



KNOW YOUR FORAGES



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A mature dairy cow consumes more than 3,000 pounds of forage each year. Her actual intake of hay or silage depends on many things. One major determinant of forage intake is its quality. The nutrient composition of a forage helps to explain expected animal performance.

Determining the chemical composition of forages is important. The amount of each nutrient in a forage, energy, protein, and mineral composition, needs to be determined before a diet can be balanced. Fiber content enables a nutritionist to estimate feed intake, digestibility of feed, energy content, and expected animal performance.

The most frequently asked questions regarding forage analysis include:

- Why should I have my forage analyzed?
- What components of the forage do I need to know?
- How do I get a representative sample of my forage?
- What is NIR and how does it differ from wet chemistry?
- Where can I get my forages evaluated?
- What recommendations exist for use of forage analysis results?

Why have forages analyzed?

Most dairymen in North Dakota try to limit feeds to home grown feedstuffs. In most cases that means the cows get some combination of prairie, native, or alfalfa hay, corn, sorghum, oat or barley silage, and grain. If your cows eat hay and grain, what is needed to increase their production? Unless your feeds have been analyzed, you can't answer this question. If you don't know the nutrient composition of the feed your cows eat, you don't know what nutrients are limiting production. Everyone wants to know how to improve production with the least amount of input. You can't determine what your cows need without knowing what nutrients they are already getting.

What components of forage do I need to know?

The most important components to identify are dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium (Ca), and phosphorus (P). Energy values can be calculated from ADF values.

Knowing forage dry matter (DM) content is important, especially when silage or haylage are fed. The actual amount of silage DM consumed by each



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cow depends on the quantity of silage eaten and its DM content. Typically, silage is about 32 percent DM, but may vary from 23 to 42 percent DM. If a cow receives 40 pounds of silage (32 percent DM) a day, she receives 12.8 pounds of DM. If the corn was wet when it was ensiled, DM may be as low as 25 percent. Feeding a cow 40 pounds of silage a day (25 percent DM) would only deliver 10 pounds of DM. If the corn was 38 percent DM when it was harvested, the cow would receive 15.2 pounds of DM.

If you underestimate DM content of silage or haylage, cows receive more than the estimated amount of DM from silage. This reduces intake of energy-dense grains. The end result is reduced milk production.

If you overestimate DM content of silage or haylage, cows get less than the desired amount of DM from silage. Overestimating DM can be detrimental in high producing cows, because high producing cows consume a larger amount of DM from concentrate feeds. The forage component represents a smaller portion of daily intake (30 to 40 percent on a DM basis). By over-estimating DM the actual amount of DM from forage can drop to as low as 20 percent of the diet. Metabolic upsets (acidosis, displaced abomasum) as well as milk fat depression may occur more frequently.

Crude protein (CP) represents the nitrogen fraction of the forage. True proteins (amino acids) and non-protein nitrogen comprise this fraction. This value does not differentiate between available and unavailable nitrogen. Some proportion of nitrogen in a feed is not available to the animal. Less than 3 percent of the protein in normal forages is unavailable. If hay is baled too wet, or oxygen is present in silos, heat damage can occur. Heat damaged forages are characteristically brown to black in color and have a sweet caramel-tobacco aroma. If your forage is heat damaged and it represents a large proportion of daily feed, you need to have a lab determine the amount of damage. Unavailable protein in heat damaged forages can exceed 10 percent of the total protein. This reduces milk production if protein is limiting in the diet. In such cases, the protein content of the forage should be discounted prior to balancing a diet. To complicate matters further, intake of a forage may be reduced if heat damage is extensive. This also results in decreased animal performance.

Fiber content of a forage is a very useful tool and must be determined. The rule of thumb is that as the fiber content increases in a feed, the energy value decreases and the feed intake potential by cattle decreases. A minimum amount of fiber must be provided to maintain proper rumen function. Some maximum amount of fiber intake also exists for each animal. Above that amount the animal is unable to consume more feed.

Fiber is determined by two lab procedures. The proximate analysis system uses crude fiber to estimate poorly digestible carbohydrates. Crude fiber is not a true chemical component. It is described as "the fiber fraction that is resistant to degradation in acid and alkali." This fraction represents a partial recovery of cellulose and lignin (Figure 1).

