NUTRITION MANAGEMENT FOR TASMANIAN DAIRY FARMERS

An Initiative of the Pasture Plu$ Program

Workshop Manual

Revised Edition May 2007

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for Tasmanian Dairy Farmers

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- Workshop Manual

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Nutrition Management for Tasmanian Dairy Farmers

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About This Workshop

The Nutrition Management for Tasmanian Dairy Farmers Workshop is an initiative under the Pasture Plu$ Program, which is funded by Dairy Australia through the DairyTas Board.

Introduction

The major profit driver for Tasmanian dairy farms is the direct conversion of high quality pastures to milk.

To achieve higher rates of pasture utilisation, many Tasmanian dairy farmers have increased stocking rates and increased their reliance on irrigation, bought-in supplements and fodder crops. With this increase in supplementation has come an increased emphasis on cow nutrition, accompanied by considerable confusion and conflicting advice on feeding strategies and products.

Unfortunately, there is no simple answer as there isn't a single 'recipe' for feeding cows which is correct (and profitable) for everyone.

Cow nutrition is a complex area and DOES NOT just refer to grain, pellets, trace elements and mineral premixes. **'Nutrition' in the Tasmanian context means pasture, silage, hay turnips, other fodder crops, cereal grains, commercial concentrate pellets and by-products such as vegetable waste.**

The challenge of nutrition in a pasture-based system is that the major component – pasture – varies from day to day and paddock to paddock. **On a day-to-day basis we know very little about the feedstuff which generally makes up to 70% or more of the cow's diet.** It's an entirely different system from feeding a Total Mixed Ration in a feedlot, and requires a slightly different approach to cow nutrition. However, there are plenty of Tasmanian farmers proving that it's not impossible, by concentrating on the basics – pasture quantity and quality – and using supplements to manipulate them.

The aim of this workshop is to enable people to make objective and informed decisions about feeding their herds, based on their own reasoning and a sound knowledge of how nutrition affects production, reproduction, health and profit.

Specific Objectives Of This Workshop

By the end of this workshop, it is hoped that participants will:

1. Understand and be able to express cow requirements in terms of energy, protein and fibre.
2. Be able to compare feeds on the basis of nutritive value.
3. Understand more about the impact of nutrition on production, health and reproduction.
4. Be able to check whether a ration is balanced in terms of energy, protein and fibre.
5. Have a better understanding of pasture-supplement interactions, including the factors which affect responses to supplements and how they determine the profitability of supplementary feeding.

How To Use This Manual

Definition	**A shaded area within the test like this is used when defining important nutrition words or terms**

∫ **This refers you to another chapter or page for more information**

Key points to remember are usually in a box like this,
often at the end of a section or chapter

Example *Examples within the text are set out like this*

Exercises *There are several exercises in the manual that relate to the different sections. These have been put at the back of the manual and reference will be made to these during the workshop.*

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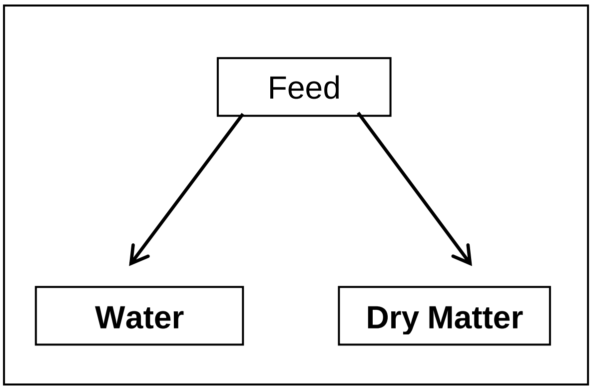
1. Nutrients Required by Cows and What They Are Used For



All feeds contain some water and some dry matter.

'Dry Matter' is the portion of the feed remaining after all the water has been removed

Water

Importance

The most essential nutrient - not only does the cow's body consist of 50-75% water but milk contains 87% water.

Functions

- Maintains body temperature.
- Transports nutrients.
- Involved in digestion, metabolism and removal of wastes.

Requirement

- A dry cow needs 30 - 40 litres (L) of water per day.
- An extra 4 litres of water is needed per litre of milk produced.
- Requirements can increase in hot weather.

A cow producing 20 litres needs 110 litres of water each day!

Measured as

Litres (drinking water) or as a percentage (%) in feed.

Sources in feed

All feeds contain some water, which is usually expressed as a percentage of the total feed. The percentage of water varies between feeds - lush spring pasture can be 85% water and 15% Dry Matter (**DM**), whereas cereal grains may be only 13% water and 87% Dry Matter.

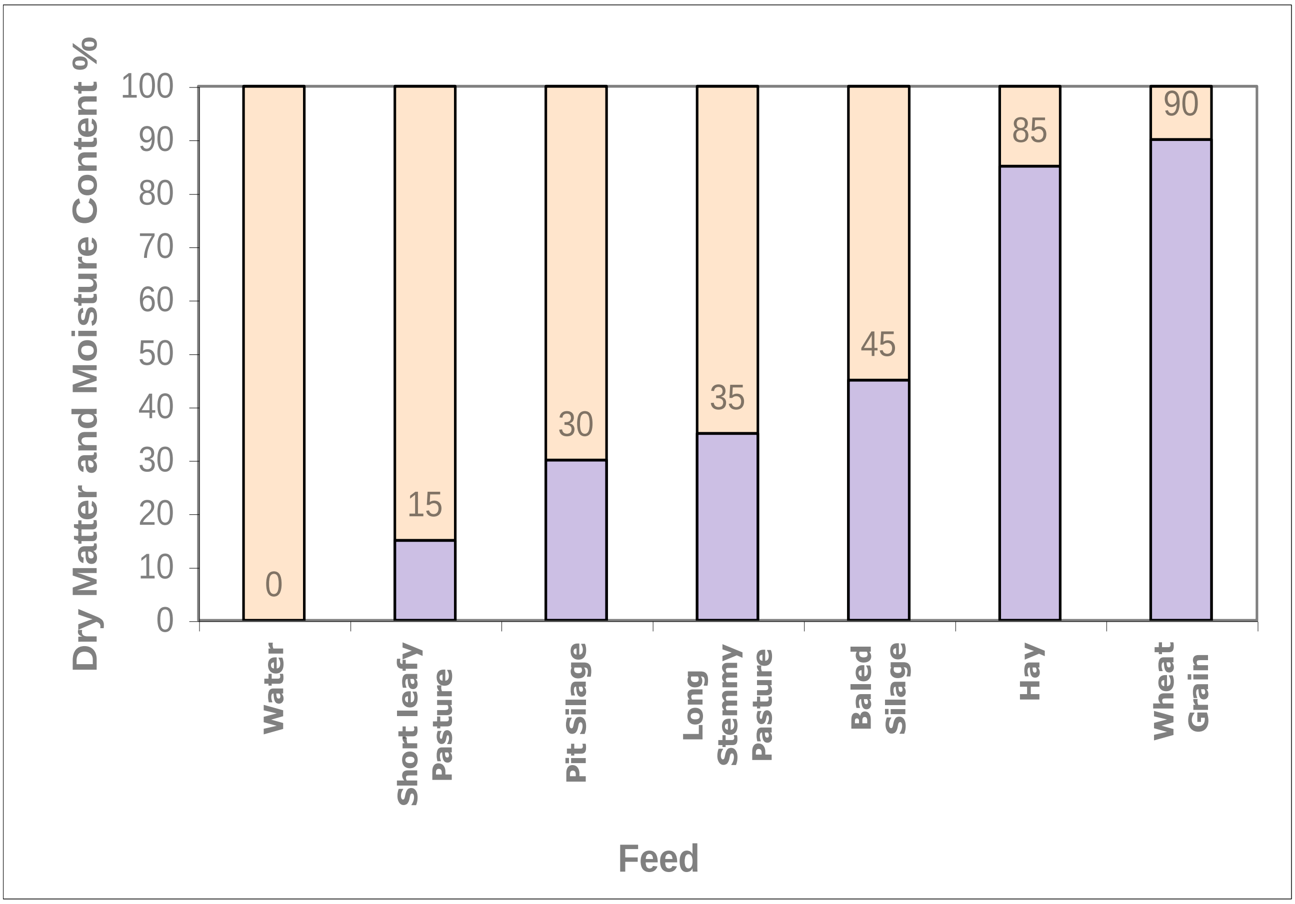


Figure 1.0: Typical Dry Matter and Moisture levels in feeds.

Dry Matter:	*The portion of the feed remaining after all the water has been removed. Dry Matter % (**DM%)** refers to the % of Dry Matter in any feed.*

'As fed':	*If you weigh fresh feed, you are weighing it on an '**as fed**' basis with moisture in it. If you dry a sample of the feed you can work out the Dry Matter (DM) content. Multiplying the DM% by the amount of wet feed gives the kg of Dry Matter fed.*

Example	***How much Dry Matter is in a feed sample?***	
	Feed type	*Grass silage*
	'As fed weight'	*200 g*
	Dry weight	*70 g*
	DM%	***=** 70 ÷ 200 **= 35%***

How much Dry Matter (DM) was eaten by the cows if we know how much wet grass silage ('as fed') was eaten?

Feed type	*Grass silage*
kg of feed 'as fed'	*24 kg*
kg of DM fed	*= 24 kg x 35/100 =* ***8.4 kg DM***

Working backwards: If we know the Dry Matter % (DM%) and the kilograms of Dry Matter which the cows consumed, how much wet grass silage 'as fed' was eaten?

kg of DM eaten	*7 kg DM*
DM% of grass silage	*35%*
kg of fresh grass silage	*= 7 kg DM ÷ 35/100 =* ***20 kg 'as fed'***

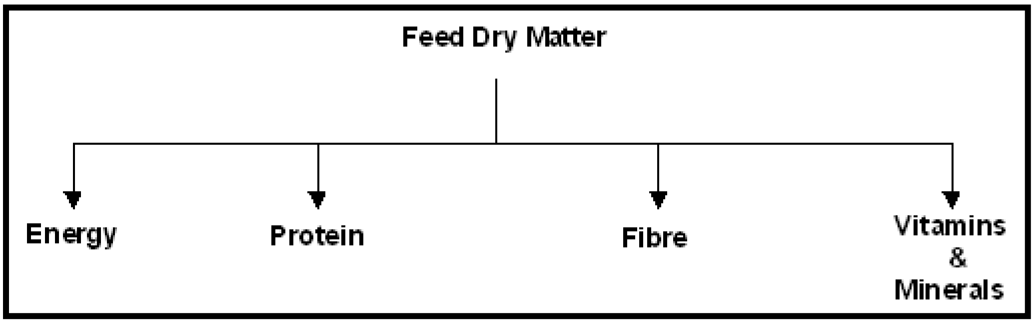


Figure 1.1: Feed components of Dry Matter.

Different feeds are always measured and compared on a 'Dry Matter' (DM) basis, as it is the Dry Matter which contains the feed components which the cows can use - ***energy, protein, fibre, vitamins and minerals*.**

Each of these nutrients is described below.

Energy

Importance	The most important nutrient for production, and under a pasture-based system it is usually the most limiting nutrient. Determines milk production, milk composition and body condition.

Functions

Energy is required by the cow to perform work, namely:

- **Maintenance** (breathing, circulation, tissue repair, digestion, regulation of body temperature)
- **Activity** (walking, grazing etc)
- Maintaining a **pregnancy**
- Gaining condition or **growing**
- **Producing milk**

Requirements

Vary with liveweight and physiological state (whether dry, pregnant, milking etc).

