Technical Note

PASTURE AND FEED FORAGE QUALITY

Grazing ruminant animals are able to survive on a wide range of pasture and forage feeds. However, the objective is to optimise the 'efficiency of conversion' of feed into animal products such as milk, meat and wool by management of the quantity and quality of feed consumed.

Chemical analysis of pasture and forage feeds to determine 'feed quality' is now widespread in many countries and is becoming increasingly important in the New Zealand farming scene. This Technical Note describes the relationship between the chemical composition of forages and 'feed quality' from the animal's viewpoint; and describes how quality attributes of forages relate to animal requirements.

Analytical testing can be used to predict how well a particular feed will meet the needs of the animal. The type of livestock and the production aimed for will influence the quantity and quality of feed required to achieve this output.

Feed Quality

For optimum productivity irrespective of animal status, the following properties of the feed are important:

- Dry matter intake
- Crude protein content
- Carbohydrate composition
- Digestibility
- Energy yield from the digested feed
- Mineral and trace element content

Dry Matter

The residual dry weight of pasture, forage or silage after removal of moisture, usually expressed as % of the fresh weight.

The dry matter intake of a cow, for example, depends on many variables including live weight, stage of lactation, level of milk production, environmental conditions, feeding history, body condition and the quality of the feed.

Crude Protein

The protein content of the pasture or forage is directly related to the Nitrogen content which varies with growing conditions, plant species, and maturity of the plant. Crude protein requirements are dependent on the class of livestock being fed. For example, a maintenance requirement for a dairy cow may be as low as 12% protein, whereas a range of 16 – 20% protein is needed for growth and lactation.

Crude Fat

Crude fat is a collective term including fats, oils, waxes and plant pigments in feeds, measured using high temperature petroleum spirit extraction.

Forages are typically low in crude fat at < 5%(DM), grains may be slightly higher up to 10%(DM) and Palm Kernel Expeller (PKE) in New Zealand is typically 7 -10%(DM).

Fats and oils contribute highly to energy for animals but caution is needed to ensure rumen function is not compromised by adding fats to animal diets in the wrong form or balance.

Plant Carbohydrates

Plant carbohydrates may be conveniently classified as structural (or cell wall) carbohydrates and non-structural (or cell contents) carbohydrates. The structural carbohydrates are dominated by cellulose and the hemicelluloses and these polymers form the basis of fibre in all plant tissue (see below). Levels of structural carbohydrates increase with increasing plant maturity with a corresponding decrease in plant digestibility.

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The key non-structural carbohydrates in forages are the soluble sugars such as sucrose, glucose and fructose, and in the case of cereal grains, starch. Plant soluble sugars fluctuate diurnally as a result of photosynthetic activity with highest levels generally found in the early to mid afternoon period – typical levels for temperate grasses can range from 5 – 15 %. Soluble sugars are important for stimulating microbial activity in ruminant animals.

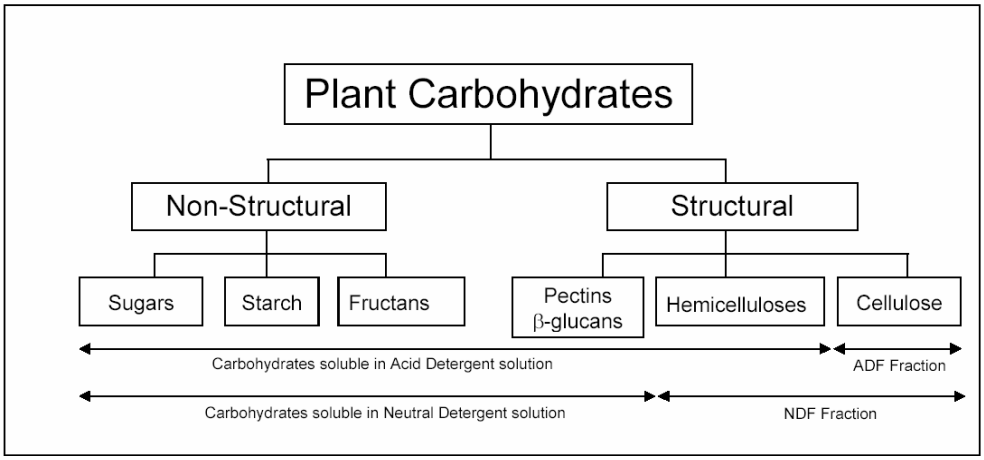
Hill Laboratories reports measured values for Soluble Sugars (%DM) and also Starch (%DM).

