Understanding Feed Analysis Terminology

One of the most important steps in developing a ration suitable for dairy animals is feed testing. It is essential to have a starting point in order to formulate a ration to the recommended level for high producing cows. Forages are the most variable of all the feedstuffs tested and because of the large inclusion rate in the rations require the most attention. The test results are only useful if the recipient can interpret the report.
The following is designed to give some explanation and insight into the various terminologies.

AS FED AND DRY MATTER BASIS
As fed refers to the actual amount of a feed or nutrient fed to livestock and includes the moisture present in the feed, whereas dry matter basis refers to the quantity of feed after the water is removed.
All nutrients in forages are contained in its dry matter and animals consume feeds to meet their dry matter requirements. High moisture content in feeds means the animal has to consume more feed to receive the same amount of dry matter as it would from a drier feed. For instance, when an animal consumes 10 kg hay at 90% DM, it consumes 9 kg DM. But if the animal consumes haylage at 40%, it would have to consume 22.5 kg to get the same amount of DM (9 kg/0.4 = 22.5kg).

PROTEIN FRACTIONS
Proteins are made up of complex combinations of various aminoacids and are required on a daily basis for maintenance, especially for muscle development and milk production.

CRUDE PROTEIN (CP) is the total nitrogen content of the feed (true protein and non-protein nitrogen) multiplied by 6.25. This is based on the assumption that true protein contains 16% nitrogen. Grains generally have a CP content of 8 to 14 percent, with corn often being at the 7 to 9 percent range and wheat and oats in the 10 to 14 percent range. The CP is used by rumen bacteria for digesting forage and concentrates in the diet. In addition to the rumen microbes (source of protein for the cow), high-performing animals, especially milking dairy cows, need larger amounts of protein to be absorbed from the intestines (by pass protein or UIP).

ACID DETERGENT INSOLUBLE PROTEIN OR BOUND PROTEIN (ADF-CP or ADP) is the portion of CP that is bound to the ADF fraction of the cell wall. This value represents heat damaged protein because excessive heating has occurred and is unavailable to both microbes and the cow. The Maillard reaction causes heat damage by covalently linking nitrogen from amino acids to sugar residues of the plant cell wall. Moisture and heat are needed to promote this reaction. This protein is often subtracted from the feed's total crude protein to estimate available crude protein. Values higher than 12% (as % CP) in silages indicate that some overheating of the silage has occurred. An adjusted CP value will be included in the report if the bound protein becomes too high (>12% of CP). If an adjusted CP value is included, this value should be used in ration formulation.

Heat treated soybeans, distillers and brewers grains, corn gluten feed and meal among other products should be tested for ADP if their color ranges from light to dark brown. Silages are also of concern with bound protein and all silage analyses should have ADP determined.

NEUTRAL DETERGENT INSOLUBLE PROTEIN OR BOUND PROTEIN (NDF-CP or NDP) is a measure similar to ADP, except the procedure to determine nitrogen content is completed on the NDF fraction of a feed. Nitrogen found in NDF includes that in ADP in addition to other feed proteins less soluble in neutral detergent or associated with cell wall fiber. These proteins are not all indigestible, similar to ADP, but are considered more slowly degraded in the rumen. This protein fraction is used by rumen computer models (CNCPS, CPM) to estimate rumen undegraded protein fraction.

DIGESTIBLE PROTEIN measures of rumen availability of feed nitrogen. Because of the feeding rate and the retention time in the rumen, not all of the protein present has time to be digested. Rumen degradable protein includes all soluble protein and those rumen insoluble proteins that can be degraded in the rumen providing their residence time is sufficient (e.g., most affected by rate of passage issues).

SOLUBLE PROTEIN (SP) is the portion of the available protein that is potentially soluble in rumen fluid. It can be expressed as percent of CP. In the new ration evaluation models, SP is measured as protein soluble in a borate-phosphate buffer (pH=6.9). SP is rapidly degraded by rumen microbes. It is present in large amounts in alfalfa silage. Haylages are generally in the range of 40-60% soluble protein, hay 20%, dry corn 12%, high moisture corn 40%, corn silage 55%, soybean meal 20%, and roasted beans 15%.