➲ **ENERGY REQUIREMENTS WILL BE DISCUSSED IN DETAIL IN CHAPTER 3.**

Measured as

Megajoules **(MJ)** of Metabolisable Energy **(ME).**

In feed: Megajoules of Metabolisable Energy *per kilogram of Dry Matter* **(MJ ME/kg DM).** The higher the number of Megajoules, the more energy is contained in the feed.

Metabolisable Energy:	*The energy available for use by the cow for maintenance, milk production, pregnancy and weight gain.*

Q. What determines the proportion of the Gross Energy in a feed that ends up as Metabolisable (useable) Energy?

A. DIGESTIBILITY.

Digestibility:	*Relates to the proportion of a feed that is **not** excreted as manure and so is available for use by the cow*

Digestibility provides an indication of the **quality** of a feed.

- A high digestibility ('good quality') feed means that the feed will be of more benefit to the animal - it can digest and use more of it. (*Example: spring pasture, cereal grains.*)

- A low digestibility feed ('poor quality') means that more of the feed is passed out in the manure and less is useful to the cow. *(Example: straws, old hay.)*

- The higher the digestibility, the higher the Metabolisable Energy (ME) content.

Sources

The main sources of energy are carbohydrates, fats and oils, and protein (when surplus protein is present).

Carbohydrates

- the main source of energy for grazing cows
- occur as
  - → soluble carbohydrates
  - → storage carbohydrates
  - → structural carbohydrates

***Soluble Carbohydrates*:**

- ***Sugars found within the plant cell***
- *Occur principally in the leaves of plants, rather than in the stem*
- *Are rapidly digested by the rumen microbes*

Storage Carbohydrates:

- ***Starches found within the plant cell***
- *Found in grains, plant leaves and plant stems*
- *Are digested more slowly than the soluble sugars but faster than the structural carbohydrates*

Structural Carbohydrates:

- ***Hemicellulose and cellulose (fibre) in the plant cell wall***
- *Found in stemmy plant material*
- *Slowly or only partially digested by the rumen microbes*

The other structural material found in plants is **lignin**, which is not a carbohydrate. Lignin is indigestible, but also reduces the digestibility of the cellulose by binding it and making it inaccessible to the microbes. Lignin content increases as the plant matures and becomes stemmy. **Increased lignin content with plant maturity means decreased digestibility.**

Figure 1.2 depicts how Plant Carbohydrates are classified.

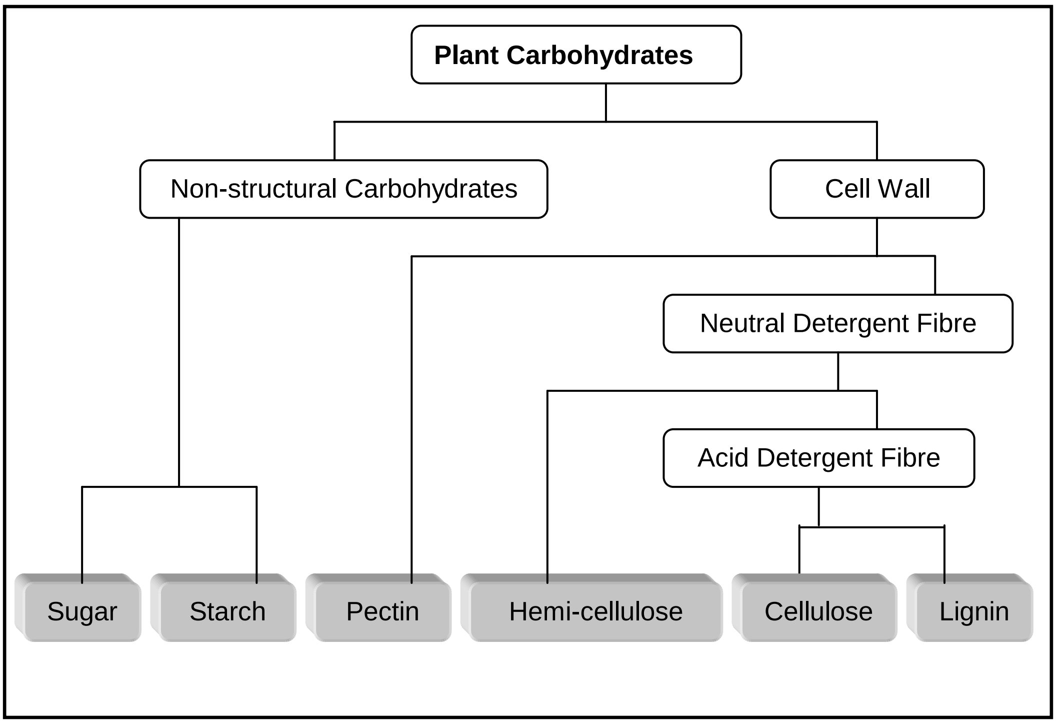


Figure 1.2: Understanding the components of plant carbohydrates.

Fats and oils
- present in minimal quantities in pasture (2-3%**).**
- can be added to the diet as vegetable oils, tallow etc.

Protein
- protein which is surplus to requirements can be broken down to provide energy. This is an inefficient process.

Protein

Importance The material which builds and repairs all body tissues. It makes up the muscle, skin and internal organs of the cow. Hormones and enzymes which assist digestion are all proteins.

Functions Protein is required for **maintenance, growth, pregnancy** and for the **production of protein in milk**.

Measured as Most commonly as a percentage of the diet or of a particular feed. There are different measures of dietary protein, including **Crude Protein % (CP%), Rumen Degradable Protein (RDP)** or **Undegradable Dietary Protein (UDP).**

All proteins are made of chains of **amino acids**, which contain Nitrogen.

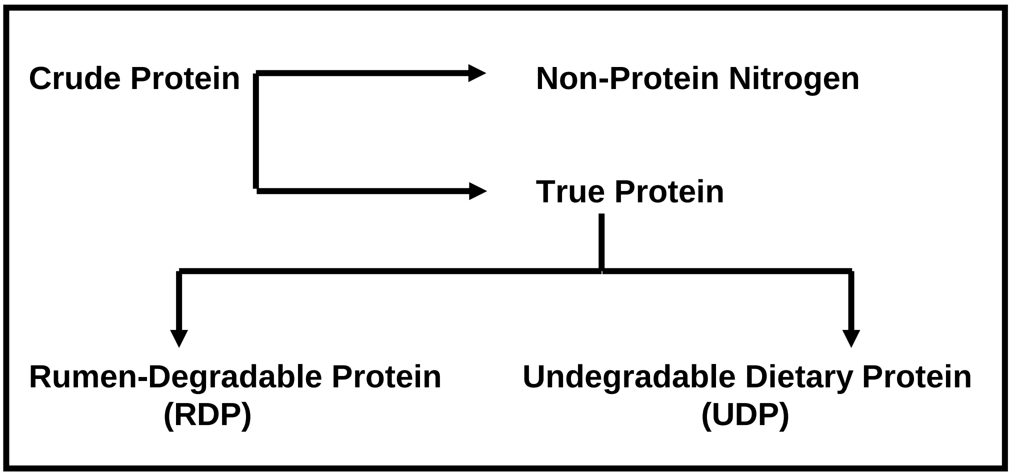
Crude Protein: *Crude Protein % of a feed is calculated by measuring the total amount of Nitrogen in a feed and applying the formula:*

Crude Protein % = Nitrogen content (%) x 6.25

Nitrogen in feeds can be found either in amino acids (**True Protein**) or in other forms (**Non-Protein Nitrogen, or NPN**). For this reason, Crude Protein % is a slightly 'crude' measure, as not all of the Crude Protein is True Protein.

True Protein consists of chains of amino acids, whereas Non-Protein Nitrogen consists of simple forms of nitrogen, such as Nitrates.

True protein can be further classified into two types - **Rumen Degradable Protein (RDP)** and **Undegradable Dietary Protein (UDP).**



Rumen-Degradable Protein (RDP *This protein is broken down (degraded) in the rumen by the rumen microbes to form peptides, amino acids and ammonia, which are then used to 'build' more microbes.*

Undegradable Dietary Protein (UDP) *This protein escapes or 'bypasses' the rumen without being attacked by the microbes. It is digested in the small intestine.*

➲ **THE FACTORS AFFECTING THE PROPORTION OF TRUE PROTEIN WHICH ESCAPES THE RUMEN AS UDP WILL BE DISCUSSED IN CHAPTER 2.**

Sources

Both the Non-Protein Nitrogen and the True Protein are a source of amino acids for the cow. If sufficient energy is available, the microbes in the rumen can manufacture additional amino acids from the Non-Protein Nitrogen. The cow can utilise both the amino acids found in the True Protein and those which were manufactured by the microbes.

Fibre

Importance	The physical bulk of the diet. Necessary for rumen function.
Functions	• **Source of energy** from digestion of the structural carbohydrates (see pages 11-12). • Causes **rumen movement and mixing of rumen contents with microbes**, **thus starting the breakdown process**. Also allows rumination (cud chewing) to occur. • **Stimulates saliva production** - saliva contains sodium bicarbonate, which acts as a 'buffer' **to prevent the rumen becoming too acid.**
Measured as	Usually as a percentage in the diet. There are different ways of measuring fibre in the diet, which relate to the digestibility of different types of fibre. These include **Crude Fibre % (CF%), Neutral Detergent Fibre % (NDF%)** or **Acid Detergent Fibre% (ADF%).**
Crude Fibre :	*Represents the fibrous components of a feed. Although still commonly used in guidelines for feeding cows, **it is a poorer measure of fibre content than ADF% and NDF% as it does not include all of the fibrous constituents of a feed.***
Neutral Detergent Fibre (NDF):	***A measure of all the fibre**, **both indigestible and digestible**. Represents the cell wall component of feeds - including the structural carbohydrates (**cellulose** and **hemicellulose,** which are partially digestible) as well as **lignin** and **silica** (indigestible).* ***As the NDF content of the diet increases (ie more bulk) animal intake decreases**.*
***Acid Detergent Fibre (ADF**):*	***Measures the less digestible or indigestible parts of the cell walls**, including the **cellulose** (more slowly digested than hemicellulose) and the **lignin** and **silica** (indigestible).* ***The ADF% is used to calculate the digestibility of a feed - the higher the ADF value, the lower the digestibility of a feed.***

Vitamins

Importance All animals require vitamins (in very small amounts). At least 15 vitamins are known to be essential for animal health, growth and performance.

Functions Required for many metabolic activities, including bone formation, milk production, reproduction and disease resistance.

Measured as The measurement unit for vitamins is the International Unit (IU).

Sources In addition to the vitamins provided in feeds, the rumen microbes can produce Vitamin K and the B-group vitamins, usually in sufficient quantities for the cow.

➲ **COW VITAMIN REQUIREMENTS WILL BE DISCUSSED FURTHER IN CHAPTER 3.**

Minerals

Importance About 25 minerals are known to be essential for animal health and growth.

Functions Required for many metabolic activities, particularly bone formation, and muscle and nerve function.

Measured as For animal requirements: usually measured in **grams per day** (**g/day**) or **milligrams per day** (**mg/day**) depending on the quantity required.
In feeds: usually measured as grams or milligrams *per kilogram of Dry Matter* (**g/kg DM or mg/kg DM**).

Macro-minerals: Are those minerals which are required in quantities of grams/day (g/day). *Examples: Calcium, Phosphorus and Magnesium*.

