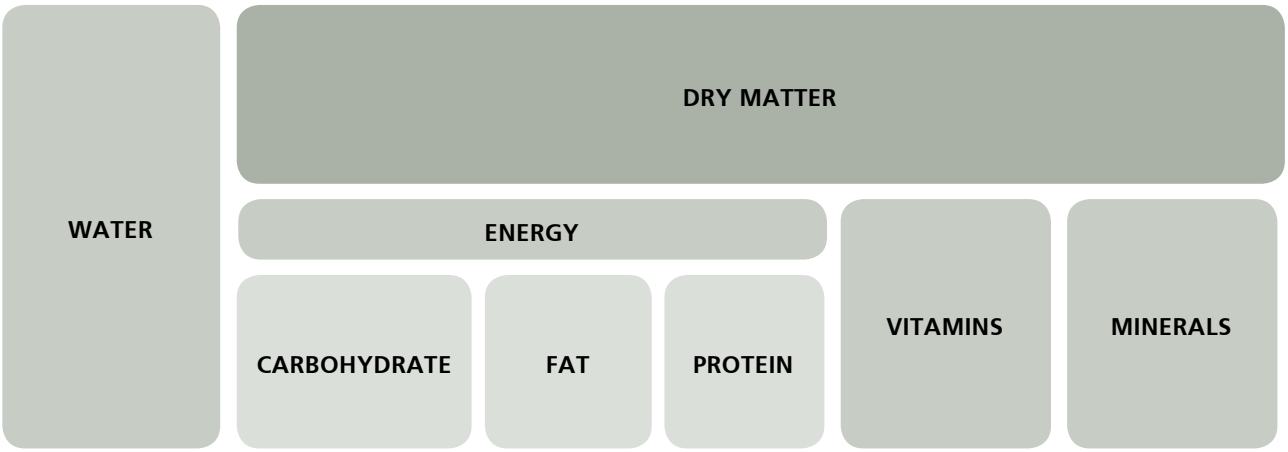
TechNote 3

Feed components

IN THIS TECHNOTE

The six major components of feed: water, carbohydrate, protein, fat, vitamins, and minerals are outlined in Figure 1. Feeds contain these components in differing quantities and together they supply the animal with the water and nutrients needed for maintenance, milk production, reproduction, condition gain, activity, and growth.

Figure 1. *The major components of feed.*



Dry matter (DM) is the proportion of the feed remaining after all water has been removed, and contains all the nutrients. The amount of DM is expressed as a percentage of the wet feed (% DM).

3.1 Energy

The amount of energy in a feed indicates the feed's ability to help the cow function optimally (e.g. maintenance of body functions, milk production, reproduction, condition gain, activity, and growth). Energy in the diet comes from carbohydrates, fats, and protein (when it is in surplus to protein requirements).

Energy can be defined as gross, digestible, metabolisable, and net energy. Generally, in New Zealand, the energy available in a feed is expressed as metabolisable energy (ME) and is measured in megajoules (MJ ME/kg DM). If feed is analysed in laboratories in other countries, it is sometimes reported in megacalories (MCal/kg DM).

Conversion from Mcal to MJ

1 megacalorie = 4.186 megajoules

1 megajoule = 0.239 megacalories

For more details see TechNote 2: Energy, mineral and vitamin requirements, and online eLearning activities: What a cow needs; dairynz.co.nz/feedright-module-1, and What's in a feed; dairynz.co.nz/feedright-module-3.