The newer and preferred system used to describe fiber constituents is the VanSoest analysis. Two fiber fractions are determined during this procedure. Neutral detergent fiber (NDF) represents the cell wall material. This value includes all components of the acid detergent fraction plus hemicellulose (Figure 1). Acid detergent fiber (ADF) consists of cellulose, lignin, heat damaged proteins, and acid insoluble ash (some minerals). Lignin is almost completely indigestible. The amount of fiber which can be degraded by rumen bacteria is inversely related to the amount of lignin in a forage. So, as lignin content increases, digestibility of fiber decreases. Reducing the amount of lignin in a forage maximizes digestibility. The best way to reduce lignin content is to harvest forages before they are mature. Once the forage is harvested you can not reduce lignin content.

"Total digestible nutrients" (TDN) is a calculated estimate of energy in a feed, based on proximate analyses. In the VanSoest system, TDN can be estimated by acid detergent fiber. Labeling forage is extremely important. For instance, you had a forage analyzed. The ADF content was 30 percent. The estimated TDN content of the feed could be 61.85 percent (legume) or 66.84 percent (corn silage).

Another estimate of energy in a forage is net energy of lactation (NE_L). The energy in a feedstuff is as useful for maintenance as for production. However, use of energy in a feedstuff differs for deposition of body tissue and maintaining body tissue. More energy is required to deposit body tissue than to maintain body tissue. For lactating dairy cows, NE_L is needed when balancing rations. NE_L is usually expressed as megacalories (Mcal) per pound or per 100 pounds of feed DM. Estimates of NE_L (Mcal per pound) can be made similarly to those for TDN: ADF is used in the calculation to estimate NE_L . A forage with 30 percent ADF may have .675 Mcal/lb (legume) or only .651 Mcal/lb (legume/grass mix).

Since TDN and NE_L values are both estimated by ADF, it is critical that ADF is determined as precisely as possible. Identification of sample type is also important. If a forage is labeled as alfalfa and it is an alfalfa/grass mix, a different set of equations should be used to estimate the energy values. It is the responsibility of the person submitting the sample for analysis to identify it appropriately. Label the sample as well as you can. If you know that the pasture was half weeds it should be labeled as such. Do not label a forage sample by what it should have been.

Equations used to estimate TDN and NE₁ should be determined for each region. Forages grown in various parts of the country differ dramatically in nutrient composition and availability. Although the equations used to estimate energy are beyond the hands of the producer, it is up to nutritionists to use reliable laboratories for feed analysis.

Taking a representative sample

The most important part of analyzing forages is taking a representative sample. Hay probes are effective when sampling dry forages. Take at least one core sample from each large bale in question (if you have less than 15 bales). If you have more than 15 bales, sample up to 15 bales from a field per cutting. Empty the probe contents into a paper bag or box. After all bales have been sampled, mix the contents of the bag or box. Do not separate out less desirable portions of the hay. If you feed the entire bale of hay to your animals, you need to send in a sample that represents the entire bale of hay. Fill a sealable bag with a portion of the contents of the box. Press out as much air as possible. Seal the bag. If bales come from different fields and cuttings, it is best to have bales from each field and cutting analyzed separately because nutrient composition can vary greatly. Try to obtain core samples from as many bales as possible. The more bales included in the combined sample, the more representative the sample will be.

If you know that there are one or two bales of quality hay and the remaining bales of hay are mediocre, sample the mediocre bales. The results you receive back from analysis will represent the majority of the bales of hay. It is better for the animals to get better hay occasionally (the few bales not sampled) than it is to include portions of the good bales. If you believe that some of the bales are good and some of the bales are not so good, divide the hay accordingly, store it separately, and have both types of hay evaluated. It is not uncommon to feed the higher quality hay to cows in early lactation and the poorer quality hay to cows in later lactation.

Sampling silage and haylage requires more effort than sampling dry hay. Once again, try to collect samples from many locations in the silo. Nutrient composition of silage retrieved from an upright silo will differ from the top to the bottom of the silo. Obtain a composite sample of the feedstuff, take a portion of the sample and fill a plastic bag. Immediately remove as much air as possible and seal the bag closed. Take care to minimize exposure of the sample to the sun or open air, as both act to dry the sample. The result would be overestimated dry matter. This translates to under feeding cows. Samples of silage should be retrieved from at least an elbow's depth to reduce the possibility of getting a sample that is too dry or too wet.

Where can I get my forages evaluated?

Once you have obtained a feed sample, immediately send it to the laboratory. Feed companies, elevators, and private laboratories analyze feeds. Your NDSU Extension Service county agent should be able to provide you with a partial list of laboratories capable of evaluating feeds.

Some values obtained are more reliable than others. Traditionally, feeds were analyzed by wet chemistry techniques, which were time consuming and costly. Dry matter, crude protein, fiber content, and mineral values from wet chemistry analysis are useful for diet formulation. More recently, "near infrared reflectance spectroscopy" (NIR) has been used for evaluation of feedstuffs. Dry matter, crude protein, and acid detergent fiber values from NIR analysis can be useful if the forage sample was predominantly one forage and labeled appropriately.