UIP BYPASS PROTEIN (% of CP) is the protein that has a slow rate of degradability and escape digestion in the rumen because it is not used by the rumen microbes. UIP is also known as escape or bypass protein and it may either be absorbed in the small intestine or part of it may not be used at all by the cow and will end up in the manure.

AMMONIA NITROGEN as a percent of total nitrogen measures the NPN component of the soluble protein fraction. This analysis is most often used as part of a fermentation profile to assess the amount of proteolytic activity within the silage. One goal of silage is to minimize proteolytic activity from plant respiratory enzymes or microbes, primarily Clostridium spp. High proteolytic activity will buffer and increase silage pH making it less stable. In addition, some toxic NPN compounds such as amines can reduce feed intake. The goal is to have ammonia nitrogen less than 8% and 10-12% of total nitrogen for corn silage and hay-crop silage, respectively. In wet, Clostridial fermentation silages this value may exceed 20% or even higher. Higher ammonia nitrogen in silage increases the rapidly degraded rumen nitrogen and can contribute to high blood and milk urea nitrogen concentrations.

CARBOHYDRATE FRACTIONS

FIBRE

Fibre is the portion of the plant that provides the plant's structural strength and form. Generally, the vegetative parts, especially the stem, have the highest fibre content. Seed hulls and/or coats also often contain fibre. Fibre is composed of several different types of compounds and is the major constituent of plant cell walls. The components of fibre that provide the fibre value are hemicellulose, cellulose and lignin. Fibre values in plants are a function of the growing

conditions and maturity. As plants mature, the fibre levels increase. Fibre is important for maintaining normal rumen function, however, excessive fibre in a ration will limit nutrient intake and ration utilization.

NEUTRAL DETERGENT FIBRE (NDF) estimates the total fibre content of a forage (cellulose, hemicelluloses, lignin). NDF results are reported as aNDF as the procedure includes sodium sulphite and α-amylase. NDF is partially digestible depending on forage crop and maturity stage. NDF levels are used to predict feed intake. High NDF levels in a forage not only decrease intake, but also limit forage value, for example, in high milk production.

NDF DIGESTIBILITY (NDFD) is the portion of NDF that is digestible in the rumen after 24 or 48 hr. Research has shown that cows eat more and produce more milk when forages with higher NDFD levels are fed. Therefore, the use of NDFD values will result in more accurately balanced rations and more predictable production. Factors such as forage species, maturity, genetics and environment influence NDFD levels. NDFD values can vary significantly among forages with similar NDFs as well as among various forage species. Although legumes tend to have lower %NDF levels than grasses, the NDFD of legumes tends to be lower than that of grass NDF. Legumes have a greater degree of lignification compared to grasses. This may explain why we often see cows producing more milk on grass forages than we would expect, based on the available feed analysis. The range of NDFD in grasses is greater than that found in legumes or corn silage because of the extreme range in conditions under which grasses are often harvested. Corn silage, which is generally harvested within a narrow range of maturity, has a narrower range of NDFDs.

ACID DETERGENT FIBRE (ADF) measures cellulose and lignin contents of a plant and is related to the digestibility of a forage. ADF is also partially digestible. When ADF levels increase, forage digestibility usually decreases, so that low levels of ADF are desirable. Some factors that increase ADF in a forage are maturity, weathering, rain damage, high temperatures and weeds.

LIGNIN is a non-carbohydrate constituent that is the main factor which influences the digestibility of plant cell wall material. It is a fibre compound with no energy value for animals but it can affect the digestibility of other fibre components. Low levels are desirable. When lignin increases, digestibility, intake and performance usually decrease. It is more abundant in legume forages than in grasses or corn silage.

NON FIBRE CARBOHYDRATES (NFC)

Non fibre carbohydrates estimate readily available CHO (organic acids, sugars, starches, soluble fibre). They represent the components of the plant that provide energy to the animal and are stored within the cell. In ruminants, NFC are broken down by the microbial population in the rumen and used as an energy source.

Starch is a polysaccharide made up of units of glucose bounded together and found primarily in the grain or seed and/or root portions of plants. Depending on the starch source and processing, the glucose units may be very tightly bonded and compacted together or they may be weakly linked together. For this reason, different starches may be either rapidly or slowly fermented in the rumen. Most of the NFC fraction is made up of starch (28-32% of the total ration DM). Starch is a good source of energy.