3.2 Main types of carbohydrates

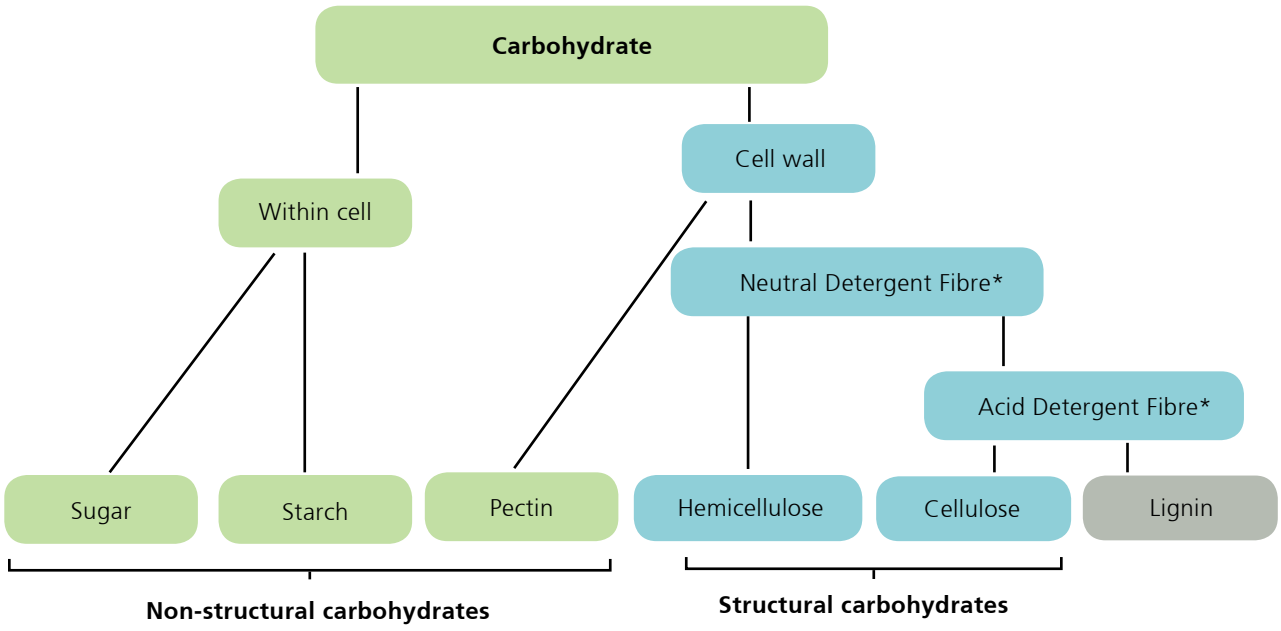
Carbohydrates make up a large proportion of plant DM and supply most of the energy for dairy cows. There are two main types of carbohydrates: structural and non-structural (Figure 2).

- **Structural carbohydrates** are part of the plant cell wall and include cellulose and hemicellulose.
- **Non-structural carbohydrates** are the soluble sugars and starches found within the plant cell.

Other compounds often associated with carbohydrates are:

- **Lignin:** often associated with structural carbohydrates, but is not a carbohydrate and is indigestible in the rumen. Lignin binds to the structural carbohydrates and making them woody and less digestible.
- **Pectin:** part of the cell wall; it is considered a non-structural carbohydrate as it is rapidly and completely fermented by rumen microbes.
- **Neutral detergent fibre** (NDF) and **acid detergent fibre** (ADF): include structural carbohydrates and are covered in more detail in section 3.4.

Figure 2. *Types of carbohydrates.*



Carbohydrates found in plants are either individual sugar units (soluble sugars), or chains made up of two or more sugar units (starches, structural carbohydrates), with the only difference being the chemical bonds that join the sugar molecules together. The make-up of the different carbohydrates can be compared with building Lego, where the individual Lego blocks are the sugar units (Table 1).

The soluble sugars are made up of many individual sugar units (or Lego blocks) already pulled apart and ready to use. In comparison the starches are made up of sugar units (or Lego blocks) joined together by α linkages into a simple structure. Finally, the structural carbohydrates (cellulose and hemicellulose) are made up of the same sugar units (or Lego blocks) joined together by ß linkages and folded around on each other to form a more complex structure. Luckily, the ruminant has enzymes capable of breaking apart the bonds in all these carbohydrates so the sugar units (Lego blocks) can be used.

3.3 Fibre components

Fibre is the term which describes what is in the cell wall, or the material that provides structure to the plant. It consists of the structural carbohydrates, cellulose and hemicellulose, plus lignin.

3.3.1 Lignin

Lignin is indigestible and provides the plant with mechanical strength. It is not a carbohydrate, but can bind to the structural carbohydrates (cellulose and hemicellulose) making them less accessible to rumen enzymes, therefore less digestible. The lignin content of a forage plant increases with age; therefore, the plant becomes less digestible as it matures.

3.3.2 Fibre definitions

The fibre content of feed comprises three types, all expressed as a % of the DM (Figure 3).

Figure 3. *The fibre components of feed.*

Neutral Detergent Fibre (NDF)

= hemicellulose + cellulose + lignin

This is a measurement of the fibre that remains after treating the plant with a non acidic, non alkaline detergent.

This contains both the indigestible and digestible fibre portions and generally relates to the bulkiness of the feed.

Effective Neutral Detergent Fibre (eNDF)

= the larger NDF particles

This is a measurement of the larger NDF particles that remain using a sieve. These long chop or larger particles are the most effective at stimulating rumination.

This often relates to the bulkiness of the feed.