Micro-minerals: Are those minerals required in smaller quantities (mg/day).
E*xamples: Cobalt, Selenium, Iron.*

➲ **COW MINERAL REQUIREMENTS AND THE ROLE OF MINERALS WILL BE DISCUSSED IN CHAPTER 3.**

2. The Digestive Process in the Adult Cow

Cows are members of a group of animals known as **Ruminants**, so called because they posses an enlarged **Rumen**, plus three other compartments (the **reticulum**, **omasum** and **abomasum**) which allows them to digest forages. (See Figure 2.0).

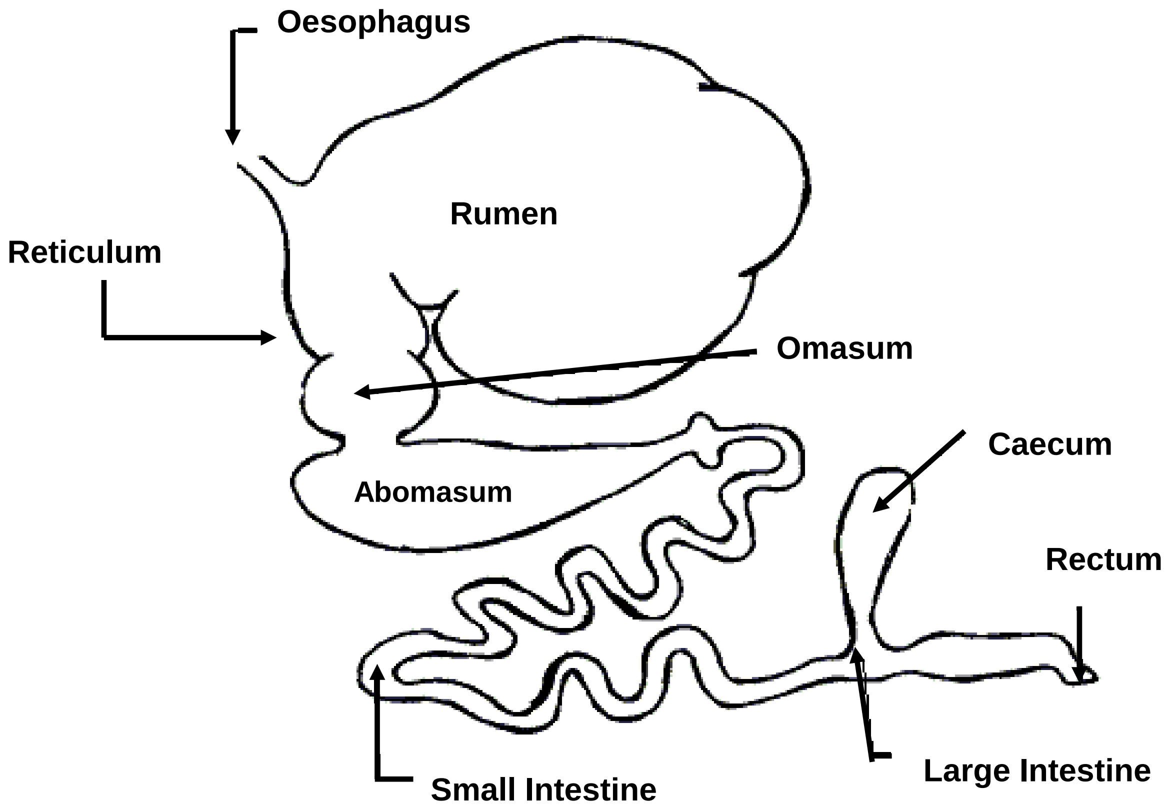


Figure 2.0: Diagram of a Ruminant Gastro-intestinal tract.

Major 'design features' of the gastro-intestinal tract

Rumen/Reticulum

The Rumen has been likened to a fermentation vat, as **its primary purpose is to play host to billions of microbes which have the ability to convert feed components, such as cellulose and Non-Protein Nitrogen, into usable sources of energy and protein for the animal.**

> ***Note:*** *Cows do not produce enzymes to digest cellulose – they depend on the bacteria and fungi in the rumen to do that for them.*

The Rumen and Reticulum are usually dealt with as a combined unit.

Major Features:

- The largest compartment of the gastro-intestinal tract, with a capacity of 50-120 litres.
- Contains billions of microbes (Bacteria and Protozoa), which break down feeds through fermentation.

The Rumen Microbial Population

- Rumen microbes are part of a dynamic population which is constantly moving (with partially digested material as it leaves the rumen), multiplying and dying.
- The products of digestion are used by the microbes for their own multiplication and growth.
- **Feeding the cow also feeds and sustains an active microbial population, which in turn leads to effective fermentation and utilisation of feed.**

Keeping the Bugs Happy

- Rumen microbes require **stable temperature (around 39°C)** and **pH (5.8)** for maximum activity and efficiency on pasture based diets.
- **Different types of microbes have different functions**, e.g. some microbes are specialist cellulose digesters whilst others digest starch. **The 'balance' of different types of microbes in the rumen is affected by the animal's diet.** A cow on a high grain ration has a different microbial population from a cow which is primarily pasture-fed.
- **Different types of microbes also have preferred conditions under which they tend to multiply and become more dominant in the population**. Some species are more tolerant of acidity than others.
- Starch and sugar digesters are more tolerant of acidity than cellulose digesters. This has important implications when mixing forages and concentrates, or when increasing concentrate levels. If these changes are made suddenly, the make-up of the microbial population swings towards the starch and sugar digesting microbes, at the expense of the cellulose digesters. This results in problems with fibre digestion and can lead to acidosis, or 'grain poisoning'.
- **The microbes (both living and dead) flow out of the rumen with the products of fermentation, to be digested further down the gastro-intestinal tract.**
- **The microbes have a additional role in synthesising nutrients for the cow**, including the B-group vitamins and amino acids (from Non-Protein Nitrogen sources).

> ***Note:*** *Maintaining an active mixture of different microbes is essential for effective rumen function and feed utilisation.*

Maintaining Rumen pH

- The acids produced as end-products of microbial fermentation of feed material are buffered by sodium bicarbonate in saliva produced during eating and rumination.

The Omasum

The primary function of the Omasum is to reduce the water content of the feed material which enters the Omasum from the Rumen. It also grinds and breaks down particles of feed material.

The Abomasum

The 'true stomach' where digestion similar to that occurring in humans takes place. The lining of the abomasum produces hydrochloric acid and enzymes which chemically break down proteins in feed material. The rumen microbes are killed due to the low pH in the abomasum (pH = 2 approximately).

The Small Intestine

The major site of enzymatic digestion and also the major nutrient absorption site (through the wall of the small intestine).

The Large Intestine

Additional fermentation of fibre occurs in the large intestine (caecum and colon), together with absorption of water, minerals and ammonia.

The digestive process

'Digestion' refers to a series of both **chemical and mechanical breakdown processes** that allow nutrients contained in food material to be absorbed by the cow in a usable form.

Mechanical breakdown of food commences with chewing, after which feed enters the rumen, where it is churned and mixed with rumen fluid (containing microbes) by the continuous movement of the rumen wall. Further mechanical breakdown occurs when the cow 'chews her cud' or ruminates. By increasing the surface area of the feed particles in this way, microbial fermentation in the rumen is quickened.

The rate of microbial breakdown depends on the composition of the feed, as well as the types of microbes present and the size and activity of the microbial population. Rumen pH and availability of energy and protein affect the growth and multiplication of the microbes, and hence the rate of fermentation.

The chemical breakdown processes for each feed component are described below.

Carbohydrates (including digestible Fibre - structural carbohydrates)

Carbohydrates represent approximately 60% of the plant Dry Matter and are also the major source of energy for the cow. There are three types of Carbohydrates in feeds (see Chapter 1).

- **Soluble** (sugars) — *Rapidly Digested*
- **Storage** (starches)
- **Structural** (Cellulose & Hemicellulose) — *Slowly Digested*

During fermentation, the microbes break down the carbohydrates into simple sugars. **These simple sugars are used by the microbes for their own growth and the end products of the microbial fermentation are then available for use by the cow**. The end products of carbohydrate fermentation are **Volatile Fatty Acids (VFA) and gases (carbon dioxide and methane)**.

These Volatile Fatty Acids are the major source of energy to the cow. The major VFA's produced are **acetate** (or acetic acid), **butyrate** (butyric acid) and **propionate** (propionic acid)

> ***Note:*** *The proportions of the different VFAs produced in the rumen depends upon the diet (which in turn affects the types of microbes present). The relative amounts of VFAs determines the milkfat test.*

Acetate

- ***The major end-product of fibre digestion*** *(cellulose fermenting bacteria produce a large proportion of acetate)*
- *The most abundant VFA in the rumen*
- ***Is a precursor for milkfat synthesis***
- ***Low fibre diets result in low acetate production and consequently lowered milkfat production***

Propionate

- ***The major end-product of starch and sugar fermentation***
- *Starch fermenting bacteria produce a VFA ratio higher in propionate and butyrate and lower in acetate*
- *The next most abundant VFA after acetate (depends on diet)*
- *Fermentations producing propionate produce less methane and Carbon Dioxide*
- ***Propionate is a more efficient energy source for the cow than acetate or butyrate***
- ***Propionate is the major source of energy for liveweight gain and milk lactose synthesis***

Butyrate	• *Produced in smaller quantities (depends on diet)* • ***Is eventually metabolized to provide an energy source for synthesis of fatty acids and skeletal muscle***

VFA's are absorbed through the Rumen wall and are transported to the liver, where they are metabolized to produce energy for maintenance, pregnancy, milk production and liveweight gain (see Figure 2.1).

