Understanding Your Forage Test Results

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Forage analysis is a management tool that gives you the information you need to properly balance livestock rations. Unfortunately, forage test results can be difficult to interpret and use without understanding the terminology. This publication defines and describes common terms found in most laboratory forage reports.

Taking a representative sample is an important step for forage testing (Figure 1). You can find instructions for proper sampling of hay for all species of livestock on the Oregon State University Beef Cattle Sciences website (http://blogs.oregonstate.edu/beefcattle/). To ensure accuracy, use laboratories that are certified by the National Forage Testing Association (http://www.foragetesting.org/).

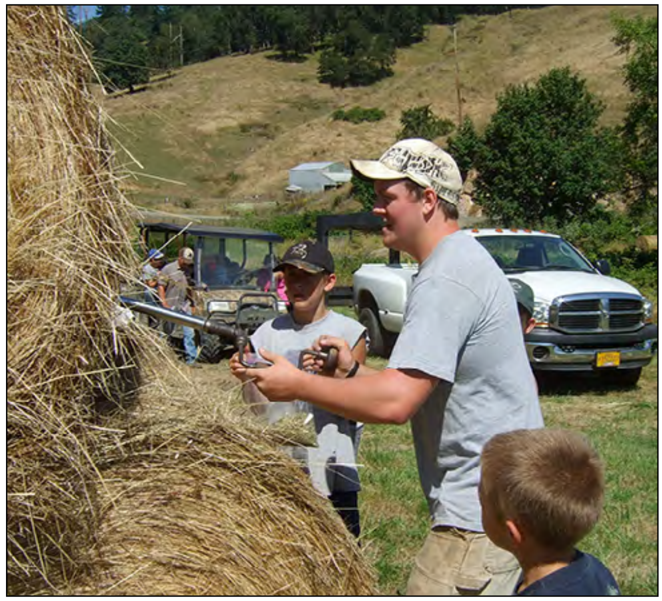

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Figure 1. Multiple core samples were taken with an approved hay probe, combined, and then submitted to the laboratory for testing.

Terms and Definitions

For the most part, forage laboratories conduct and report similar forage analysis tests. However, the presentation of results may be different among laboratories. See the sample test result sheet on page 5.

The following terms and definitions pertain to both ruminants and non-ruminants. Where differences occur, an explanation is included.

Feed

Moisture is the percent water in a sample.

As-fed is the actual feed, including moisture content, as it is offered to the animal. This feed is also called "as-sampled" or "as-received" if it has not been altered between sampling, testing, and feeding time.

Dry matter (DM) is the feed without the moisture:

$$DM\% = 100\% - Moisture\%$$

It represents everything in the sample—including protein, fiber, fat, minerals, and carbohydrates—without the water.

When balancing rations for livestock, be sure to correct for percentage DM. This is important for determining the actual quantities of feed (as-fed basis) to give your animals to meet nutrient requirements and/or performance expectations. For example:

Two sources of forage are available: one is 89% DM and the other is 40% DM. If you want your animals to consume 25 lb of DM, then on an as-fed basis the animals must eat 28.1 lb of the dryer feed and 62.5 lb of the wetter feed to consume equal amounts of DM.

$$25 \text{ lb DM} \div 89\% \text{ DM} = 25 \div 0.89 = 28.1 \text{ lb}$$
$$25 \text{ lb DM} \div 40\%\text{DM} = 25 \div 0.4 = 62.5 \text{ lb}$$

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Correcting for DM helps ensure that feeding programs provide the correct quantity of nutrients to meet management goals.

Dry matter basis (DM basis) means nutrient results for the sample with the water removed. Feeds vary in their moisture content, but nutrient content of feeds can be compared directly by disregarding the water.

For example, let's compare the crude protein (CP) content (see "Crude protein," below) of alfalfa-grass hay (90% DM) and corn silage (33% DM). Suppose the alfalfa-grass hay tested 9% CP and the corn silage tested 2.7% CP on an as-fed basis. Initially, it looks like the alfalfa-grass hay has CP levels three times higher than the corn silage. However, converting the nutritional value on a DM basis (without the water), the two feeds have relatively similar values:

The alfalfa-grass hay is 9 CP ÷ 0.9 DM = 10% CP

The corn silage is 2.7 CP ÷ 0.33 DM = 8.2% CP

Assuming equal dry matter (DM) intake, animals consuming the alfalfa-grass hay will get more CP compared to animals consuming corn silage.

Be sure to use DM values when you want to compare the nutritional value of different feeds. Also note that animal nutrient requirements are reported on a DM basis. Therefore, be sure to use those values when formulating diets.