Non-structural carbohydrates are also reported by calculation:[NSC = 100 - (CP + Ash + CFat + NDF)] all on a dry matter basis.

Acid Detergent Fibre (ADF) & Neutral Detergent Fibre (NDF)

ADF and NDF provide empirical estimates of the less digestible structural carbohydrates in forages. ADF consists mainly of cellulose and lignin with small amounts of nitrogen and minerals. The NDF fraction includes the hemicelluloses in addition to the ADF component of plant tissue. Very high fibre levels slow the rate of digestion and limit dry matter intake, but a certain amount of fibre is required to stimulate rumen activity. The following diagram indicates which plant carbohydrates are partitioned into these fibre fractions.

Simplified Diagram of Plant Carbohydrate Fractions and their relationship with ADF and NDF



Modified diagram, courtesy of Mary Beth Hall (University of Florida, now USDA)

Lignin

Lignin is a cell-wall polymer that consists of polymerised phenolic acids bound to structural carbohydrates in the cell walls of plants. Lignin physically impedes access by enzymes, limiting the energy that can be made available to rumen microbes and the livestock during digestion. The lignin concentration of a plant or an animal feed is inversely related to it's digestibility and the energy value that it can provide to an animal. As lignin content of a feed increases, the

digestibility and intake of the feed, as well as the performance of the animal will decrease.

Lignin values may be used in conjunction with other parameters such as neutral detergent fibre (NDF) to estimate the indigestible NDF (INDF) fraction of a feed. This fibre fraction provides no energy and is typically excluded when estimating energy content of a feed.

This method gravimetrically assesses the lignin content of plant based feed samples following digestion in acid detergent solution and then 72% sulphuric acid. The residue is termed acid detergent lignin (ADL). The method is capable of determining values from 0 -100% although lignin results for typical feeds are expected be less than 15%. Results are reported on a dry matter basis.

Digestibility

Feed digestibility is simply defined as the proportion of forage dry matter able to be digested by the animal. It is largely influenced by the maturity of the plant species and declines as the plant matures because of increasing levels of the structural carbohydrates. Within pastures, the species type also influences digestibility. For example, clovers retain a higher leaf:stem ratio with increasing maturity compared with temperate grasses and so maintain a higher digestibility relative to grasses.

Digestibility is measured in two quite distinct procedures:

- *in vivo* digestibility – determined directly by animal feeding trials by way of a mass balance from what is consumed, what is digested, and what is excreted.
- *in vitro* digestibility – determined by wet chemistry using rumen fluid taken from research animals, or using purified cellulase enzymes.

In vivo digestibility provides the most meaningful estimate of animal performance, but nowadays, the cost of setting up animal trials for measuring *in vivo* digestibility, or for providing rumen fluid is prohibitive. Thus, most laboratories measure *in vitro* digestibility by incubating samples with enzyme preparations and use these data to predict *in vivo* digestibility.

Note that Digestibility may be expressed in different ways:

DMD% expresses all of the solubilised material as a portion of the dry matter of the sample (in effect the proportion of the dry matter eaten which is digested and absorbed in passage through the alimentary tract).

OMD% expresses the solubilised organic matter as a portion of the organic matter mass of the sample.

DOMD% expresses the solubilised organic matter as a portion of the dry matter of the sample.