Many producers have questions about NIR. The precision of the results obtained from NIR relate directly to laboratory procedures. This can best be understood by describing the NIR procedure. Samples of feeds are ground to a very fine powder which is placed in a sample cup and loaded into the machine. Nutrient composition of a sample can be determined in seconds. This is much quicker than wet chemistry, which requires days for analyses. The chief disadvantages of NIR include expensive instrumentation, dependence on calibration procedures, method of data treatment, and lack of sensitivity for microminerals. Calibration of the machine used is a key point. Furthermore, equations must be programmed into the NIR machine to evaluate each feed type. It is important that laboratories compare results from NIR analysis to results from wet chemistry on a regular basis. If a feed is mislabeled the information provided by the machine will be incorrect. In many cases such differences will be dramatic.

The next major point is the equations used to estimate energy value TDN and NE₁. An equation must be established for each feed type evaluated. In many laboratories, the equations used were derived for forages grown in the Northeast. The nutrient composition of forages in the Northeast is quite different from similar forages grown in the upper Midwest. It may be quite imprecise to use equations developed for New York forages on North Dakota forages.

A pointer or two: When a sample is not "pure" it is important the label the sample appropriately, i.e., 50 percent alfalfa, 50 percent weeds. In most cases, forages that are of mixed varieties should be evaluated via wet chemistry. If only a few pounds of a mixed hay are consumed daily, it may not be as critical to know the exact nutrient composition of the forage. If you feed a total mixed

ration, send in individual feeds. Do not send a sample of a total mixed ration in for analysis. It is extremely difficult to get a representative sample of a mixed ration, and the dry matter content of the ration can change hourly and daily.

Recommendations

Once you get the results, what should you use them for? That's going to depend on the type of analysis. If a representative sample of your forage was evaluated by wet chemistry, you can probably rely on all the reported values. Dry matter, crude protein, fiber, estimates of energy, and mineral values should be used to determine diet composition of individual feed ingredients. If you didn't take a representative sample of the forage, use the results with some understanding that they do not represent the feed your animals will consume.

What about using results from NIR analysis? Again, a representative sample had to have been labeled correctly and sent in to the lab. If the forage was a mixture of a few grasses you should ask if the NIR machine has the needed equations to determine nutrient composition. Just because you get a nice computer printout back from lab analysis does not mean the numbers on the printout are valuable. If your hay was 90 percent of one type and sampled appropriately, there is more confidence in the values you receive for crude protein and ADF. Values for macro minerals (calcium, phosphorus, potassium, and magnesium) may or may not be precise.

Certain feedstuffs can be evaluated successfully with NIR while other feedstuffs should be evaluated under wet chemistry conditions (Table 1). Once you take the time to obtain a representative forage sample, be sure the method of analysis will provide useful nutrient composition data.

Knowing what's in your forages will allow you to formulate diets and maximize production. If you don't know the nutrient composition of your forage, you may be wasting nutrients. Spending \$15 to \$20 on forage analysis will provide added savings to livestock operations. In many cases, once forages are analyzed and diets are formulated to provide necessary nutrients at least cost, feed costs are reduced up to 30 percent and production is increased. Assistance in developing complete diets is available at your local NDSU Extension Service office.

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Table 1. Use of lab procedures to evaluate feedstuffs.

Feed type	NIR	Wet chemistry
Silage (pure)	yes	yes
Silage (mixed)	no	yes
Pure hay	yes	yes
Mixed hay	depends ¹	yes
Grain	yes	yes
Grain mix	depends ²	yes
Grain mix w/mineral ³	no	yes
Total mixed ration ⁴	no	yes

- ¹Label sample mixed hay. Find out if lab can evaluate properly.
²Label sample mixed grain and list types.
³Use caution to obtain a representative sample.
⁴TMR's can be evaluated via wet chemistry. However, it is difficult to obtain a representative sample. See text discussion.

Figure 1. Fractions of feed dry matter.

Proximate	Chemical fraction	Van Soest fractions
Ash ₁	Detergent soluble ash	cell contents
Ether extract	Triglycerides pigments	
Crude protein	Protein NPN	Neutral Detergent Fiber (cell wall)
Nitrogen-free extract	Sugar Starch Pectin	
	Hemicellulose	Acid Detergent Fiber
Crude fiber	OH soluble Lignin OH insoluble	Fiber (cell wall)
	Cellulose	
Ash ₂	Detergent insoluble ash	

Total ash = ash₁ + ash₂