Iowa Beef Center
IOWA STATE UNIVERSITY

Interpreting your forage test report

Forage testing is an important step in the process of using forages in livestock production systems. It provides a management tool to help determine if the forage you have is adequate for your livestock, or whether you will need to formulate more complex rations with other feed ingredients to meet the nutritional needs of your livestock. Different laboratories will report many of the same, standard nutritional values. Some laboratories also report values that will be more appropriate for ensiled forages, or for balancing rations for lactating dairy cows or for horses.

Forage lab test reports contain values that are analyzed, and values that have been calculated from your analysis. None of the values reported on your forage test report, either measured or calculated, should be considered to be "absolute." There always is some degree of variability associated with your on-farm sampling, and variation introduced in standard lab sample preparation and analyses. If two people sampling the same forage lot send the samples to the same lab, you could expect this 'normal variation' between samples to be in the range of +/- 0.5% for protein analyses and slightly more for fiber analyses. For example a forage lot with a 'true' crude protein value of 20% could differ anywhere between 19.5 and 20.5% due normally expected variation between samples.

As you study your forage test report, consider the following definitions and descriptions of laboratory analyses terms.

%Moisture & %Dry Matter

Labs determine the %moisture content of submitted samples by drying the sample, and calculate the %dry matter; (DM% = 100 - %moisture). Most lab analysis reports list test values on both the basis of %Dry Matter, and "As Fed", "As Is" or "As Received." Forage nutritive values should be evaluated, and **rations balanced on a dry matter basis.** Once the forage needs have been determined, the forage is then allocated or fed according to how many pounds of "as is" hay will meet those requirements.

The %moisture of the "as is" or "as received" forage is useful. It indicates whether the forage moisture is in the "normally expected range" for the specific type of forage: 12% to 20% for baled, "dry" hay; and 45% to 70% for silage. Moisture contents outside those ranges may indicate storage problems. Hay with excessively low moisture could indicate brittleness or excessive leaf loss. Forages ensiled too dry or hay baled too wet can heat excessively, reducing protein and dry matter digestibility and/or mold. Ensiling forages too high in moisture can lead to "seepage losses" and undesirable fermentation.

Crude Protein (CP)

The protein in a forage is important since protein contributes energy, and provides essential amino acids for rumen microbes as well as the animal itself. The more protein that comes from forage, the less supplemental protein is needed. However, most nutritionists consider energy value of forages to be more important than CP.

The crude protein content of a feed sample represents a mixture of true proteins, amino acids, nitrate, and non-protein nitrogen, such as urea and ammonia in a forage. Non-protein nitrogen has the potential to be utilized for protein synthesis by rumen microor-ganisms. The lab tests for the total nitrogen (N) in the sample and calculates the % crude protein by the calculation (CP% = N, % × 6.25).

Crude protein in feeds for ruminants can be further evaluated according to its rate of breakdown in the rumen. Some feed and forage protein is broken down in the rumen, while some will not be broken down in the rumen and will pass through to the lower gastrointestinal tract, where it may or may not be digested.

Some test labs designate these as rumen-degradable intake protein (DIP) and rumen-undegradable intake protein (UIP; or as "by- pass protein"). Laboratory separation of these **(Soluble Protein)** is based on a test of the solubility of the feed protein in a specified laboratory solution that simulates degradation in rumen fluid. Ruminant nutritionists may use the estimates of DIP and UIP to predict how efficiently fiber will be digested. They may recommend additional DIP for a high fiber, low protein diets. Excess soluble protein will be excreted by the animal as urea. Nutritionists may also recommend additional "protected" forms of protein supplements if there is not enough dietary "by-pass protein."

Protein Solubility

Soluble protein is a measure of the protein soluble in a specified solution. It can be used to estimate rumen degraded protein and rumen undegraded protein. Forages vary greatly in their protein solubility.
(See *Crude Protein*.)