Acid Detergent Fibre (ADF)

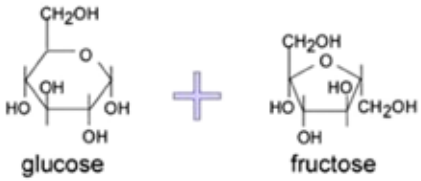
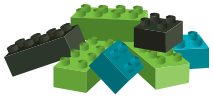
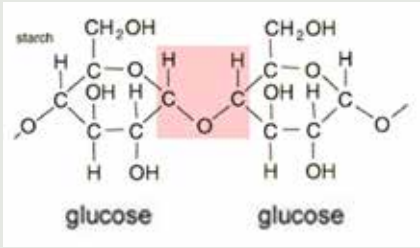
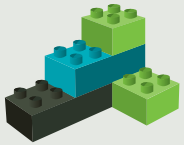
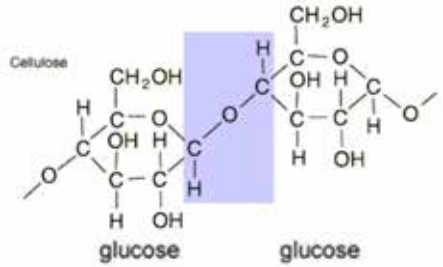
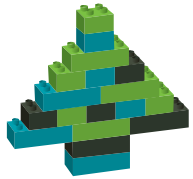
= cellulose + lignin

This is a measurement of the fibre that remains after treating the plant with an acidic detergent. The higher the ADF, the lower the digestibility of the fibre fraction of the plant, and generally the lower the available energy.

ADF ↑ = ↓ Digestibility and energy available

For more details see TechNotes 5: Carbohydrate metabolism, and 8: Fibre metabolism, and online eLearning activities: The role of carbohydrates; dairynz.co.nz/feedright-module-4, and The role of fibre; dairynz.co.nz/feedright/module-6.

Table 1. *Carbohydrate types and characteristics.*

Type of carbohydrate	Commonly called	Characteristics	Chemical structure	Example
Non-structural	Soluble Sugars	• Individual and simple sugars within the plant cell. • Primarily found in the plant leaves. • Rapidly digested and used quickly by microbes as an energy source.		 Lego bricks loose and ready to be used by rumen microbes
Non-structural	Starch	• Sugar sub-units within the plant cell joined by an α-bond. • Found in grains, leaves, and plant stems and bulbs. • Rumen enzymes can break the α-bond between the glucose units. • Digested more slowly than soluble sugars.		 Lego bricks simply joined together that can be seperated by rumen microbes
Structural*	Hemicellulose and cellulose	• Sugar sub-units found in the plant cell wall joined by a ß-bond. • Provide structural support for the plant. • Rumen enzymes can break the ß-bond between the glucose units. • In high quality pasture, digested at a similar rate to starch.		 Lego bricks joined in a complex way that require different microbes to dissemble

For more details see TechNotes 5: Carbohydrate metabolism, and 8: Fibre metabolism.

3.4 Crude protein components and characteristics

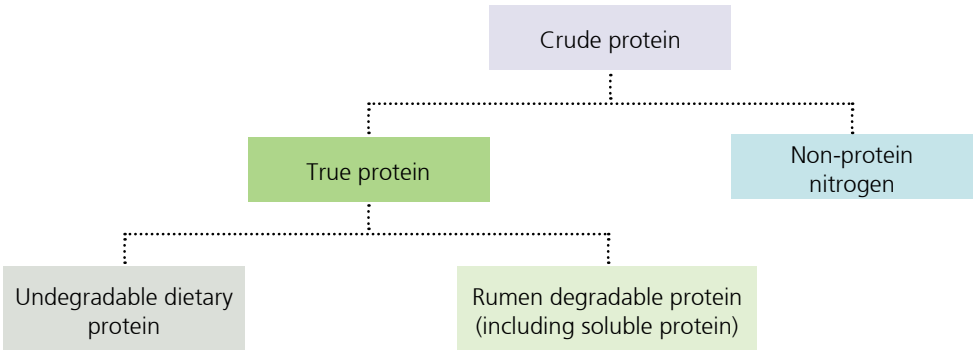
The protein content in feed is commonly reported as crude protein (CP). Crude protein is not a direct measure of the protein, but rather an estimate based on the nitrogen (N) content. Protein contains 16% N, so crude protein is calculated by multiplying the N content in the feed by 6.25.

Therefore, crude protein includes not only true proteins (that contain amino acids) but also non-protein nitrogen (Figure 4 and Table 2).