Since the ash within a feed does not provide energy to animals, predictions of Metabolisable Energy (ME) would be erroneous based on DMD (given ash may be highly variable). Estimates of ME based on OMD account for the ash content, but since diet formulation uses ME predictions as MJ/kg DM (rather than /kg OM) then DOMD becomes the most useful expression of digestibility to use.

Metabolisable Energy (ME)

ME is an estimate of the energy content of the feed potentially available for maintenance and production in ruminant animals. It is that proportion of feed energy absorbed from the digestive tract and retained for metabolic processes and the value is expressed as a proportion of the dry matter (MJ/kg). Although ME is a frequently sought measure of feed quality, it is a value derived from other feed factors such as *in vivo* digestibility and cannot be measured directly. As such it has a number of limitations.

Hill Laboratories have adopted the universal equation ME = DOMD% x 0.16 for pastures and other forages.

Minerals & Trace Elements

Livestock require adequate levels of certain elements e.g. Magnesium, Copper, Zinc, Cobalt and Selenium. For optimum animal health, efficiency of energy utilization, and productivity, forages need to contain sufficient levels of these and other elements.

Typical Feed Values

The following table gives general information on the feed quality of a range of typical forages.

Table 1 **Feed Quality for Forage Samples**

Feed Type	Dry Matter (%)	Crude Protein (%)	Acid Det.Fibre (%)	Neutral Det.Fibre (%)	Digestibilty (%DOMD)	Metabolisable Energy (MJ/kg)
Mixed Pasture	12 – 25	20 – 30	20 – 30	30 – 45	65 – 80	9 – 12
Pasture Silage	25 – 30	14 – 20	20 – 35	30 – 45	65 – 75	9 – 11
Cereal Silage	35 – 40	8 – 12	25 – 40	35 – 60	55 – 65	8.5 – 10.5
Maize Silage	25 – 35	6 – 9	25 – 35	35 – 50	60 – 70	9.5 – 11
Lucerne Forage	15 – 25	20 – 30	25 – 30	35 – 45	60 – 70	9 – 12
Lucerne Hay	85 – 90	18 – 25	25 – 35	35 – 50	55 – 65	8 – 11

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Animal Dietary requirements

It is not the purpose of this Technical Note to provide recommendations for dietary requirements. However, Table 2 does provide some general examples of the way in which feed requirements differ depending on the type and status of animals.

Table 2 Indicative Feed Requirements for Ruminant Animals

Animal	Crude Protein (%CP)	Acid Det. Fibre (%ADF)	Neutral Det. Fibre (%NDF)	Digestibility (%DOMD)	Metabolisable Energy (M/kg)
Cattle (Beef)	>12	19	25	61	9.5 – 10.5
Dairy Cow – Dry	>12	27	35	56	8.6
Dairy Cow - Lactation	>16	21	28	71	11
Calf	>16	>16	23	69	11
Sheep	9 – 12	20 – 25	25 – 35	55 – 65	8 – 10
Lamb	11 – 14	16 – 20	20 – 25	65 – 75	9 – 11

Summary

The feed values shown in Table 1 indicate a substantial range between protein, fibre and digestibility levels and ME for different forages, and within pastures depending on their maturity. However, highest levels of protein, digestibility and energy do not always result in the best productivity. Provided that a feed contains sufficient protein and fibre for the appropriate livestock class, higher levels may not be beneficial. For example, excessively high protein levels raise the amount of Nitrogen excreted in the urine, so that digestion of the excess protein is actually an energy cost to the animal.

Dry matter intake and subsequent production/liveweight gain increase in the short term with an increased pasture allowance. However, at a constant dry matter intake, increases in production may be achieved when more digestible feed is offered. Optimum feeding is therefore a balance between amount (quantity) of available feed and the quality of that feed. Supplements may also be used to complement any deficiencies in quality or quantity in the ration.

References:

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