Protein

Proteins are made up of amino acids. They are essential for reproduction, lactation, growth, and maintenance of the body.

Crude protein (CP) is an estimate of a feed's protein content. Most forage has a range of 4% to 24% CP on a DM basis. Laboratories measure the nitrogen (N) content of forage and then calculate CP as %N x 6.25. The factor 6.25 is used because protein is approximately 16 percent N (100 ÷ 16 = 6.25).

Crude protein includes both true protein and non-protein nitrogen (NPN). True proteins are organic compounds made up of amino acids. They are a major component of vital organs, tissue, muscle, hair, skin, milk, hormones, and enzymes. In contrast, molecules classified as NPN include urea, ammonia, and building blocks for proteins, such as amino acids and peptides. Dietary NPN may be useful when it is digestible and needed by rumen microbes.

Adjusted crude protein is the CP with adjustments for its availability to the animal. Some protein might be tied up with the fiber, making it indigestible.

Acid detergent insoluble nitrogen (ADIN or ADF-N) is a measure of the protein bound to fiber due to overheating of stored forage. This indigestible protein is called "heat-damaged protein." Some amount of ADIN is also the result of natural processes. If ADIN is significant, CP of a feed is listed as adjusted CP.

Carbohydrates

Carbohydrates are parts of the plant. They can be structural (cell wall components) or nonstructural (cell contents). Both serve as potential energy sources for the animal.

Structural carbohydrates

Neutral detergent fiber (NDF) measures three cell-wall components: hemicellulose, cellulose, and lignin. These carbohydrates give a plant structure and rigidity. Cellulose and hemicellulose can be partially broken down by microbes in the rumen to provide energy to the animal, but lignin is indigestible. Because of its bulk, NDF is negatively correlated with feed intake: the higher the NDF% of forage, the lower the intake. Generally, forages in Oregon range from 29% to 66% NDF on a DM basis.

Acid detergent fiber (ADF) is a measure of cellulose and lignin. It is negatively correlated with digestibility: the higher the ADF% of a forage, the lower the digestibility. Most forages in Oregon range from 24% to 51% ADF on a DM basis.

Nonstructural carbohydrates

Nonfiber carbohydrates (NFC) are starch and sugars inside the cell that can serve as energy sources for the animal.

Water-soluble carbohydrates (WSC) are a part of NFC. WSC include several types of sugars that are soluble in water, including an important one called fructan. It is important to note that WSC does not include starch.

Ether-soluble carbohydrates (ESC) are also a part of NFC. ESC include several types of sugars that are soluble in ether (a solvent for extracting certain compounds from feeds), but they contain only a small amount of the fructans. ESC do not include starch. WSC and ESC can be used to estimate how much of these certain carbohydrates (sugars) that may negatively impact horse health conditions (such as insulin insensitivity, laminitis, and colic) is in the feed.

Fat

Crude fat is comprised of fats, oils, and other compounds soluble in ether. Fats and oils contain 2.25 times the energy found in carbohydrates and proteins. They can be added to rations to increase energy concentration when feed intake is limited.

Energy

Energy is used in all biological processes and is essential for life. For livestock, specific energy requirements have been determined for reproduction, lactation, growth, and maintenance. Failure to supply adequate energy results in poor performance.

A feed's energy values usually are not measured directly but are calculated using equations and relationships with various nutrients that have been determined previously in animal experiments.

Total digestible nutrients (TDN) can be calculated several ways. Basically, TDN is the sum (total) of the digestible protein, digestible carbohydrates, and 2.25 times the digestible fat.

Ruminants: The main TDN value on the lab report is for use in ruminants.

Non-ruminants: A separate "TDN for horses" may be listed, usually at the bottom of the report.

Digestible energy (DE) is the total energy of the feed (gross energy) minus the energy remaining in the feces (fecal energy).

Non-ruminants: Be sure you use the "DE for horses" if you are formulating rations for them.

Net energy for maintenance (NE_m) is an estimate of the energy value of a feed to maintain animal tissue without gain or loss of weight. In formulating beef cattle and sheep rations, NE_m values include energy for maintenance plus energy for pregnancy and lactation.

Net energy for lactation (NE_l) is used to formulate rations for dairy cattle. NE_l estimates the energy available from the feed to support an animal's requirements for maintenance plus milk production during lactation, and for maintenance plus the final 2 months of gestation for dry, pregnant cows.

Net energy for gain (NE_g) is an estimate of a feed's energy value for body weight gain above the energy required for maintenance. It is used in ration balancing for ruminants when weight gain is desired (Figure 2).