True proteins comprise rumen degradable proteins, some of which are soluble proteins, and undegradable dietary proteins, often referred to as by-pass proteins.

Crude protein %
=
N content (%) x 6.25
e.g. If pasture has 3.8% N
3.8 x 6.25 = 24% CP

Figure 4. *Protein components of feed.*



In the rumen, microbes use amino acids, ammonia and N that are generated from the breakdown of rumen degradable proteins, (including soluble proteins), and the non-protein nitrogen compounds for their own growth. Microbes then flow out of the rumen and are degraded and digested in the abomasum and small intestine, providing an amino acid source for the cow. The protein that comes from microbes is known as microbial protein.

In contrast, undegradable dietary proteins pass through the rumen unaltered, and are degraded and digested by enzymes in the abomasum and small intestine to provide amino acids for the cow. These two sources of protein (microbial and undegradable dietary protein) provide the dairy cow with the amino acids needed. This is known as her metabolisable protein. Only if protein is in excess to requirements does it act as an energy source for the cow.

For more details see TechNote 6: Protein metabolism, and online eLearning activity: The role of protein; dairynz.co.nz/feedright-module-5.

Table 2. Feed protein components and characteristics.

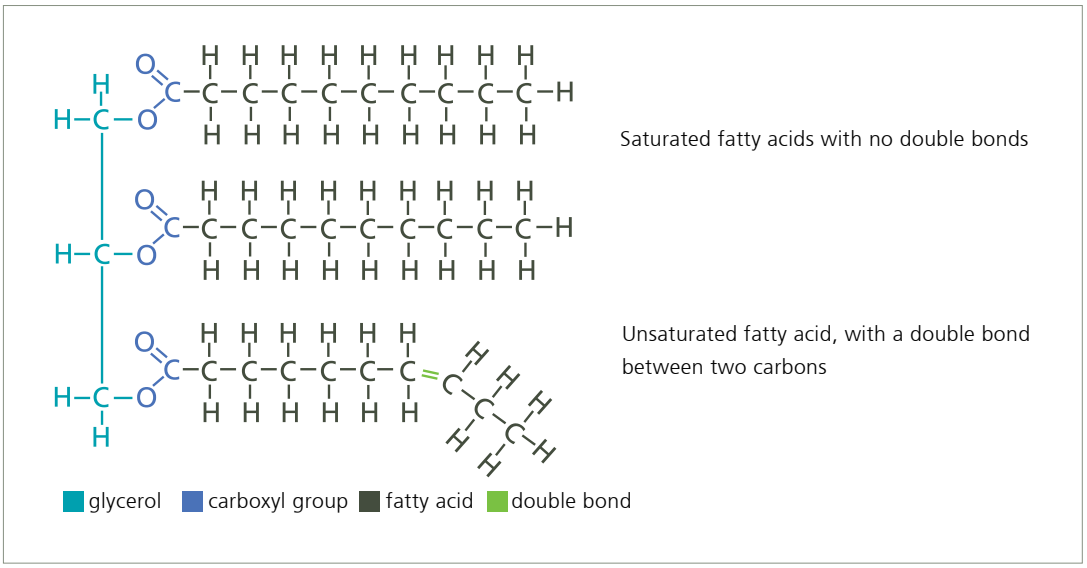
True protein (TP)	Compounds that contain amino acids and include rumen degradable protein (RDP), soluble protein, or undegradable dietary protein (UDP).
Undegradable dietary protein (UDP)	Protein in the diet that is not degradable in the rumen (sometimes referred to as by-pass protein) and passes through the rumen unaltered.
Rumen degradable protein (RDP)	Dietary Protein that is degradable in the rumen. Providing a source of energy is available (carbohydrates), RDP is used by the rumen microbes to produce microbial protein.
Soluble protein (SP)	A form of RDP that is instantly available to the rumen microbes, soluble proteins are degraded and used quickly to produce microbial protein.
Non-protein nitrogen (NPN)	Compounds that contain nitrogen but do not contain amino acids. Non-protein nitrogen is degradable in the rumen and used by rumen microbes to make microbial protein.

3.5 Different types of fats

Fats can provide an additional energy source for the cow. On a weight basis, fat contains more than twice the energy content of carbohydrates. They are found in feedstuffs such as oilseeds (e.g. cottonseed or whole soybean) or by-products (e.g. palm kernel extract) and are present in relatively small amounts in many forages (e.g. 2 – 3 % in pasture and maize silage). The basic structure of a fat is a carbon or glycerol backbone with three fatty acids connected to it (also known as a triglyceride).