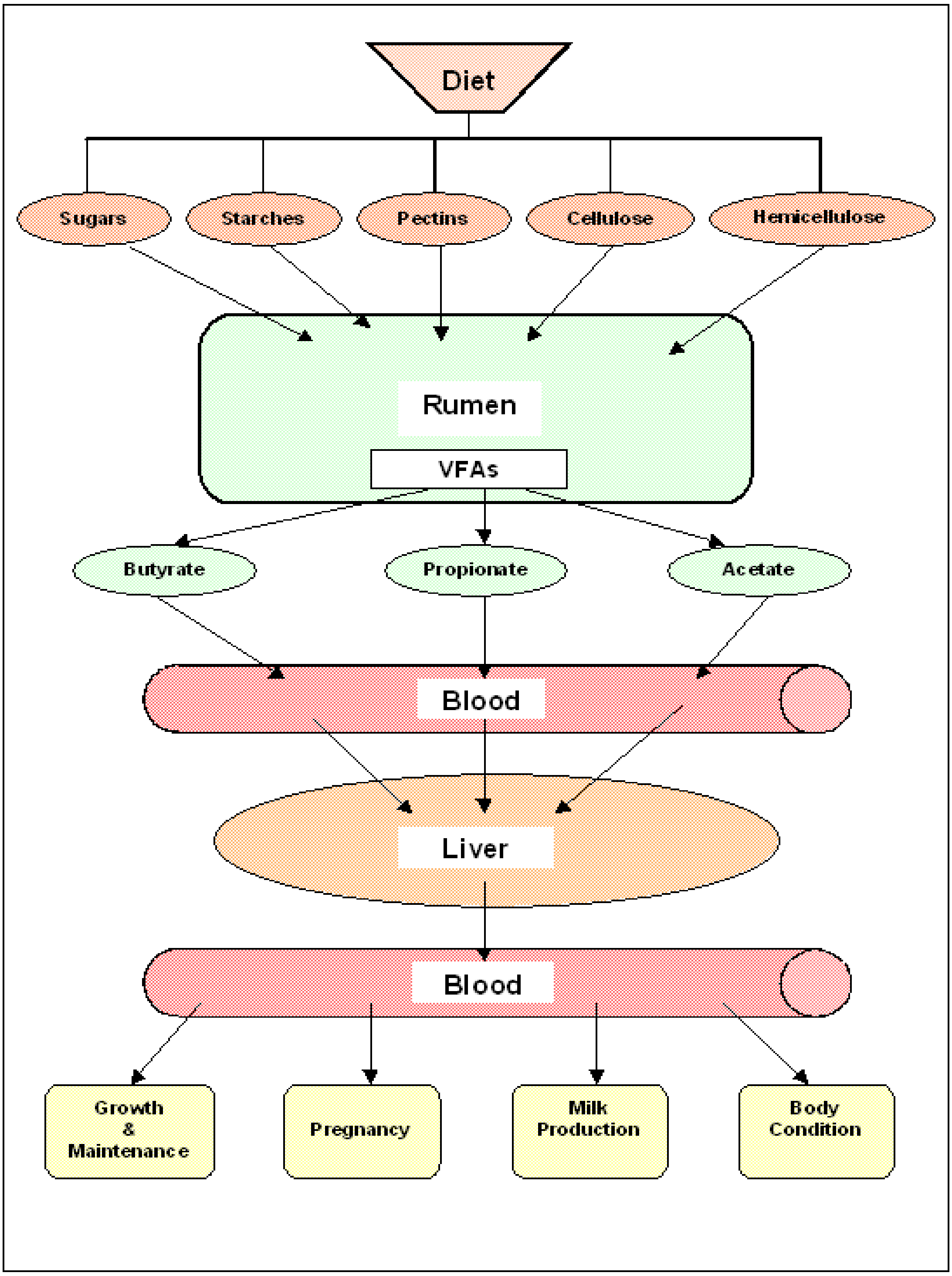


Figure 2.1: Digestion and metabolism of carbohydrates.

Protein

Rumen Degradable Protein (RDP)

Rumen Degradable Protein and the Non-Protein Nitrogen in feeds are degraded in the rumen to produce amino acids and ammonia (see Figure 2.2).

These products are then used by the rumen microbes to produce more microbes - commonly referred to as 'microbial protein', as the microbes (bacteria and protozoa) consist of about 60% protein.

Rumen microbes are constantly being 'flushed' out of the rumen with the partially digested feed material. Upon reaching the abomasum, they are killed by the acidic conditions there and are digested through the action of enzymes in the abomasum and small intestine. This digestion results in the microbes being broken down to form amino acids which are absorbed by the cow and re-synthesised into body protein (e.g. tissues, organs).

> ***Note:*** *It is this microbial protein (i.e. the microbes themselves) which supplies the majority of the cow's protein requirements.*

This breakdown and re-synthesis process is energy intensive, but has benefits as it supplies the cow with certain 'essential' amino acids which the cow requires (for building and repairing body tissues) but cannot manufacture herself.

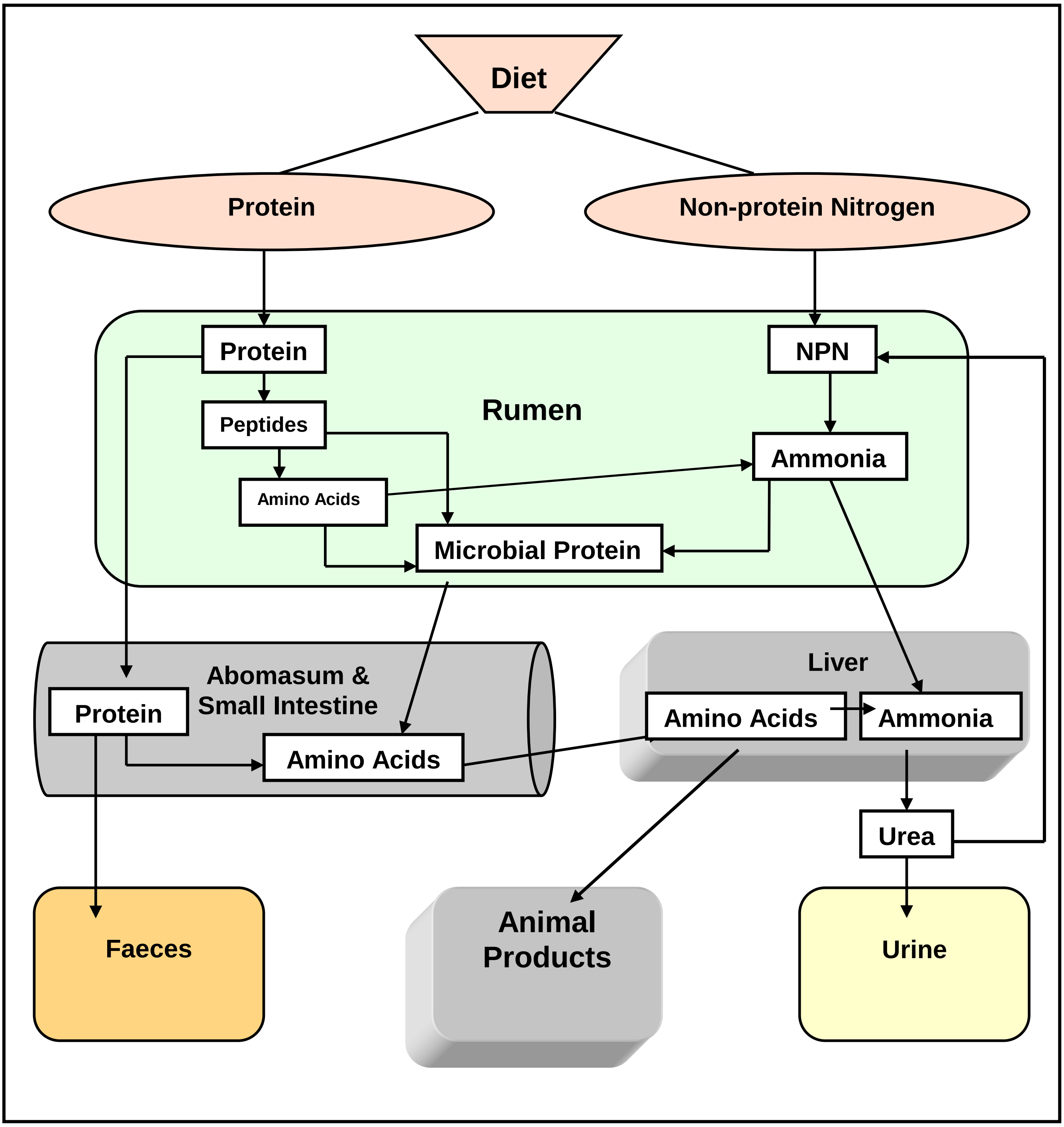


Figure 2.2: Digestion and metabolism of proteins.

Factors affecting the proportion of True Protein which by-passes the rumen

The proportion of True Protein in feeds which bypasses the rumen as Undegradable Dietary Protein (UDP), or escaped Rumen Degradable Protein, varies depending on:

- **Whether the feed has been heated or chemically treated** to protect the protein from microbial attack.
- **Level of intake and speed of transit through the rumen** - if large quantities of feed are flowing through rapidly, some protein which could be degraded in the rumen may escape to the abomasum and small intestine.

- **Energy availability for the microbes** - if there is insufficient energy for the microbes, they cannot utilise protein as efficiently and more protein escapes the rumen

Fats

Fats are an additional source of energy for the cow. Some microbial fermentation of fats occurs in the rumen to produce vitamins. 'Bypass' or protected fats pass through the rumen without being degraded and are digested and absorbed in the small intestine.

No more than 5% of diet Dry Matter should consist of fats, as higher levels of rumen-degradable fat interfere with microbial breakdown of fibre by coating its surface. High levels of fat also decrease palatability.

Protected fats (e.g. Prime, Megalac, etc) can be fed at higher levels than 5% of the diet. This is because they are stable in the rumen, instead being digested and absorbed from the small intestine. This avoids problems with fibre digestion and also increases the energy density of the diet. However, as these supplements are expensive, their use is generally confined to high producing herds which experience severe weight losses in early lactation. The concentrated energy from protected fats may help to reduce these losses.

The importance of fibre

Fibre (including the structural carbohydrates, plus indigestible lignin and silica) maintains gut movement which mixes incoming feed with the rumen contents and improves the microbes' access to the feed material. Fibre also stimulates rumination (cud-chewing) which further aids mechanical and chemical breakdown. Importantly, fibre also stimulates saliva production, which helps to buffer the rumen pH.

Speed of passage through the digestive tract - effects on intake and extent of digestion

There is a constant flow of material through the digestive tract, but **the speed of digestion is affected by the particle size and density of the feed, its digestibility and level of intake** (see Figure 2.3).

Feed material will only exit the rumen when it has been broken down into particles which are small enough to be flushed out. Low digestibility feeds take longer to break down so they stay in the rumen longer, resulting in lowered intakes. If low digestibility feeds (e.g. poor hay) are finely ground, the smaller particle size increases speed of passage and intakes increase. However, this rapid movement of feed through the rumen reduces the exposure of the feed to microbial attack and hence digestion is reduced even though the intake may have increased.

Also, at high intake levels, feed tends to stay in the rumen for shorter periods of time (i.e. throughput is quicker). Again, this reduces the extent of microbial breakdown. Where intakes are restricted, throughput is slower and utilisation of the nutrients in the feed improves.

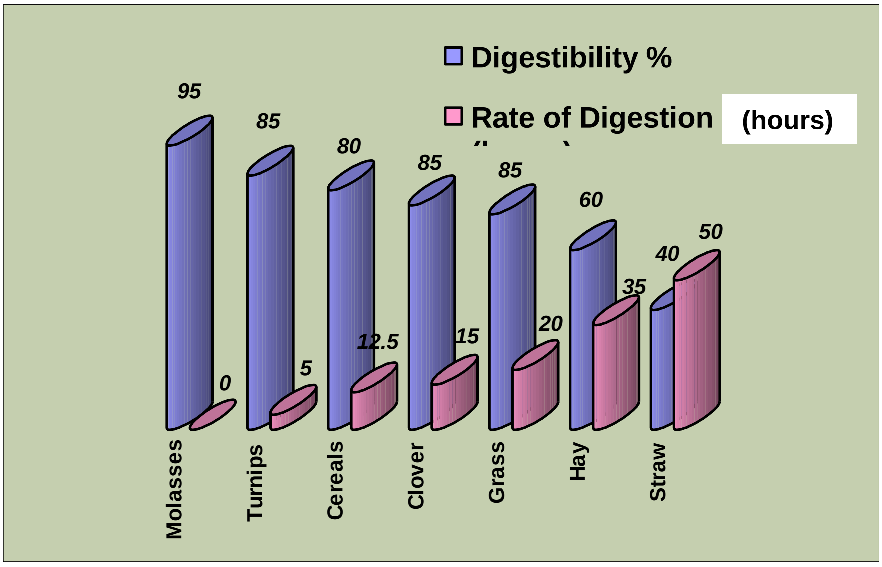


Figure 2.3: Digestibility % versus rate of digestion for various feeds.

