Forage Quality Parameters Explained

Introduction

Some understanding of forage quality parameters for ruminant animals can help agronomists and crop consultants that are working with dairy farms to better manage forage production on the farm. Many things influence forage quality, including plant maturity at the time of harvest, variety selection, and crop species. Forage quality tests should be utilized to quantify and compare components, but results often include many acronyms. The focus of this fact sheet is to help agronomists understand the main forage quality components related to carbohydrates, fat, protein, and mineral content of forage.

Dry Matter

The first line of a forage quality report is the percent dry matter (DM). This is the material remaining after the sample is dried to remove water. To be useful for determining actual DM content of a forage on farm, seal the sample and mail it to the laboratory right after it is collected to minimize moisture loss during transport. Forage quality parameters are reported on a DM basis, or per unit weight of DM, unless otherwise noted.

Carbohydrates

Carbohydrates include fibrous and non-fibrous carbohydrates. Fibrous carbohydrates (fiber) are compounds that make up cell walls. Fiber enables rigidity in plants, is a major energy source for livestock, and promotes rumen health and cud chewing. A diet high in fiber is more slowly digested and decreases overall feed intake because the animal remains full longer. A balance between slowly digested fiber and rapidly digested carbohydrates is necessary.

Fiber can be broken down into three categories: cellulose, hemicellulose, and lignin. All three increase with plant maturity because cell walls thicken with age (Figure 1). Cellulose and hemicellulose are mostly digestible in the rumen. Lignin, an indigestible fiber component, often binds to cellulose and hemicellulose, blocking digestion. Brown midrib (BMR) crop varieties have lower lignin content, which increases digestibility.

Two indicators of fiber content are acid detergent fiber (ADF) and neutral detergent fiber (NDF). The names reflect a laboratory procedure: "neutral detergent" is isolated using a neutral wash, as opposed to an acid wash that is used to determine acid detergent fiber.

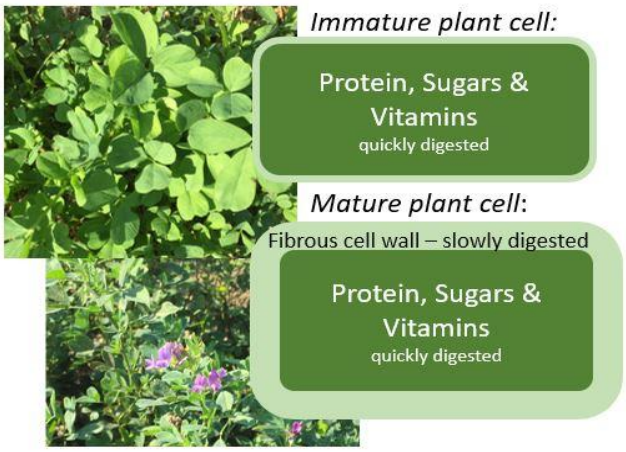

Figure 1: Mature plant cells have thickened cell walls, which increases fiber content, but decreases digestibility.

Acid detergent fiber is the measure of the cellulose and lignin content. Neutral detergent fiber is a measure of cellulose, hemicellulose, and lignin, and correlates well with animal feed intake. Issues arise if a forage has high levels of either proteins or soil contaminants, which can falsely inflate NDF estimates in the lab because these contaminants are left behind by the neutral wash. Energy content is estimated using NDF, so falsely inflated NDF leads to underfeeding of animals. If extra steps to remove non-organic contaminants and proteins are taken, it will result in an estimate of "aNDFom," a value that better represents fiber and energy content than NDF. The "a" stands for amylase, an enzyme, and "om" stands for organic matter. When contaminants are present, aNDFom is often lower than NDF. These corrections are important if a forage sample is particularly high in protein, or was harvested on sandy soil or during wet field conditions. Neutral detergent fiber digestibility (NDFD) describes the digestible portion of NDF. Digestion over different amounts of time are reported for NDFD, usually 24, 30, and 48

hours. When reported as percentage of NDF, NDFD will range from 40-60%, but it can be reported on a DM basis as well, resulting in lower values. Un-digestible neutral detergent fiber digestibility (uNDFD) describes the un-digestible portion, as percentage of NDF or DM.

Table 1: Appropriate ranges for high quality hay (grass and alfalfa mixtures) and corn silage in NY.

Feedstuff	Hay crop	Corn silage
NDF	48-55%	38-44%
Crude protein	15-25%	7-9%
Ash	<9%	<5%

http://ccedelaware.org/wp-content/uploads/2016/09/How-to-Interpret-a-Forage-Analysis-report.pdf

Non-fibrous carbohydrates, or NFC, are carbohydrates that do not make up the cell wall and can be digested quickly. This includes starches, sugars, and some acids. Non-fibrous carbohydrates are quickly digested in the rumen and used as energy by rumen microbes, or digested in the hindgut if they escape the rumen. Water soluble sugars (WSC) and ethanol soluble sugars (ESC) are two measures of simple sugar content, which range from 3% to 8% in good quality forage. Starch is found in the grain portion of forage crops and is energy dense. Starch ranges from 30 to 40% in corn silage, but is very low in hay.

Fat

Fats are essential to animal health to absorb some vitamins, provide insulation, protection, and for neural functions. Crude fat (CF) is a measure of all fat molecules, but it can include contamination from plant pigments, esters, and aldehydes. Total fatty acid (TFA) is a measure of fat that does not include these contaminants.

Protein

Crude protein (CP) is the total nitrogen (N) content of a forage, which is slightly higher than total protein because it includes non-protein N. See table 1 for appropriate CP ranges for hay and corn silage. Protein can be divided into subgroups. Soluble protein (SP) is an estimate of true protein and non-protein N that is digested in the rumen and used by microbes as a source of N. Soluble protein is targeted at 55% of crude protein or less. Rumen degradable protein (RDP) includes soluble protein as well as some other proteins that are partially digested in the rumen. This contrasts with RUP (rumen un-degradable protein) that bypasses the rumen. Neutral detergent insoluble crude protein (NDICP) describes RUP that is digested in the hindgut, as protein is in non-ruminant animals. Acid detergent insoluble crude protein (ADICP) is protein that is unavailable for digestion, most likely due to heat damage. On a forage quality report, ADICP is subtracted from CP to find available protein.

Minerals

Ash is the total mineral content in a forage, which includes inorganic compounds in the plant as well as soil contaminants. A high ash content indicates significant contamination by soil, which can inflate NDF. See table 1 for appropriate ash values for hay and corn silage. Mineral nutrients essential for metabolic functions are included in a forage report, including but not limited to Ca, P, Mg, K, Na, Fe, Zn, Cu, Mn, Mo, S, and Cl.

Summary

Carbohydrates, fat, protein, and mineral composition contribute to forage quality. These parameters vary based on crop species, environment, nutrient management, harvest time, and more. Testing forage for key quality parameters aids in creating a balanced ration.

Additional Resource

- "Understanding and Significance of Forage Analysis Results" by Dairy One: http://dairyone.com/wp-content/uploads/2014/01/Understanding-Significance-of-Forage-Results.pdf.
- "Understanding a Forage Analysis Report" by Cornell Cooperative Extension: http://ccedelaware.org/wp-content/uploads/2016/09/How-to-Interpret-a-Forage-Analysis-report.pdf.

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.cals.cornell.edu

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