – An estimate of the rapidly available carbohydrates in a forage (primarily starch and sugars). This value is calculated from one of the following equations: $NFC = 100\% - (CP\% + NDF\% + EE\% + Ash\%)$ or, if corrected for NDFCP, $NFC\% = 100\% = [CP\% + (NDF\% - NDFCP\%) + EE\% + Ash\%]$. Contrast with *total nonstructural carbohydrate*.

Non-protein nitrogen (NPN) – The portion of the total nitrogen that is not in protein. If high, NPN is an indicator of potential for nitrate toxicity.

Nutritive value (NV) – Protein, mineral, and energy composition, availability of energy, and efficiency of energy utilization.

Organic matter (OM) – The portion of the dry matter that is not ash (mineral).

Organic matter digestibility (OMD) – The portion of the organic matter that is digestible.

Protein – A long chain of amino acids essential for plant and animal life. Animals meet protein needs by breaking down plant and microbial (from the rumen) protein and reassembling as animal protein.

Relative forage quality (RFQ) – A new term and calculation developed by Dr. Dan Undersander, University of Wisconsin and Dr. John Moore, University of Florida. A replacement for RFV to provide a better index of how a forage will perform in an animal diet using the following formula:

$$RFQ = \frac{(DMI, \% \text{ of BW}) \times TDN, \% \text{ of DM}}{1.23}$$

DMI = dry matter intake
TDN = total digestible nutrients
BW = body weight

Relative feed value (RFV) – An index for ranking cool-season grass and legume forages based on combining digestibility and intake potential. Calculated from ADF and NDF. The higher the RFV, the better the quality. It is used to compare varieties, match hay/silage inventories to animals, and to market hay.

Rumen degraded protein (RDP) – That portion of total protein that is degraded to ammonia in the rumen.

Rumen undegraded protein (RUP) – That portion of the protein not degraded in the rumen. While often called *bypass protein*, *escape protein*, or *undegraded intake protein*. *Rumen undegraded protein* is the preferred term.

Soluble intake protein (SIP) – That portion of total protein rapidly degraded to ammonia in the rumen.

Soluble protein – Protein soluble in a specified solution. Can be used to estimate rumen degraded protein and rumen undegraded protein.

Total digestible nutrients (TDN) – The sum of crude protein, fat (multiplied by 2.25), non-structural carbohydrates, and digestible NDF. TDN is often estimated by calculation from ADF. The formulas for calculating TDN vary by region and by nutritionist.

Total nonstructural carbohydrate (TNC) – A measure of the starch and sugar in forages. It has a lower value than nonfibrous carbohydrates because NFC contains compounds other than starch and sugars. Same as nonstructural carbohydrate; contrast with nonfibrous carbohydrate.

Voluntary intake – Consumption of a forage when forage availability is not limiting.

SOURCE: Ball, D.M., M. Collins, G.D. Lacefield, N.P. Martin, D.A. Mertens, K.E. Olson, D.H. Putnam, D.J. Undersander, and M.W. Wolf. 2001. Understanding Forage Quality. American Farm Bureau Federation Publication 1-01, Park Ridge, IL.