3. Nutrient Requirements of Dairy Cows

As discussed in Chapter 1, all cows require energy, protein, fibre, vitamins and minerals for maintenance, lactation, growth/condition and pregnancy. **These nutrients are supplied in feed Dry Matter.**

As Dry Matter Intake (DMI) directly influences nutrient intake, and grazing management and feed budgeting revolve around the availability of Dry Matter, Dry Matter Intake needs to be considered when discussing cow nutrient requirements.

Dry Matter Potential intake of Dry Matter is primarily affected by the **size and/or weight of the animal**, the **digestibility of the feed** on offer and the **stage of lactation.**

Size/Weight A cow can eat 3-4% of her bodyweight in Dry Matter each day, but some high producing cows will consume more than 4% of their bodyweight.

Feed Digestibility- importance of ***QUALITY*** Feeds of higher digestibility pass through the digestive tract faster, (making more room for incoming feed) and therefore stimulate higher intakes (see Figure 3.0).

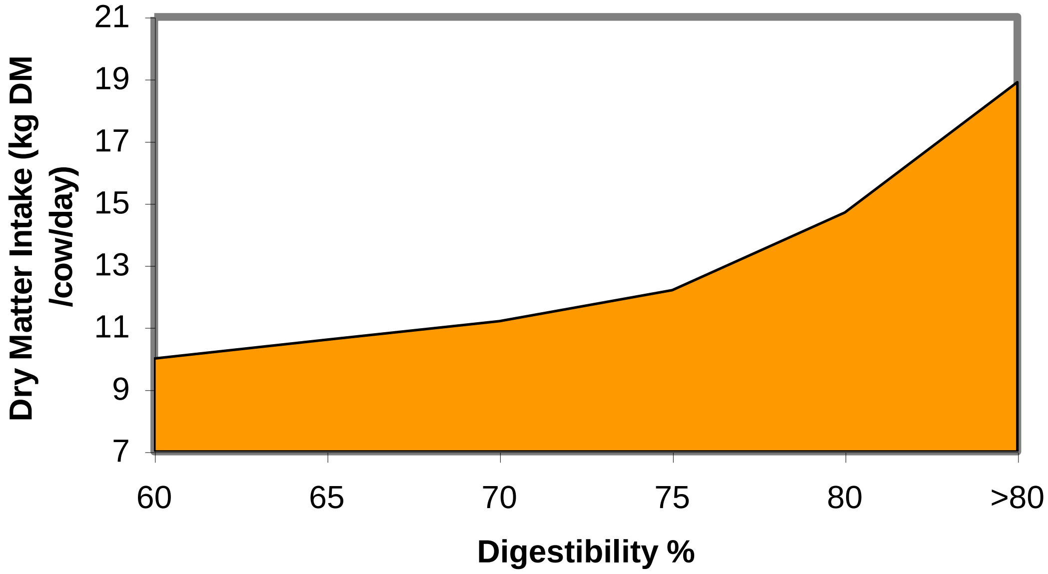


Figure 3.0: Pasture Quality (digestibility) vs Pasture Intake.

> *Feeding highly digestible (i.e. high quality) material has a 'multiplying' effect on total nutrient intake, as not only does the cow consume more nutrient from each kilogram of Dry Matter, but her overall intake of Dry Matter increases.*

Stage of Potential Dry Matter Intake (DMI) at calving is only about 75% of

Lactation

peak Dry Matter Intakes achieved 12-14 weeks later. This is because the volume of the cow's rumen reduces in late pregnancy due to extra space being taken up by the calf. The rumen takes time to stretch, and it is not until weeks 10-12 that maximum potential intake is reached.

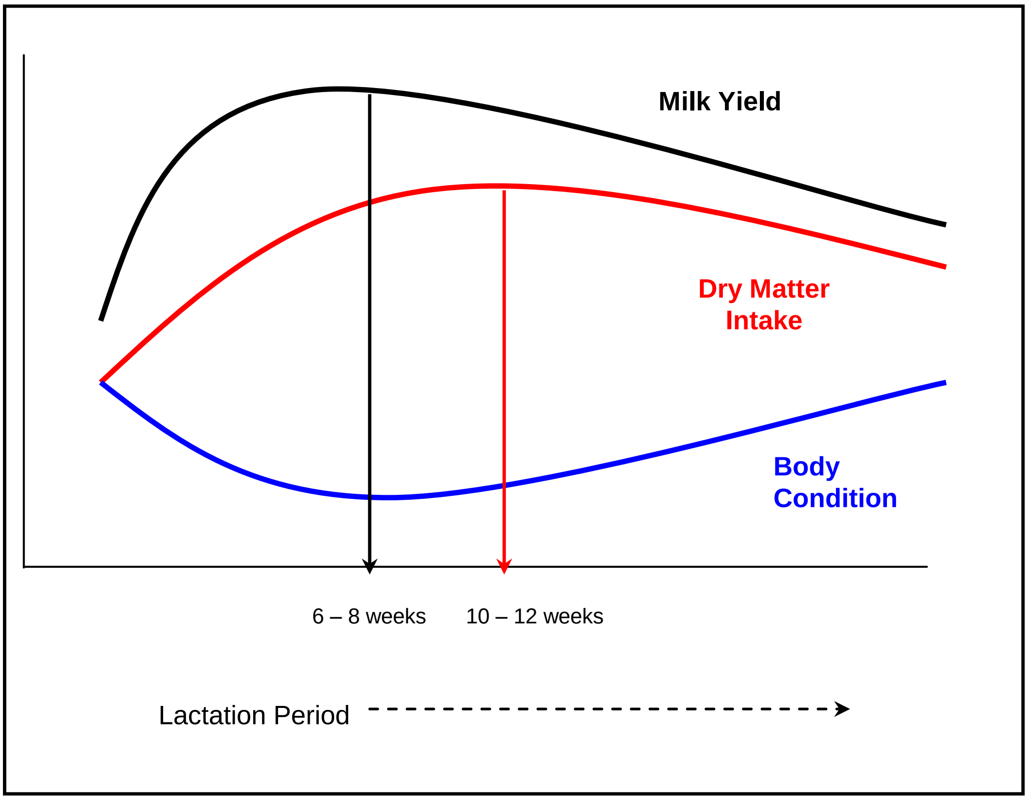


Figure 3.2. Changes in milk production, liveweight and Dry Matter intake during the lactation cycle. (*Source: Lawson, 1994)*

Peak Dry Matter intake 'lags behind' peak milk production, which occurs 6-8 weeks after calving. This has two important implications:

- **To meet the shortfall between nutrient requirements and what she can physically consume, the cow has to use body reserves, i.e. lose condition**
- **Because there is a physical limit on intake, feed provided to the cow in early lactation needs to be of the highest quality to maximise nutrient intake**

➲ **THE IMPACT OF FEED SUPPLY THROUGH THE DIFFERENT STAGES OF LACTATION ON PRODUCTION AND BODY CONDITION WILL BE DISCUSSED FURTHER IN CHAPTER 5.**

'Thumbrules' for predicting DMI

There are a couple of 'rules of thumb' which allow us to estimate how much Dry Matter an animal can consume daily.

Potential Dry Matter Intake is based on Body Weight:

DMI = 3.5% of Cow Liveweight

Dry Matter Intake of a feed is based on the quality of that feed and the liveweight of the animal:

A cow will eat 120 ÷ the NDF% of the feed as a percentage of her body weight (see Example 2).

Remember that NDF refers to the fibre content of a feed and as such provides an indication of feed quality.

Example:

1. ***Potential Dry Matter Intake based on Body Weight***
   500 kg cow
   3.5% of 500 kg = 17.5 kg DM potential intake

2. ***Dry Matter Intake of a feed based on the quality of that feed***
   500 kg cow
   Feed with a tested NDF% of 35%
   120 ÷ 35 = 3.4
   3.4% of 500 kg = 17 kg DM/day expected intake of this feed

---

Energy

You will recall from Chapter 1 that Energy **(as Megajoules of Metabolisable Energy, or MJ ME)** is required for maintenance, activity, pregnancy, growth and production. **The major source of energy in feeds is carbohydrates, although fats and excess protein can also be broken down to produce energy**.

Maintenance

Maintenance energy requirements vary with the liveweight of the cow (a larger, heavier animal has a higher maintenance requirement). Maintenance requirements are increased further in extreme temperatures.

Liveweight (kilograms)	Energy Requirement (MJ of ME/day)
100	19
150	26
200	32
250	38
300	44
350	49
400 (average Jersey)	54
450	59
500 (average Friesian)	64
550	69
600	73

Table 3.0: Maintenance Requirements

Activity

Walking represents an additional energy requirement.

- For each kilometre that cows walk to the dairy, an extra 1 MJ ME is needed.
- In hilly country, this can increase to 5 MJ ME for every kilometre the cows walk.

Pregnancy

Extra energy is needed by the cow for the development of the foetus, but it is only in months 6-9 that these requirements become significant. The additional MJ ME/day required to support the pregnancy in months 6-9 are shown in Table 3.1.

Month of Pregnancy	6	7	8	9
MJ ME/day	8	14	25	43

Table 3.1: Pregnancy Requirements

Growth/ Condition

Weight gain, or putting on condition, requires additional energy above that needed for maintenance. On the other hand, losing weight or condition releases energy to the cow.

Weight Gain - energy required	
When Lactating:	**34** MJ ME/kg Liveweight Gain
When Dry	**43** MJ ME/kg Liveweight Gain
Weight Loss - energy released	
Weight lost	**28** MJ ME/kg Liveweight Lost

These figures for liveweight gain or loss have two important implications:

1. When liveweight is lost in early lactation (due to the cow's intake capacity lagging behind her requirements), energy is released for milk production.

   In high yielding cows in early lactation, trials have shown that up to one third of daily nutritional requirements for milk production can come from body reserves. This can mean 10-11 litres, which is equivalent to 2 kg of body weight loss each day!

   Liveweight (i.e. condition) at calving is therefore an important determinant of peak yield.

2. For cows of low to medium genetic merit, it takes less energy to gain a kilogram of liveweight in late lactation than when the cow is dry. This is because the cow converts ME to liveweight gain more efficiently whilst lactating. This assumes that the lactating cow is being fully fed on average to good quality feed.

   This means that for cows of low to medium genetic merit, it is easier to put condition on in late lactation than when she is dry.

➲ **THE FACTORS AFFECTING THE PARTITIONING OF ENERGY BETWEEN PRODUCTION AND BODY CONDITION WILL BE DISCUSSED FURTHER IN CHAPTER 5.**

In terms of condition score, it should be remembered that the amount of liveweight in a condition score varies with the size of the cow, and therefore the breed of cow. (On a larger-framed animal, more liveweight is needed to show up visually as a condition score).

What's in a Condition Score?	
Jersey	**26** kg Liveweight
Jersey/Friesian Cross	**34** kg Liveweight
Friesian	**42** kg Liveweight

Example **_How much extra energy (above maintenance, pregnancy and production requirements) does a Friesian cow need to put on half a condition score in late lactation?_**

1 Condition Score = 42 kg, therefore half a score = 21 kg.
Each kg Liveweight gain in late lactation requires 34 MJ ME.
21 kg x 34 MJ ME/kg gain = 714 MJ ME in total.

Production **Energy supply is the most important factor affecting milk yield, and also maintains milk protein test.**

The amount of energy (in MJ ME) required to produce a litre of milk varies with milk fat and protein test - the higher the fat and protein test, the more energy required.

