TechNote 1

The digestion system and nutrient requirements

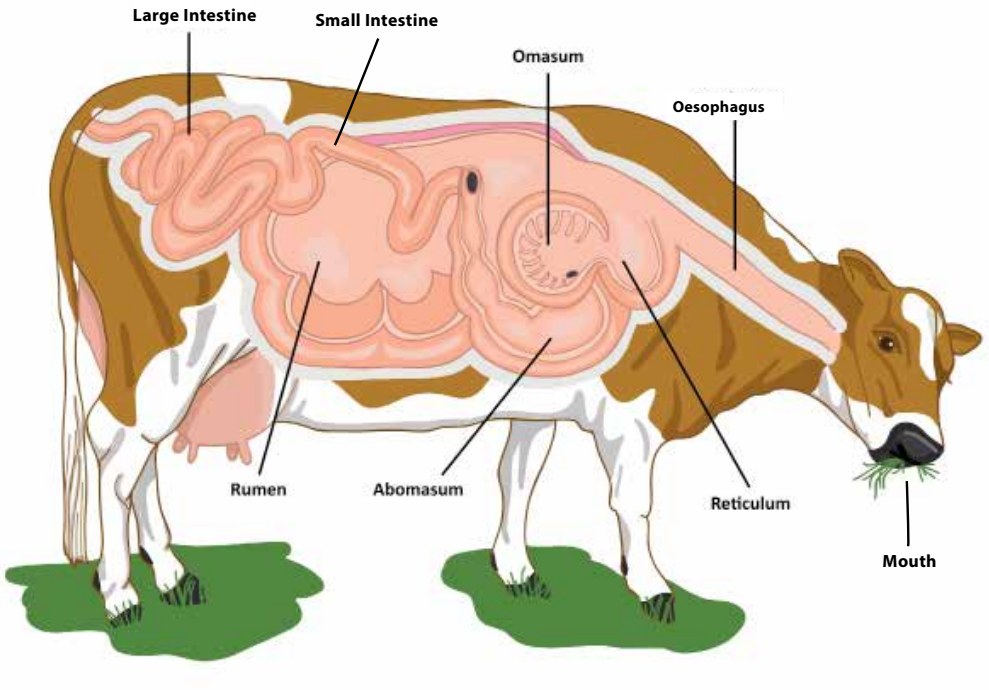
IN THIS TECHNOTE

Dairy cows are ruminants. A ruminant is an animal with a complex 4-chambered stomach, comprising the rumen, reticulum, omasum and abomasum.

Each of the stomach compartments has a specific role in the degradation and digestion of feed, and the absorption of nutrients. The whole digestive system (Figure 1), involves both mechanical and chemical digestion, and is designed to utilise fibre from plant material to generate energy.

For more details see online eLearning activity: A cow's digestive system; dairynz.co.nz/feedright-module-2.

Figure 1. *Digestive system of the dairy cow.*



1.1 Functions of the ruminant digestive system

Digestive system	Function
Mouth (saliva)	A dairy cow has no incisor teeth in the top jaw, but instead has a hard dental pad. When grazing she initially uses her tongue to grasp a clump of grass and pulls this into her mouth. Then she bites down on it by pinching it between her lower front teeth and the pad. This process is called prehension. After biting off the food, she uses her top and bottom back teeth (molars) in a side to side motion to grind/break down the plant material. This process of chewing is known as mastication. Saliva is secreted in the mouth and a dairy cow can produce between 50 – 150 L saliva daily. The amount produced depends on the type and amount of food eaten and the amount of time spent ruminating or 'chewing her cud'. Saliva has several key functions: • lubricates the feed for easier chewing and swallowing, • provides a medium for bacteria to attach to feed particles, • supplies bicarbonate and phosphate ions to buffer acidity in the rumen. When a cow first takes a mouthful of grass, it is only partially chewed a little before it is swallowed. However, during the process of rumination, a feed bolus is regurgitated back into the cow's mouth, so the cow can further grind/chew the food. This increases the surface area of the food particles, making them more accessible to the rumen microbes for digestion.
Oesophagus	Muscular movements of the oesophagus allow food to travel up and down the oesophagus between the mouth and the rumen.
Rumen	This is the largest compartment of the adult ruminant stomach and is often described as a 'fermentation vat'. The internal surface of the rumen comprises tiny projections called papillae; these increase the surface area and allow better absorption of nutrients. The rumen contains large numbers of many types of microorganisms that degrade and digest the food. Through the process of fermentation, the microbes grow and multiply fermenting the digesta to produce volatile fatty acids that are used by the cow for energy. The microbes eventually pass out of the rumen and are killed and digested in the abomasum and small intestine to provide a protein source. **Rumination** Rumination, or 'chewing the cud', is the process whereby recently eaten food is returned to the mouth where it is re-chewed, more saliva added and then re-swallowed back into the rumen. This extra chewing breaks the food down into smaller pieces, thereby increasing its surface area for further digestion.