Fatty acids can vary in length (the number of carbons in the chain), and in the number and position of double bonds that join the carbons (Figure 5). If there are no double bonds, the fatty acid is saturated. If there are one or more double bonds, the fatty acid is unsaturated. The number and position of double bonds alters the way the fatty acids are digested, and can also alter their biological activity.

Figure 5. Triglyceride structure containing a glycerol backbone and 3 fatty acids.

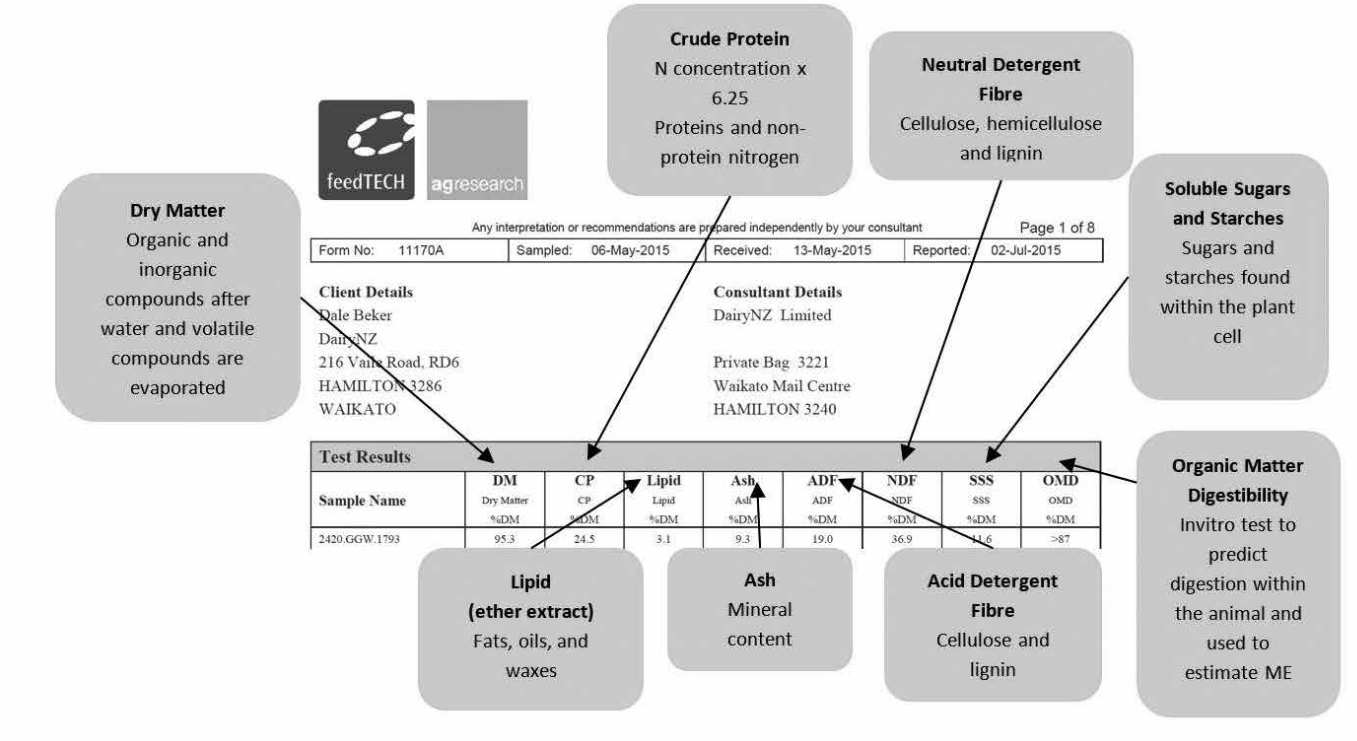


For more details see TechNote 7: Lipid metabolism, and online eLearning activity: The role of lipids; dairynz.co.nz/feedright-module-7.

3.6 How to read a feed analysis report?

Figure 6 is an example of a typical laboratory feed analysis report with an explanation of the measurements reported.

Figure 6. *Feed analysis report.*



3.7 Further reading

Holmes, C. W., I. M. Brookes, D. J. Garrick, D. D. S. Mackenzie, T. J. Parkinson, and G. F. Wilson. 2007. Milk production from pasture (2nd rev. ed). Massey University: Palmerston North, New Zealand.

NRC. 2001. Nutrient requirments of dairy cattle (7th rev. ed). Washington, United States of America: National Academy Press.