Sugars are fermented in the rumen to the stronger acids, propionic acid and lactic acid. Sugars are not present in large amounts (4-6% of the ration DM) in traditional dairy cattle diets.

Starch and sugars are used as an energy source for the rumen microbes. The microbes convert the starch and sugars into volatile fatty acids, primarily propionic acid, which is absorbed across the rumen wall. The volatile fatty acids are used for energy or for glucose production by the cow.

MINERALS

Minerals are the inorganic component of animals and plants and are determined by burning off the organic matter and weighing the residue. The total mineral content of a forage is called **Ash** and represents 3-12% of DM. Values above 10% for grasses or 14% for legumes usually indicate soil contamination of forage.

MACRO MINERALS are those required in relatively large amounts by livestock and include: Calcium (Ca), Phosphorous (P), Potassium (K), Magnesium (Mg) and Sulphur (S).

MICRO MINERALS are those required in relatively small amounts by livestock and include: Manganese (Mn), Iron, (Fe), Copper (Cu), Zinc (Zn) and Molybdenum (Mo).

ENERGY

Energy is the nutrient required in the greatest amount. For livestock, energy requirements are determined for maintenance, growth or gain, lactation, reproduction and activity level. It is predicted based on the amounts of nutrients, such as protein, fibre, non-structural carbohydrates, and fat. Accurately predicting the digestible energy of forages for ration formulation and animal performance is important. There are different measures to describe the energy value of a feed. The most popular ones are: net energy (NE), total digestible nutrients (TDN) and relative feed values (RFV) that can be calculated from core analyses.

TDN represents the digestible portion of a feed and it can also be used to estimate the energy content of a forage. TDN is the sum of the digestible fiber, protein, lipid, and carbohydrate components of a feedstuff or diet. TDN is directly related to digestible energy and is often calculated based on ADF. TDN is useful for beef cow rations that are primarily forage. When moderate to high concentrations of concentrate are fed, net energy (NE) should be used to formulate diets and predict animal performance. TDN values tend to underpredict the feeding value of concentrate relative to forage.

SGS AgriFood Labs provides two different approaches to predict total digestible nutrients (TDN) and net energy for lactation (NEl).

a) Summative equations based on contributions of protein, fibre, non-structural carbohydrates and fat and;
b) Equations based on a single fibre fraction (ADF).

NET ENERGY (NE) is the energy used for maintenance and for productive purposes (growth, gestation, and lactation). NE is derived from animal studies by measuring the gross energy minus fecal energy, minus energy lost in urine and minus combustible gases and heat loss.

NET ENERGY FOR LACTATION (NEl) represents the amount of digestible nutrients in a feed or forage fed to a milking cow whose energy needs are 3 times what they would be if she were just

in a maintenance state. It also represents the nutrients that are used for non-productive purposes (such as heat) and the efficiency with which the cow uses energy for milk production, pregnancy and maintenance. For a lactating dairy cow, **NEl** is the only energy estimate needed for ration balancing.

NET ENERGY FOR GAIN (NEg) reports the energy value of a feed used for body weight gain above that required for maintenance.

NET ENERGY FOR MAINTENANCE (NEm) reports the energy value of a feed used to keep an animal at a stable weight.

RELATIVE FEED VALUE is a factor that evaluates forage quality based on ADF and NDF as compared to full bloom alfalfa with assigned value of 100. RFV is an index that accounts for an animal's potential forage intake and its energy or digestibility. It is useful for comparing forages of the same type although nutritionists are more interested in the amount of CP, ADF, NDF and minerals in a forage. Higher RFV indicate higher quality forage.

RELATIVE FEED QUALITY (RFQ) is a factor that combines predicted intake (NDF) and digestibility (ADF). However, RFQ differs from RFV because it is based on estimates of forage intake and digestibility determined by incubating the feedstuff with rumen microorganisms in a simulated digestion. Therefore, it is a more accurate predictor of forage value than RFV. Neither RFV nor RFQ are used in ration formulation.