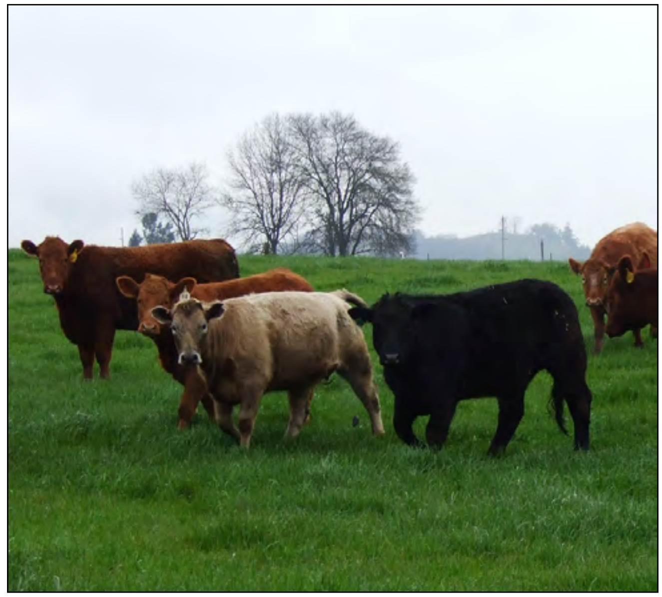
Photo by Shelby Filley, © Oregon State University

Figure 2. Fast-growing steers require high-energy forage. Pasture in excellent condition will meet this requirement, whereas low to moderate quality hay will not.

Ash

Ash is the inorganic residue that remains when a forage is ignited in a furnace at a very high temperature and all the organic matter is burned. Ash consists of minerals.

Minerals

Minerals make up 3 to 5 percent of an animal's body weight on a DM basis and enable structural and physiological functions. They are classified into two groups: **macrominerals** (major minerals) that normally are present at greater levels in the animal body or needed in relatively larger amounts in the diet, and **microminerals** (trace minerals) that are present at lower levels or needed in very small amounts. Minerals cannot be synthesized; they must come from the diet (feed plus mineral supplement).

Macrominerals and their functions

Calcium (Ca)—bone and teeth formation, blood clotting, muscle contraction, transmission of nerve impulses, cardiac regulation, and enzyme function. Calcium is also a component of milk.

Phosphorus (P)—bone and teeth formation, key component of energy metabolism, body fluid buffer systems. Phosphorus is also a component of milk.

Sodium (Na)—muscle contraction, nerve transmission, acid–base balance, osmotic pressure regulation and water balance, glucose uptake, and amino acid transport

Chloride (Cl)—osmotic pressure regulation and water balance, acid–base balance, component of gastric secretions

Magnesium (Mg)—enzyme activator, found in skeletal tissue and bone, neuromuscular transmissions

Potassium (K)—osmotic pressure regulation and water balance, electrolyte balance, acid–base balance, enzyme activator, muscle contraction, nerve impulse conductor

Sulfur (S)—used for microbial protein synthesis, especially when NPN is fed

Microminerals and their functions

Cobalt (Co)—required for vitamin B_{12} synthesis

Copper (Cu)—required for hemoglobin synthesis and coenzyme functions

Fluoride (F)—prevents tooth decay

Iodine (I)—required for proper thyroid function and to guard against goiter, stillbirths, and woolless lambs

Iron (Fe)—hemoglobin and oxygen transport, enzyme systems

Manganese (Mn)—growth, bone formation, enzyme activation, fertility

Molybdenum (Mo)—component of enzymes, may enhance rumen microbial activity

Selenium (Se)—antioxidant properties, prevention of white muscle disease and retained placenta

Zinc (Zn)—enzyme activation, wound healing, skin health, some positive impact on udder health

pH, Nitrates, RFV and RFQ

pH measures the degree of acidity. Good corn silage typically has a pH of 3.5 to 4.5, and haylage or baleage a pH of 4.0 to 5.5.

Nitrates. Forage plants can accumulate nitrates under stressed conditions such as drought, freezing, or heavy fertilization. Corn, sorghum, sudangrass, and oat hay tend to accumulate nitrates more easily compared to other plants.

Forage with nitrate nitrogen levels of less than 1,000 ppm are safe to feed. Those with nitrate levels higher than this are problematic. Learn more about nitrates in feeds for all classes of livestock from the Oregon State University Beef Cattle Library (http://blogs.oregonstate.edu/beefcattle/).

Relative Feed Value (RFV) and **Relative Forage Quality (RFQ)** are terms used to compare forage quality. They are an objective way to determine a market value for forages. They are not used for balancing livestock rations.