Adjusted crude protein (ACP)

There is a small amount of feed and forage nitrogen that's chemically linked to and analyzed as forage fiber. This may amount to as much as 12% of the forages nitrogen content. This fraction is "normally occurring," and is "nutritionally unavailable" protein . It does not contribute to either DIP or UIP supply. Labs may list this unavailable, fiber-bound nitrogen as "Estimated **Neutral detergent insoluble crude protein**" (NDICP) , or "**Acid Detergent Insoluble Nitrogen or Crude Protein**" (ADIN or ADICP). If hay or silage heats excessively in storage, additional forage protein become unavailable for digestion and increases this estimate of this unavailable protein. Some forage analyses may list the unavailable fraction as "**Heat Damaged Protein**," but, it is more correctly called **Insoluble Crude Protein** (ICP). When the unavailable protein fraction exceeds 12% of the total crude protein, a calculated adjustment is made to account for it and a lab analysis valued called **Adjusted Crude Protein** may be listed. If there has been an adjustment made for excessive heat damage, the "Adjusted Crude Protein" value will be less than the "Crude Protein" value on the report. It there has been an adjustment, rations should be balanced on the forage "Adjusted Crude Protein" rather than its Crude Protein content.

NDF

Neutral Detergent Fiber (NDF) is the laboratory determination of the indigestible and slowly digested fibrous portion of the forage. It includes most of the cell wall material (hemicellulose, cellulose, lignin) and other indigestible plant materials such as tannins, cutin, some fiber-bound nitrogen**,** and some of the mineral or ash**.** Cell wall pectin is not a part of NDF. The plant cell wall fibers (hemicellulose, cellulose and lignin) represent the fibrous "bulk" of the forage. This "bulkiness" relates to animal digestive tract "fill" and thus is negatively related to the animal's potential intake of the forage. As the total dietary NDF level increases, *voluntary feed intake* tends to decline. NDF often is used in formulas to predict the dry matter intake of a forage.

The NDF (fiber content) of forages is influenced by type of forage, its maturity when cut or grazed, and its management. Grasses, as a group, are higher in NDF than legumes, thus, grasses generally have lower potential intakes than legumes. Early-cut, bud, or late vegetative stage legumes are low in fiber, and have the highest potential intake of any forages. Young, vegetative grasses also can have high intakes, but become increasingly higher in fiber and increasingly lower in intake potential as they mature with seedstems. If dietary NDF (or fiber) is too low, rumen function and digestive upset can occur. Nutritionists use forage NDF when assessing intake potential of livestock diets.

ADF (Acid Detergent Fiber)

Acid detergent fiber is a laboratory test that represents the least digestible fiber portion of forage. It is primarily the lignin, some of the ash, most of the cellulose and the insoluble forms of fiber-bound protein. It represents the amount of ingested forage that the animal does not digest! Therefore, ADF provides a good measure to use for estimating the amount of forage dry matter that will be digested. ADF often is used to calculate **total digestible nutrients** (TDN) and/or **net energy for maintenance** (NE_m):**net energy for lactation** (NE_l) and n**et energy for gain (NEg)**.

When comparing NDF and ADF, both are measures of forage fiber, the least digestible part of the forage. Forage that's low in both NDF and ADF represents a relatively high nutritive quality feed; a feed that is providing both higher potential intake and higher digestibility than a forage with high concentrations of NDF and ADF. Some of the dietary fiber is digestible by microorganisms in animals with either a rumen (e.g., cattle, goats or sheep) or hind-gut fermentation (e.g., horses, rabbits, guinea pigs) as part of their digestive tract. The difference between NDF and ADF is a good representation of this digestible fiber. Forage tests of legumes often have about 10 percentage points of dry matter difference between NDF and ADF. While grasses can have up to 20 percentage units difference between NDF and ADF, indicating a greater potential fiber digestion for grasses.

Estimated ND-ICP, ADI, and AD-ICP

Neutral detergent insoluble crude protein (NDICP) and **Acid Detergent Insoluble Nitrogen** or **Crude Protein** (ADIN or ADICP) are laboratory determinations of the amount of forage nitrogen (sometimes calculated as forage protein) that is "fiber-bound" and indigestible in the rumen and the intestine. A portion of this unavailable protein is considered to be normally occurring. Excessive heating in storage can render additional protein unavailable to digestion and is represented as ND-ICP, ADIN or AD-ICP). See *Adjusted Protein*. ADIN or AD-ICP should be expressed as a percent of the dry matter.