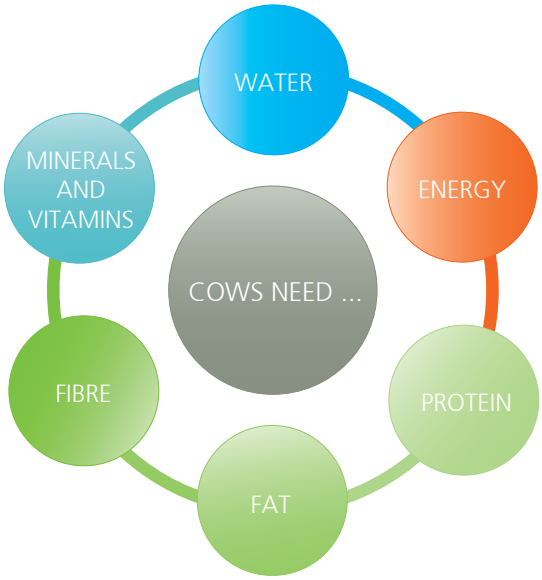
Digestive system	Function
Reticulum	The reticulum is not physically separate from the rumen and these two compartments are often jointly referred to as the reticulorumen. The primary function of the reticulum is to act as a filter, trapping large food particles that require further digestion (rumination). Small food particles pass through into the omasum.
Omasum	This is the third stomach compartment, made up of many folds of tissue, which create a large surface area for water absorption. The folds of tissue are like leaves and act as a filtration system. They only allow fine particles and a small amount of fluid to pass into the abomasum.
Abomasum	The abomasum is the 'true stomach' of the ruminant and acts similarly to the stomach of a monogastric animal (e.g. human, pig). It has an acidic environment, and secretes hydrochloric acid and digestive enzymes, which begin the process of breaking down microbial and dietary proteins, and other complex molecules.
Small intestine	This is about 40 metres long and has three sections - the duodenum, the jejunum, and the ileum. The small intestine receives secretions from the pancreas and the gall bladder that aid digestion. Most of the digestive processes are completed here and many nutrients are absorbed through villi (finger like projections that sit on the surface of the small intestine).
Large intestine	The large intestine is the final compartment of the digestive tract and is made up of the caecum (similar to our appendix), the colon which is the largest portion, and the rectum. The main function of the large intestine is active transport of sodium and absorption of water by osmosis. Waste that will eventually be excreted in the faeces is stored here.

For more details see online eLearning activity: A cow's digestive system; dairynz.co.nz/feedright-module-2.

1.2 Requirements of the dairy cow

Dairy cows require water, energy and other key nutrients in their diet to survive and to optimise health, production and performance. The key dietary components that a dairy cow requires, what these are used for and links to appropriate TechNotes are outlined in Figure 2.

***Figure 2**. Cow requirements.*



Water is essential for the dairy cow and it is crucial that clean drinking water is always available. Water is important because it:

- transports nutrients throughout the body,
- aids in digestion,
- removes wastes,
- helps maintain body temperature,
- is required for milk production.

The amount of water that a cow needs depends on several factors and increases with:

- size and age (calf vs heifer vs cow),
- a warm and/or humid environment,
- increased productivity,
- increased dietary dry matter content.

Dairy cows need energy for maintenance, milk production, reproduction, condition gain, activity, and growth.

Energy is obtained from dietary carbohydrates, proteins (if in excess of protein requirements) and fats.

Energy is charecterised as gross, digestible, metabolisable or net energy.

In New Zealand, energy is generally measured in megaJoules (MJ); however, other countries may use megacalories (Mcal) as the units.

For more details see TechNotes 2: Energy, vitamin and mineral requirements, and 5: Carbohydrate metabolism, and online eLearning activities: What a cow needs; dairynz.co.nz/feedright-module-1. The role of carbohydrates; dairynz.co.nz/feedright-module-4.

PROTEIN

Protein is used by the cow to build and repair tissue (e.g. muscle, skin, organs) and is also important for the production of enzymes, hormones, and milk.

Proteins are made of amino acids and cows require 25 different amino acids. Fifteen of these can be manufactured by the cow's own metabolism (non-essential); the remaining ten amino acids must be supplied in the diet, or come from rumen microbial proteins (essential).

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

FAT

Fat (or lipid) is required by the cow for optimum cell function. It can also supply the energy. Dietary fats are in the form of triglycerides, composed of a glycerol backbone with three fatty acids attached.

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

FIBRE

Cows need fibre for efficient rumen function. The ruminant evolved to eat fibre and the physical structure of the fibre influences time spent ruminating or 'chewing the cud'.

Rumination stimulates the production of saliva, which acts to buffer against rumen acidity and helps to maintain a stable rumen environment.

For more details see TechNote 8: Fibre metabolism, and online eLearning activity: The role of fibre; dairynz.co.nz/feedright-module-6.

MINERALS AND VITAMINS

Minerals are essential for optimal body function and a cow requires 25 different minerals. A deficiency or oversupply of a mineral can result in metabolic disorders, reduced health and possibly death.

A pasture-based diet provides many of the required minerals; however, some minerals can be in scarce e.g. calcium, magnesium, phosphorus, iodine, selenium, zinc, copper, cobalt, and sodium.

Vitamins are required for immune function, feed absorption and metabolism, reproduction, and production.

A dairy cow requires vitamins C and the B complex vitamins which are water soluble, and vitamins A, D,E and K which are fat soluble.

Generally, in a pasture-based system it is only vitamin D that may require supplementation.

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

1.3 Further reading

Grace, N., S. Knowles, A. Sykes. 2010. Managing mineral deficiencies in grazing livestock. Occassional Publication 10 – New Zealand Society of Animal Production: Palmerston North, New Zealand.

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

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

Ruminant Physiology: Digestion, Metabolism, Growth and Reproduction. P. B. Cronje, ed. Oxon, UK: CAB International.

The Ruminant Animal: Digestive Physiology and Nutrition. D. C. Church, ed. Illinois, United States of America: Waveland Press, Inc.