Fat %	***Protein %***					
	2.6	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**
3.0	4.5	4.5	4.6	4.7	4.8	4.8
3.2	4.6	4.7	4.7	4.8	4.9	5.0
3.4	4.7	4.8	4.9	4.9	5.0	5.1
3.6	4.9	4.9	5.0	5.1	5.1	5.2
3.8	5.0	5.1	5.1	5.2	5.3	5.3
4.0	5.1	5.2	5.3	5.3	5.4	5.5
4.2	5.3	5.3	5.4	5.5	5.5	5.6
4.4	5.4	5.5	5.5	5.6	5.7	5.7
4.6	5.5	5.6	5.7	5.7	5.8	5.9
4.8	5.6	5.7	5.8	5.9	5.9	6.0
5.0	5.8	5.8	5.9	6.0	6.1	6.1
5.2	5.9	6.0	6.0	6.1	6.2	6.3

Table 3.2: Energy required (MJ ME) to produce 1 L milk of varying composition

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Protein

As with energy, protein is required for maintenance, growth, pregnancy and milk production. Again, requirements vary with level of production, liveweight and stage of pregnancy.

As described in Chapter 1, protein is measured as either **Crude Protein** or more specifically as **Rumen Degradable Protein (RDP)** and **Undegradable Dietary Protein (UDP).** Cow protein requirements can be described in either way.

Crude Protein Requirements (% in the diet) at different stages of lactation	
Dry/Maintenance	**12%** CP
0-12 litres/day	**14%** CP
13-19 litres/day	**16%** CP
20-30 litres/day	**18%** CP
30 litres +/day	**20%** CP

To be more specific, once a certain level of milk production is reached some of the Crude Protein in the diet must be Undegradable Dietary Protein (UDP). Although microbial protein produced in the rumen from the breakdown of Rumen Degradable Protein supplies a large proportion of the cow's protein requirements, there is a limit.

Up to 12 litres of milk production can be maintained by microbial protein supply - i.e. all the dietary protein can be in the Rumen Degradable form (RDP) with no specific requirement for Undegradable Dietary Protein (UDP). Above this production level, however, some of the dietary protein must be in the UDP form, so that it passes through the rumen and gets digested directly in the small intestine.

Requirements for UDP rise with higher levels of milk production. Estimates of RDP and UDP requirements appear in Table 3.3.

Although cows do have a requirement for UDP in early/peak lactation, if production is less than 30 litres/cow/day and cows are grazing ryegrass/white clover pasture it is unlikely that additional UDP supplements need to be fed. Good quality pasture contains both RDP and UDP.

If Rumen Degradable Protein (RDP) enters the rumen in excess quantities, not all of the ammonia produced from the breakdown of this RDP can be utilised by the microbes. The excess ammonia is transported to the liver and converted to urea, which is then excreted. This process requires energy.

Spring pasture may contain high levels of RDP. The implications of this for production and fertility are discussed in later chapters.

Cow LWT (kg)	Milk Production (litres/day)									
	15		20		25		30		35	
	MJ of ME	RDP UDP (g/d)	MJ of ME	RDP UDP (g/d)	MJ of ME	RDP UDP (g/d)	MJ of ME	RDP UDP (g/d)	MJ of ME	RDP UDP (g/d)
450	129	1084 229	155	1302 323	182	1529 411	208	1747 506	235	1974 594
500	134	1126 219	160	1344 314	187	1571 402	213	1789 496	240	2016 584
550	139	1168 209	165	1386 304	192	1613 392	218	1831 486	245	2058 574
600	143	1201 206	169	1420 300	196	1646 389	222	1865 482	249	2092 570

Table 3.3. Energy, RDP and UDP requirements for different levels of milk production

Fibre

A certain level of fibre is needed in the diet to maintain the milk fat test and keep the rumen functioning normally. As explained in Chapter 1, there are three ways of measuring dietary fibre - **Crude Fibre**, **Acid Detergent Fibre** and **Neutral Detergent Fibre**.

Although Crude Fibre is still commonly used as a measure of dietary fibre, NDF% and ADF% are more accurate measures of fibre content.

Effective Fibre

Long fibre in the diet stimulates chewing activity and the production of saliva. Saliva acts as a buffer and helps keep rumen pH at more desirable levels. To be fully effective in stimulating chewing activity, the fibre fraction needs an average fibre length of at least 6.25mm with about 20% of fibres longer than 25mm. The amount of **effective NDF (eNDF)** in the total DM diet should be at a minimum of 25%.

	ME (MJ /kgDM)	NDF (% DM)	Effectiveness (%)	eNDF (% DM)
Immature Pasture	12.0	35	40	**14.0**
Leafy Pasture	11.0	45	50	**22.5**
Stemmy Pasture	8.0	55	100	**55.0**
Hay/Straw	8.0	65	100	**65.0**
Silages	10.0	50	75	**37.5**
Cereal Grains	12.0	10	25	**2.5**
Root Crops (Bulbs)	12.0	5	25	**1.3**

Table 3.3: Effective NDF concentrations in typical feeds for dairy cows. (*Source: Holmes et al. 2002. Milk Production from Pasture)*

Requirements

Fibre Requirements (% in the diet)	
Crude Fibre (CF)	*17%*
Neutral Detergent Fibre (NDF)	*30%*
Effective Neutral Detergent Fibre (eNDF)	*25%*
Acid Detergent Fibre (ADF)	*15%*

Repercussions

Pasture provides sufficient fibre in the diet. However, a deficiency of fibre may occur in early lactation with lush, good quality pasture, particularly when cereal grains are fed as well. Including extra fibre such as hay or straw at this time often results in a compromise, as doing so may decrease the concentration of nutrients in the diet and depress Dry Matter Intake just when the cow's requirements are highest.

High starch diets cause the rumen pH to fall, leading to acidosis (grain poisoning). Buffers added to the diet (e.g. sodium bicarbonate) reduce rumen acidity and reduce the likelihood of acidosis. However, **buffers are not a substitute for fibre**.

Changes in the proportions of fibre and starchy feeds such as grain in the diet should be made gradually to give the different types of rumen microbes time to adapt to the new diet.

➲ **THE USE OF BUFFERS AND THE DIFFERENT TYPES OF BUFFERS AVAILABLE WILL BE DISCUSSED IN CHAPTER 9.**

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Minerals

Estimating mineral requirements of dairy stock is extremely difficult, as the requirement for any given mineral varies with its efficiency of absorption, the age and production stage of the animal and the presence of other minerals which interact with it.

About 25 minerals are essential for health and growth in dairy stock, and these are classified into **Macrominerals (required in quantities of grams/day)** and **Microminerals (required in smaller quantities, i.e. milligrams/day). Microminerals are also commonly described as trace elements.**

Macrominerals include	Microminerals include	
Calcium	Copper	Selenium
Phosphorus	Cobalt	Chromium
Magnesium	Iron	Fluorine
Potassium	Zinc	Vanadium
Sodium	Iodine	Nickel
Sulphur	Manganese	Tin
Chlorine	Molybdenum	Arsenic

Extensive independent research work in many countries has not demonstrated any consistent responses to trace element supplementation in terms of production or fertility in pasture-based dairy cows.

This suggests that trace element deficiencies need to be kept in perspective as only one of a variety of possible reasons behind production and fertility problems.

Calcium, Phosphorus and Magnesium are important macrominerals which are discussed below.

➲ **DETAILS OF OTHER MINERALS AND TRACE ELEMENTS APPEAR IN CHAPTER 6 AND IN THE APPENDIX.**

Calcium (Ca)

Role

- Important component of skeleton and teeth.
- Nerve and muscle function, blood coagulation.
- **Milk Production.**

Interacts with

- Phosphorus - excess P interferes with Calcium absorption from the diet but evidence is lacking that really establishes this claim. The normal Calcium:Phosphorus ratio ranges from 1:1 to 3:1.
- Vitamin D - increases Calcium retention in the body by stimulating absorption of dietary Calcium from the intestine.
- High levels of Zinc may depress Calcium absorption.
- Mg is most the most important mineral in Ca absorption.

Signs of Deficiency

- **Acute deficiency - milk fever.**
- **Reduced DMI, weight gain and milk production**.
- Muscular weakness, weak bones (osteoporosis)

> ➲ **AS MILK FEVER IS A METABOLIC CONDITION BROUGHT ON BY PHYSIOLOGICAL CHANGES, IT WILL BE DISCUSSED IN CHAPTER 6.**

Major Sources

- Grasses, legumes (e.g. clover), Dicalcium Phosphate (DCP), ground limestone
- **The skeleton represents a 'bank' of stored Calcium and Phosphorus which the cow can draw upon when her requirements increase, e.g. in early lactation.**

Requirements

Vary with liveweight and physiological state. Table 3.4 shows the recommended daily allowance of Calcium.

Animal Liveweight	**Requirements for Maintenance and Growth Liveweight Gain *(kg/day)*** 0	0.4	0.8	1.2
50	1.3	11	20	28
100	2.7	12	21	31
200	5.3	15	24	33
400	10.7	20	29	39
500	13.3	22	32	-
600	16.0	25	-	-

Additional Requirements to be added to those above

Pregnancy				**Milk Production**
Month 5-6	Month 7	Month 8	Month 9	Per litre produced
2.3	5.3	8.7	13.2	1g

Table 3.4: Recommended Calcium Allowances - grams/day.

> **Recommended minimum concentrations of Calcium in feed Dry Matter to satisfy the above requirements**:
> **From 1.9 g Calcium/kg DM (maintenance/low production) to 4.0 g Calcium/kg DM (growing/lactating).**

(*Source: Feeding Standards for Australian Livestock 1990*)

Supplementary Sources

- Dicalcium Phosphate (DCP)
- Monocalcium Phosphate (MCP)
- Ground Limestone

Diagnosis of Calcium status

- blood test

In Practice...

Deficiency of Calcium (as opposed to the acute metabolic condition, milk fever) is unusual in dairy cattle on pasture-based diets, as forages normally contain adequate Calcium.

Studies have found that the calcium content of pastures generally exceeds the recommended concentrations of calcium in feed.

- Victorian research indicates that well-managed perennial ryegrass/white clover pastures have Calcium concentrations ranging from **4.2 - 7.8 g** Ca/kg DM (O'Brien 1988).
- Pasture sampled over the spring/summer period at Elliott Research and Demonstration Station ranged from **4.6 - 6.4 g** Ca/kg DM.

However, when Calcium requirements are very high in early lactation, **the cow can be in negative Calcium balance (i.e. requirements exceed intake) for some time with no obvious ill-effects. The skeleton has the capacity to mobilise Calcium to make up the shortfall**.

Cows being fed high levels of grain can encounter Calcium deficiency, as grains are poor sources of Calcium. Di-Calcium Phosphate (DCP) is commonly added to high grain rations to overcome this deficiency.

➲ **RATES OF INCLUSION FOR BUFFERS AND MINERAL ADDITIVES WILL BE DISCUSSED IN CHAPTER 9.**

Phosphorus (P)

Role

- Important component of skeleton and teeth
- Important roles in energy and protein metabolism

Interacts with

- The normal Ca:P ratio ranges from 1:1 to 3:1, but providing that adequate Phosphorus is present a fairly wide range of Ca:P can be tolerated.