A RFV or a RFQ of 100 is assigned to full-bloom alfalfa hay for "relative" comparisons. The higher the RFV or RFQ, the better the forage quality. The RFV is based on the concept of an animal's potential digestible DM intake of forage, and is calculated from forage ADF and NDF. RFQ uses TDN and NDF to estimate intake.

Dairy One

FORAGE LABORATORY
730 Warren Road, Ithaca, NY 14850
Ph: 800.496.3344 Fax: 607.257.1350
http://www.dairyone.com

DATE SAMPLED	LAB RECEIVED	DATE PRINTED	LAB USE
	02/13/14	02/14/14	.919

ADDITIONAL DESCRIPTIONS
LOT D ALFALFA

JOHN A FARMER
123 STREET
SOMEWHERE, NY 12345

ENERGY TABLE - NRC 2001		
	Mcal/Lb	Mcal/Kg
DE, 1X	1.25	2.75
ME, 1X	1.05	2.32
NEL, 3X	0.60	1.32
NEM, 3X	0.63	1.39
NEG, 3X	0.37	0.81
TDN1X,%	59	

KIND DESCRIPTION	CODE	LAB SAMPLE
LEGUME HAY	100	3046900

DESCRIPTION 1
STANDARD

ANALYSIS RESULTS

COMPONENTS	AS SAMPLED BASIS	DRY MATTER BASIS
% Moisture	8.1	
% Dry Matter	91.9	
% Crude Protein	18.7	20.4
% Available Protein	17.6	19.2
% ADICP	1.1	1.2
% Adjusted Crude Protein	18.7	20.4
Soluble Protein % CP		47
Degradable Protein%CP		73
% NDICP	2.7	3.0
% Acid Detergent Fiber	28.2	30.7
% Neutral Detergent Fiber	36.9	40.2
% Lignin	5.9	6.4
% NFC	26.2	28.5
% Starch	.9	1.0
% WSC (Water Sol. Carbs.)	8.5	9.3
% ESC (Simple Sugars)	6.5	7.1
% Crude Fat	2.3	2.5
% Ash	10.42	11.34
% TDN	58	63
NEL, Mcal/Lb	.61	.66
NEM, Mcal/Lb	.58	.63
NEG, Mcal/Lb	.33	.36
Relative Feed Value		150
% Calcium	1.13	1.23
% Phosphorus	.20	.22
% Magnesium	.20	.22
% Potassium	1.50	1.63
% Sodium	.124	.135
PPM Iron	1,550	1,690
PPM Zinc	22	24
PPM Copper	11	12
PPM Manganese	42	46
PPM Molybdenum	1.1	1.2
% Sulfur	.21	.23
% Chloride Ion	.41	.45
IVTD 30hr, % of DM		78
NDFD 30hr, % of NDF		44
kd, %/hr		4.99
% Lysine	.95	1.04
% Methionine	.29	.32
Horse DE, Mcal/Lb	.99	1.08

Using the results

Once you have your forage test results, carefully go through each item and consider how the results will influence the way you use the feed in your livestock nutrition program. You can use the information to formulate a balanced ration for your livestock or for general feeding decisions (Figure 3).

You will need to understand the nutrient requirements for different livestock in order to match forage resources with animal needs. You can find these requirements in *Nutrient Requirements of Domestic Animals* (see "For more information") and other resources available through your local OSU Extension Service office (http://extension.oregonstate.edu/find-us) and from the OSU Extension Service Catalog (https://catalog.extension.oregonstate.edu).

Photo by Shelby Filley, © Oregon State University

Figure 3. Heifer development at the OSU Soap Creek Ranch requires rations with high quality alfalfa hay as a supplement to grass hay, which tests low in crude protein.

For more information

Nutrient Requirements of Domestic Animals (National Research Council, National Academy Press, Washington, DC). https://www.nap.edu/search/?term=Nutrient+Requirements+of+Domestic+Animals

Oregon State University Extension Service Catalog, "Beef Cattle." (https://catalog.extension.oregonstate.edu/topic/agriculture/beef-cattle)

Oregon State University Beef Cattle Extension Library. http://blogs.oregonstate.edu/beefcattle/extension-publications/

Oregon State University Beef Cattle Library. Sample Collection and Submission (http://blogs.oregonstate.edu/beefcattle/forage-evaluation/)

References

Undersander, D. and J. Moore. 2002. Relative Forage Quality (RFQ), Indexing Legumes and Grasses for Forage Quality. *Focus on Forage* 4, no. 5. University of Wisconsin Board of Regents

Understanding and Significance of Forage Analysis Results. Dairy One, Ithaca, NY. http://dairyone.com/wp-content/uploads/2014/01/Understanding-Significance-of-Forage-Results.pdf

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