The ABC's of Forage Analysis – Fiber & Digestibility

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High quality forages in dairy cow diets provide energy and nutrients that support milk yield. As we discussed in our first ABC's article on forage analyses, forages are typically variable in chemical composition. The primary reason for this variability is that forages are harvested at various stages of physiological maturity, but many other factors including harvest methods, plant variety, soil fertility, storage conditions, and weather conditions also play important roles. Because of this variability in chemical composition, it is important to analyze forages for chemical composition prior to formulating diets. It is important to obtain a representative sample of the forage so take many samples to create your composite sample since sampling error is often large. A future article will discuss sampling methods. In this article we'll take a closer look at the fiber component of your forage analyses, specifically fiber digestibility.

Measures of fiber: NDF and ADF

Fiber is an important component of forages that impacts the digestibility of plant organic matter. Organic matter includes everything except the water and inorganic minerals in the plant; it includes, for example, the proteins, carbohydrates, and lipids that are used by the cow for energy.

Terminology:
Neutral Detergent Fiber (NDF) – hemicellulose, cellulose, and lignin.
Acid Detergent Fiber (ADF) – cellulose and lignin.

For most forages, as plant maturity increases the amount of fiber (cell wall constituents) increases. Cell wall is often measured as **NDF**. Hemicellulose and cellulose are both structural carbohydrates that can be digested to some extent by rumen bacteria to provide energy to the lactating cow. These structural carbohydrates are digested by rumen bacteria more slowly than nonstructural carbohydrates (e.g. sugars and starches). **Lignin** is not a carbohydrate but an essentially indigestible compound. Lignin in the cell wall of plants reduces the digestibility of cellulose and hemicellulose by rumen microbes. Wood from trees is highly lignified and not very digestible. **Acid detergent fiber** is also a measure of plant fiber content, but ADF does not measure hemicellulose.

Predicting forage quality from fiber

As the alfalfa plant matures, the amount of fiber increases and digestibility of the organic matter decreases. If digestibility decreases, the energy content is also decreased because if the cow cannot digest the fiber, energy cannot be obtained. As the alfalfa becomes more mature or is harvested during the hot summer months, the ADF and NDF contents increases. Since lignin is essentially indigestible, and because it reduces fiber digestion by the rumen microbes, energy content (%TDN) decreases with increasing %ADF and % NDF. Energy content is not measured in the lab, but is predicted from ADF and NDF measurements. High quality alfalfa hay is low in ADF and NDF content.

Because of the relationship between fiber digestibility and energy content of forages, researchers began to study the digestibility of the fiber (NDF) fraction using *In vitro* and *In situ* methods.

More Terminology:
In vitro: often means using test tubes with rumen fluid to digest plant material.
In situ: often refers to using animals with rumen fistulas (openings into the rumen) to digest plant material.

Why use NDF and not ADF? There are many reasons. First, NDF is a better measure of total fiber because it includes hemicellulose. Second, legumes (example: alfalfa hay) and grasses differ; grasses contain more hemicellulose than legumes, making NDF a better fiber method to compare grasses with legumes.

What is NDFd and how is it measured?

While sugars, starches, and proteins are highly digestible in most plants, it is the range in fiber digestibility that sets forages apart. Neutral detergent fiber digestibility (NDFd) is a measure used to improve the predicted energy value of forages. Digestibility of NDF can be measured by either *In vitro* or *In situ* methodology. Incubation times vary, although 24, 30, or 48 hours are typical times used by commercial labs. Using the amount of NDF present at the beginning of the incubation and the amount of NDF remaining at the end of the incubation, NDF digestibility is calculated (often this is called **NDFd**).

Helpful Hint: NDFd values will vary across laboratories, as there will be differences in either rumen fluid (In vitro) or rumen environment (In situ). For this reason, it is important to compare forage reports from a single lab.

Let's look at an example.

A summary of corn silages, both conventional and BMR (brown midrib), from a commercial lab is shown in Table 1. The BMR gene in corn plants results in lower lignin content, which is important since lignin is indigestible and reduces plant fiber digestibility.

The conventional corn silage varieties contained 3.34% lignin (Table 1), while the BMR corn silage varieties contained 2.43% lignin. The average 30 hour NDF digestibility for the conventional corn silages was 59.9%, which results in a predicted energy value of 0.65 Mcal NEL/lb of silage dry matter. For the BMR corn silages, the 30 hour NDF digestibility was 68.5%, which results in a predicted energy value of 0.68 Mcal NEL/lb.

Table 1. Summary of Conventional and BMR Corn Silage

	DM	NDF	Lignin	30-hr NDF**	Predicted Energy*
Conv. Corn	34.5%	43.5%	3.34%	59.9%	0.65
BMR Corn	35.3%	44.9%	2.43%	68.5%	0.68

**30-hr NDF digestibility; *In vitro* methodology
*Mcal NEL/lb, calculated using the summative equations of W.P. Weiss, The Ohio State University, using 30-hr NDF digestibility

Why is NDFd important?

Yes, there is only a small difference in the predicted energy value between the two types of silages, but small differences are important when you consider (1) the amount of corn silage cows are consuming in the TMR and (2) energy intake is a limiting factor for high milk production. Fiber (NDF) is slowly digested and because it is only about 40 to 60% digested in the rumen, it has a fill effect in the rumen that can restrict feed intake. The dairy cow needs rumen fiber fill to create a mat to retain feed particles for digestion and maintain normal rumen function and pH. But that fiber mat must also be digested to provide energy to the cow and to allow the cow to consume more energy (TMR). Nutritionists use the information on NDFd in a variety of ways to best create a TMR for high milk production while maintaining normal rumen function, feed intake, and milk fat test.

To put some numbers (and potentially dollars) to the importance of NDFd, let's look to the results of a study reported in the Journal of Dairy Science. The study found that a one-unit increase in NDFd was associated with a 0.37 pound increase in dry matter intake and a 0.55 pound increase in 4% fat corrected milk. These responses are why nutritionists are paying closer attention to NDFd.

Take Home Message

The composition of your forages provides valuable information to feed your cows. It also provides information that aids in determining forage pricing. Forage carbohydrates can be thought about in terms of structural carbohydrates that are measured by NDF and ADF. The structural carbohydrates are limited in digestibility by lignin and for that reason NDF digestibility (NDFd) is often measured. Your nutritionist uses NDFd information to formulate diets that support high milk production.