Signs of Deficiency

- **Poor appetite and reduced DMI**
- Reduced liveweight gain and milk production, reduced fertility
- Stiff-legged gait, bone fragility
- Depraved appetite - chewing bones, wood, soil etc

Major Sources

- Cereal grains, grains, Dicalcium Phosphate (DCP), pastures with good fertiliser history.
- **As with Calcium, the skeleton represents a 'bank' of stored Phosphorus which the cow can draw upon. P moves along with Calcium when Ca is mobilised from the skeleton.**

Requirements

Vary with liveweight and physiological state. Table 3.5 shows the recommended daily allowance of Phosphorus.

Animal Liveweight	Requirements for Maintenance and Growth Liveweight Gain *(kg/day)* 0	0.4	0.8	1.2
50	1.4	6	10	15
100	2.9	8	12	17
200	5.7	10	15	19
400	11.4	16	21	25
500	14.3	19	24	-
600	17.1	22	-	-

Additional Requirements to be added to those above

Pregnancy				**Milk Production**
Month 5-6	Month 7	Month 8	Month 9	Per litre produced
1.3	2.7	4.4	6.9	0.8

Table 3.5: Recommended Phosphorus Allowances - grams/day.

Recommended minimum concentrations of Phosphorus in feed Dry Matter to satisfy the above requirements:
From 1.8 g Phosphorus/kg DM (maintenance/low production) to 3.2 g Phosphorus/kg DM (growing/lactating).

(*Source: Feeding Standards for Australian Livestock 1990*)

Supplementary Sources

- Dicalcium Phosphate (DCP)
- Monosodium Phosphate

(Note: Fertiliser sources (DAP, Superphosphate) are not preferred options for P supplementation because of heavy metal contamination, e.g. Cadmium.)

Diagnosis of Phosphorus status

- blood test (serum inorganic phosphorus) - but blood levels are not related to skeletal reserves
- rib bone biopsy

In Practice...

Phosphorus deficiency in dairy cattle can occur, but is unusual on temperate pastures with good fertiliser history. In terms of the specified minimum concentrations of P in feed Dry Matter above, Ryegrass/clover pastures sampled over spring/summer at Elliott Research and Demonstration Station ranged from 2.7-3.5g P/kg DM.

Supplemental sources such as DCP contain both Calcium and Phosphorus.

Magnesium (Mg)

Role

- **Structural and nervous functions, important for muscular functions**
- Important in carbohydrate, fat and protein metabolism

Interacts with

- **Potassium** - high levels of dietary Potassium decrease Mg absorption
- **High levels of rumen ammonia** also interfere with Mg absorption (i.e. high RDP intake)
- **Note that low blood magnesium levels in cows reduces the amount of Calcium absorbed from the intestine mobilised and may predispose milk fever around calving**

Signs of Deficiency

- **Grass Tetany (also known as Grass Staggers or Hypomagnesaemia). It can occur with low Mg concentrations**, **particularly when pastures have been heavily fertilised with potassium and nitrogen**. Commonly recognised symptoms include excitable/nervous behaviour, muscular twitching, convulsions, collapse and eventually death. Onset of grass tetany also depends on the cow's ability to maintain a calcium balance - tetany occurs once blood calcium levels drop.

Major Sources

- **Although the skeleton contains Magnesium, mobilisation from bone is slow and therefore the cow depends upon dietary Magnesium to satisfy her requirements.**
- **The majority of Magnesium absorption occurs in the rumen but the efficiency of absorption varies**, depending upon the age of the animal and the concentration of other minerals (e.g. Potassium, see above) in the rumen.
- **Clover is a better source of Mg than grass**. Nitrogen-fertilised grass-dominant pastures are often associated with grass tetany, as nitrogen promotes grass growth.
- Magnesium Oxide (Causmag), Magnesium Sulphate (Epsom Salts) and Dolomite.

Requirements

Recommended minimum concentrations of Magnesium in feed Dry Matter to satisfy requirements:
2.8g /kg Dry Matter

(*Source: Feeding Standards for Australian Livestock 1990*)

Supplementary sources

- Magnesium Oxide (Causmag)
- Magnesium Sulphate (Epsom Salts)
- Dolomite (Mg in Dolomite is less available than in Causmag or Epsom Salts)

In Practice…

There are a variety of ways of supplementing cows with Magnesium, although most supplementation is confined to the spring period when a combination of lush, rapidly growing grass and cows in early lactation creates the greatest risk of grass tetany. Causmag or Epsom salts added to grain supplements, and dusting of Causmag onto pasture or hay are commonly used.

➲ **NUTRITIONAL MANAGEMENT OF GRASS TETANY WILL BE DISCUSSED FURTHER IN CHAPTER 6.**

Vitamins

Vitamins are small, organic compounds which are required in very small amounts. They are essential for health, production and reproductive performance.

Vitamins are classified as either Fat soluble or Water soluble, and are measured in **International Units (IU).**

Fat soluble Vitamins include	Water soluble Vitamins include
A	B1
D2	B2
D3	B6
E	B12
K	C

The rumen micro-organisms can synthesise all of the water-soluble vitamins, namely the B-group Vitamins and Vitamin C. Under normal conditions microbial synthesis is sufficient to meet the cow's requirements and the cow does not need a dietary supply.

The rumen microbes also synthesise adequate quantities of Vitamin K to meet the needs of most dairy cattle. In addition green feeds are a good source of Vitamin K.

The fat-soluble vitamins are stored in body tissues whilst readily available, and these body stores can meet cow requirements for several months when dietary supply is inadequate.

In normal grazing situations, vitamin deficiencies are rarely encountered in dairy stock.

Vitamin A (Retinol)

Role

- Needed for **tissue and bone formation, growth, milk production and fertility.**
- Vitamin A is important for the **maintenance and health of tissues** such as the teat canal lining. Low plasma Vitamin A has been correlated with an increased severity of mastitis, but is unlikely to occur when cows are grazing fresh forages.

Signs of Deficiency

- Night blindness, staggering gait, a variety of reproductive problems.

Major Sources

- **Vitamin A is formed from Beta-carotene in the diet.**
- **Fresh forages (including pasture) are excellent sources of Beta-carotene.**
- Some losses of Beta-carotene occur during conservation of forages.
- **Surplus Vitamin A can be stored in the liver for 3-4 months. Because of these stores, it is generally not necessary to supplement animals with Vitamin A during periods of low green feed intake.**

In Practice...

Vitamin A deficiency is very rare in grazing dairy cattle. It may occur when cattle do not consume green feed for 6 months or more, or when diets high in cereal grains or straw are fed over long periods. Body stores can meet the animal's vitamin A demands for several months (e.g. during drought). Concentration in blood is not a reliable indicator of Vitamin A status.

Vitamin D2 (ergocalciferol) and D3 (cholecalciferol)

Role

- **Stimulate increased Calcium and Phosphorus absorption.**
- Closely interrelated with Calcium and Phosphorus in skeletal development.

Signs of Deficiency

- Rickets (skeletal deformities).
- Very few incidences of deficiency have been reported in farm animals.

Major Sources

- **Is formed in the skin through the action of sunlight.**
- The D-Vitamins are rarely found in plants (except in sun-dried hays). **However, the substances that are converted to Vitamin D in the skin are present in plants.**
- Vitamin D is stored in several organs in the body

In Practice...

Vitamin D deficiencies are very rare. Even in conditions of inadequate sunlight, body stores can meet requirements for several months.

Vitamin E (alpha-tocopherol)

Role

- Prevents cell membrane damage.
- **Has a complementary action to Selenium.**

Signs of Deficiency

- Muscle degeneration, stiffness.
- Low levels of Vitamin E and Selenium have been related to retention of placenta, increased severity of mastitis, and sub-optimal fertility. **However, the role of Vitamin E, particularly in relation to fertility and health, is still being defined**.

Major Sources

- Fresh forages, pastures.

In Practice...

Vitamin E deficiency should not present a problem in grazing cows. However, as Vitamin E interacts with Selenium, specified daily requirements for Vitamin E usually assume that the cow's Selenium status is adequate.

Vitamin K

Large amounts of Vitamin K are present in green forages. In addition, deficiency is unlikely in adult ruminants as rumen microbes also synthesise Vitamin K.

The B Group Vitamins

The rumen microbial population usually makes sufficient quantities of all of the B-group vitamins.

Two practical implications regarding the B group vitamins:

1. Vitamin B12 cannot be produced unless cattle are supplied with adequate quantities of Cobalt. **Cobalt is required by the rumen micro-organisms for the purpose of producing Vitamin B12.** Cobalt itself is not required by the animal.

2. Vitamin B1 **(Thiamine)** is essential for energy metabolism, growth and maintenance. Like the other B-group vitamins, it is produced by the rumen microbes. However, under certain circumstances, a thiamine deficiency can occur. This results in a condition known as polio-encephalomalacia, which can appear in older calves (6-9 mths of age). Symptoms include muscle tremors, blindness, head pressing and chomping of the jaws. The deficiency can be corrected by injecting Thiamine.

Note: This condition occurred in some calves grazing dry pasture in Tasmania during the dry summer of 1995. Eating bracken fern can also result in Thiamine deficiency, as it contains substances which destroy Thiamine.

4. The Composition of Feeds

Knowing the nutrients required by cows is important, but before these requirements can be met you have to know what is contained in the feeds which you have available. Estimates of nutrient supply are only as good as the information available on the ration ingredients. Therefore, as well as outlining average values for the nutrient composition of common feeds, this chapter also describes the options which are currently available for obtaining information on your own feed samples.

Feed Types and Nutrients Supplied

Pastures

Pastures provide the bulk of the feed requirements for dairy cattle in Tasmania, and thus it is vital to have some idea of their nutrient value. Although it is impractical to measure pasture quality on a farm on a day-by-day basis, it is important to realise that pasture quality (or nutritive value) is affected by factors such as:

- **Species composition**
- **Stage of Maturity**
- **Time of year**

High quality pasture has a high proportion of the most digestible species (ryegrass and white clover), is leafy, with less stem and little or no dead material at the base.

Poor quality pasture has more stem than leaf, has a higher fibre content, and usually has dead material in the base.

Species

Of the pasture species commonly found in Tasmania, White clover generally has the highest nutritive value, followed by Ryegrass. Table 4.0 depicts nutritive values for White Clover, Ryegrass, Cocksfoot and Prairie Grass. Note the higher energy and protein content and lower fibre content for White Clover compared to Ryegrass.

	MJ ME/kg DM	Crude Protein (%)	NDF%
Perennial Ryegrass	11	18	30-45
White Clover	11.5	25	20-35
Cocksfoot	11	18	30-45
Prairie Grass	11	18	30-45

Table 4.0: Average Quality of Individual Pasture Species.

A number of trials have demonstrated that cows offered clover eat more and produce more milk than cows offered equivalent quantities of ryegrass.

Browntop/Bent Grass (*Agrostis capillaris)*, Fog Grass (*Holcus lanatus)* and Sweet Vernal *(Anthoxanthum odoratum)* mature and lose nutritive value more quickly than other species. In addition, they tend to dry off early and become unpalatable to stock.

Stage of Maturity

Digestibility, energy and protein levels in pasture decline as plants mature or 'go to head'. At the same time, fibre levels increase as the proportion of stem increases relative to leaf.