Starch and Non Fiber Carbohydrates (NFC)

Forages contain carbohydrates that are not part of the cell wall or the structural fiber. This fraction contains rapidly available compounds such as starches, sugars and pectin. **Starch**, **starch digestibility**, and **Non Fiber Carbohydrates** are being reported by some labs for corn grain and small cereal grains, corn silage, small grain silage, and TMR samples. The current preferred term for this collective group of carbohydrates is "Non Fiber Carbohydrates" (NFC). Laboratories determine NFC's using enzyme fermentation tests. The NFC and starch digestibility rates are not standardized tests and may not be provided by all laboratories, so producers and nutrition consultants need to work closely with their laboratories when interpreting these results.

pH (reported for ensiled forages)
The pH of an ensiled sample is a measure of its acidity. The pH of a silage is not used in ration balancing, but can be an indicator of the success (or possible problems with) the ensiling process. Good corn silage typically has a pH of 3.5 to 4.5 and hay crop silages 3.8 to 5.3.

Energy Calculations based on ADF

Some nutritionists would say that the greatest feeding value obtained from forage is energy; and an important part of ration balancing is to meet the energy needs of the animal. Several energy relationships are estimated from the ADF analysis on a forage test report. (*See ADF*). Among the energy values listed on forage analyses are:

--Total Digestible Nutrients (TDN)

Historically, TDN was the end-result value from a multi-step analysis of a feed or forage and was used to balance rations for energy. Today, reported TDN values are calculated, not measured values. Formulas for calcu-lat-ing TDN are often based on ADF and may vary by region and the nutritionist doing the calcula-tion.

-- Net Energy (NE)

Estimates the "useable" energy in a forage; the energy available to support an animal's needs for body maintenance and production. NE is further partitioned into the net energy neces-sary for maintenance (no gain or loss of body weight), growth (or gain in body weight) and lactation (produc-tion of milk). The NE requirements for maintenance, growth and lactation are denoted by **NE_m**, **NE_g**, and **NE_l**, respectively.

-- Digestible Energy (DE)

DE is an energy estimate provided by some laboratories that is used when balancing rations for horses.

Relative Feed Value (RFV) (for hays/haylages)

The various tests and estimates previously described can be used directly in ration balancing, but trying to use all these tests to evaluate quality differences in legume, grass and mixtures of legume-grass forages can be confusing. Relative feed value was established as an index to combine important nutritional factors (potential intake and digestibility) into one number for a quick, easy and effective method for comparing different forages and for providing a general evaluation of a forages feeding value or quality. RFV is calculated from ADF and NDF. Both ADF and NDF are measures of forage fiber, so, RFV is a representation of the impact of forage fiber relationships in animal nutrition.

As an "index," RFV varies above and below a base index value of 100. On the RFV index scale, full bloom alfalfa hay would have an index of 100. Forages with RFV's greater than 100 are of higher quality than the nutritional value of full bloom alfalfa hay, and forages with a value lower than 100 are of lower nutritional value than full bloom alfalfa. While grasses can provide very good nutrition for livestock, grasses are generally higher in both ADF and NDF than legumes, and thus grasses tend to be 'undervalued', nutritionally using RFV. Very mature grassed rank quite low on the RFV scale. RFV is not used by nutritionists to balance rations, but is sometimes used to compare hay lots, to match hay/silage inventories to the needs of various animal classes, and as a means to set a premium or discount when pricing hay.

A limitation of the RFV system is that it as-sumes constant relationships between NDF and intake, and between ADF and digestibility. Two forages can have identical fiber levels and RFV's but have very different fiber digestibility, producing different livestock performance. A newer comparative index system is being developed that can be more broadly applied across different forages, and that give more 'nutritional credit' to grass forages. This improved index is called **Relative Forage Quality Index (RFQ)** and is being included on forage test reports by some forage testing laboratories.

Minerals

An analysis of some of the minerals required by animals are included on most forage analysis reports. The most commonly tested are calcium (Ca), phosphorus (P), potassium (K), magnesium (MG), and frequently sulfur (S). Other minerals, called "minor" or "trace" minerals, are required in smaller amounts, and analyses of these trace minerals generally are not provided on standard forage tests. Trace mineral analyses are often special tests and are and added cost. The total mineral content of feedstuffs is called ash. Forages normally contain 3 to 12% ash on a DM basis. Excessive levels of ash in forage samples often indicate soil contamination and adversely affect forage dry matter digestibility.

File: Animal Science 11

Prepared by Stephen K. Barnhart, Extension Forage Specialist, Department of Agronomy, and Sherry Hoyer, Iowa Beef Center, Iowa State University.