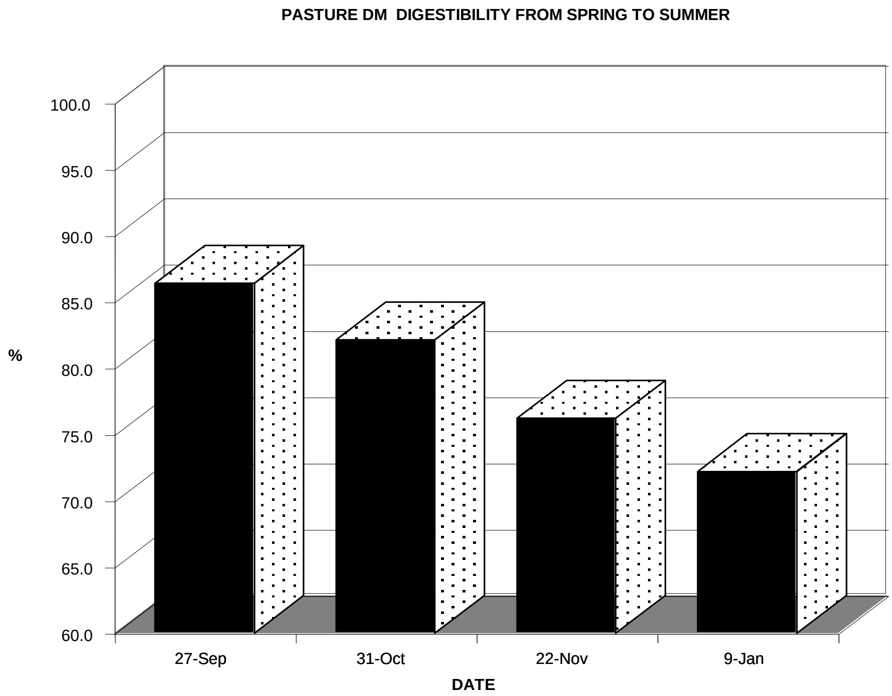


Figure 4.0: Changes in Digestibility of ryegrass/clover pastures sampled pre-grazing over spring/early summer at Elliott Research and Demonstration Station.

Actively growing pasture which is kept in a vegetative (non-seeding) state through grazing pressure will retain its nutritive value into summer better than pasture which is allowed to go to head early.

Stage of maturity	MJ ME/kg DM	Crude Protein %	NDF%
Young/immature	10.8 –13.0	18 -30	30
Early-mid Flowering	10 -11	15 - 24	35
Mature	8-9.5	10 -14	45

Table 4.1: Range of nutritive value of Perennial Ryegrass/White Clover pastures.

Time of Year

Changes in pasture composition at different times of year will also affect the overall quality. As clover grows better with warmer temperatures in spring/summer, higher proportions of clover in pasture at these times can reduce the decline in pasture nutritive value associated with increasing maturity of the ryegrass component.

Example ***How does pasture composition stack up against cow requirements?***

Cow requirements are based on a 500 kg cow in early lactation, producing 25 litres at 4% fat, 3.2% protein, with a potential intake of 14.5 kg DM. Liveweight loss aim is no more than 0.5 kg/day.

Recall from Chapter 3
Maintenance for 500 kg cow = 54 MJ
Each litre of 4% fat, 3.2% protein milk requires 5.3 MJ. Therefore 25 litres requires 133 MJ.
Liveweight loss (if 0.5 kg LW/day) contributes 14 MJ/day.
Total Requirement = 54 MJ + 133 MJ - 14 MJ = 173 MJ

Nutrient	Ryegrass/White Clover Spring Pasture	Cow requirements
Energy (MJ ME/kg DM)	11.8	11.9
Crude Protein (%)	28%	16% of diet
Neutral Detergent Fibre (%)	30%	25-30%
Calcium (g/kg DM)	5.7	4.7
Phosphorus (g/kg DM)	3.5	3.4
Magnesium (g/kg DM)	2.4	2.0

Table 4.2: An example of composition vs. requirements.

The example above indicates that high quality spring pasture can meet a high proportion of cow requirements. Relative to requirements, certain excesses and deficiencies can arise at certain times of year, including:-

Crude Protein

Highly digestible spring pasture generally contains excess levels of crude protein, with a large proportion of this protein in the Rumen Degradable form. Protein which is excess to requirements results in high levels of rumen ammonia, which cannot be captured by the rumen bacteria and instead is converted to urea and excreted. This process requires energy, which is then unavailable for milk production and maintenance. Summer dryland pasture is low in protein and this will have an impact for lactating dairy cows and rising 1 heifer replacements. Imbalances for these stock will need to be corrected so as not to jeopardise production and weight gain.

➲ **THE IMPLICATIONS OF EXCESS CRUDE PROTEIN ARE DISCUSSED FURTHER IN CHAPTER 6.**

Fibre

Fibre levels which are below recommended levels of 25-30% NDF have been recorded in lush, rapidly growing pastures. However, on average NDF values in spring pasture are at adequate levels.

Despite this, the biggest nutritional limitation to pasture on most Tasmanian dairy farms is not related to its composition, but rather to level of intake at critical times of year.

Supplements

Nutritive composition of a variety of supplements is presented in Tables 4.4 - 4.7. Information has been compiled from local and interstate sources. A (-) indicates that either insufficient data is available or a high level of variation occurs.

The level of Undegradable Dietary Protein supplied by feeds has been categorized in the following table.

Category	Undegradable Dietary Protein	Rumen Degradable Protein
High (H)	More than 69%	less than 31%
Good (G)	50-69%	31-50%
Moderate (M)	30-49%	51-70%
Poor (P)	10-29%	71-90%

Table 4.3: UDP and RDP by category.

Energy Supplements These supplements include the cereal grains, commercial concentrate pellets or meals, and by-products. The nutritive value of a variety of energy-rich supplements appears in Table 4.4.

Feed	Dry Matter (%)	Metabolisable Energy (MJ of ME/kg DM)		Crude Protein (% of DM)		UDP Supply	NDF (% of DM)
	Average	Average	Range	Average	Range		
Cereal Grains							
Barley	90	13	12-14	12	8-18	P	20
Wheat	90	13	12-14	13	9-17	P	14
Oats	90	11	9-13	10	6-13	P	32
Triticale	90	13	12-13	12	8-16	P	14
Maize	90	14	12-16	10	7-14	M	9
Sorghum	90	11	7-13	11	6-15	M	18
Commercial Pellets	90	12	11-13	14	12-16	M	15
By-Product Feeds							
Brewers Grain	25	10	-	23	21-27	M	42
Potato Waste	23	12.5	-	9	-	-	-
Apple Pomace	24	10	-	6	-	-	-

Table 4.4: Energy Supplements.

Cereal grains are generally poor sources of Undegradable Dietary Protein (UDP). The UDP content of commercially prepared concentrates varies with their ingredients and can also be affected by the high temperatures used in their manufacture.

Most cereal grains are low in calcium, and when feeding high levels of grains, particularly in early lactation, it is common to add a supplementary source of Calcium, such as DCP.

Protein Supplements

Protein supplements include grain legumes, such as lupins, and meals derived from oilseed extraction and animal protein. Nutritive values of protein meals appears in Table 4.5.

Feed	Dry Matter (%)	Metabolisable Energy (MJ of ME/kg DM)		Crude Protein (% of DM)		UDP Supply	NDF (% of DM)
	Average	Average	Range	Average	Range		
Urea	100	0	-	250	-	Nil	0
Grain Legumes							
Lupins	90	13	12-13	32	28-40	P	27
Peas	90	13	12-13	24	20-27	P	13
Protein Meals							
Soybean	85	13	12-14	52	46-59	M	15
Safflower	85	11	9-12	43	22-54	M	58
Cottonseed	85	12	-	42	37-45	M	30
Rapeseed	85	12	-	39	33-43	M	28
Sunflower	85	10	6-12	35	26-50	M	40
Linseed	85	12	-	34	30-40	M	-

Table 4.5: Protein Supplements.

Grain legumes, such as lupins, are a multi-purpose supplement because they are high in both energy and protein. For reasons of availability and price compared to other protein supplements, they are sometimes used in Tasmania as a supplement to youngstock during dry summers, when they are mixed with cereal grains. The protein in lupins is mainly in the Rumen Degradable (RDP) form.

Urea is a source of nitrogen which can be utilised by rumen microbes, not a true protein source. It may be used to substitute for true protein in feed mixtures. Urea is more commonly used in northern areas of Australia as a source of nitrogen for the rumen microbes when animals graze poor quality or limited pasture.

Note: When feeding urea, care needs to be taken as excess urea in the diet is toxic and can have fatal consequences.

Meat and Bone meal was a widely used protein meal in the past. Although it is not particularly palatable it was usually cheaper than other protein meals. However, in response to the widespread publicity about BSE (Mad cow disease) in Britain, feeding protein meals of animal origin to ruminants has been banned.

There are a variety of other protein meals. Plant meals supply only moderate amounts of Undegradable Dietary Protein (UDP).

To recap on Chapter 3, supplementary UDP is generally considered unnecessary for cows producing up to 30 litres whilst grazing quality pastures. **Responses to protein supplements only occur in cases of genuine protein deficiency, otherwise they are used inefficiently (and expensively) as an energy source.**

Although it is useful to know what they are, most of these supplements are not particularly relevant to many Tasmanian farms, where energy is the first limiting nutrient.

Roughages

Refers to silages and other conserved forages. Depending upon the composition of the cow's base diet, these supplements can be looked upon as energy supplements, or as a specific source of fibre.

Typical nutritive value for a variety of conserved forages appears in Table 4.6.

Feed	Dry Matter (%)	Metabolisable Energy (MJ of ME/kg DM)		Crude Protein (%)		UDP Supply	NDF (%)
	Average	Average	Range	Average	Range		
Conserved Feeds							
Pasture silage-(range)	17-75	8.5	6.5-11	14	5-25	M/P	36-60
Hay-mature grass to clover	75-85	8.0	4.5-11	13	2-30	M/P	45-60
Oaten Hay	85	7.8	-	9		P	50-60
Maize Silage	35	10	9-11	6	5-8	P	40-55
Lucerne Hay	85	8	7-9	16	14-20	M/P	40-60

*** Pit silages = 30% dry matter, round bale silages = 40 to 50% dry matter**

Table 4.6: Roughage supplements

The nutritive value of hay and silage varies considerably. The major factor affecting nutritive value is cutting date, as pasture quality is higher earlier in the season. For this reason, silage is often assumed to be of better quality than hay, as it can be made earlier in the season. Depending on stage of maturity when cut and the silage-making process used, energy levels in pasture silage can be as high as 11 MJ ME/kg DM.

However, a number of silage surveys, both in Tasmania and elsewhere, have shown that **silage quality is, on average, not much higher than hay quality**, and that there is a wide range in nutritive value. Making quality silage is a complex topic which cannot be fully addressed here; however, **it is important to be aware of the wide range in nutritive value which is possible.**

For this reason, it is vital to have roughages tested for their nutritive value when trying to balance a ration, or when comparing prices of bought-in feed.

Fodder Crops

The nutritive value of fodder crops appears below in Table 4.7. Figures have been compiled from local Tasmanian data as well as interstate estimates.

Feed	Dry Matter (%)	Metabolisable Energy (MJ ME/kg DM)	Crude Protein (%)	NDF (%)
	Average	Average	Average	Range
Fodder Crops				
Turnips				
- tops	12	12.7	12.6	-
- bulbs	10	13.2	7.6	-
- whole	11	12.5-13	10.1	18-30
Oats young-flowering	15-25	8.6-10.7	8-9	45-60
Rape	13	10-12	9-20	30
Maize (tassel stage)	19	10	11	50
Millet	18	9	11	40-60
Annual Ryegrass	16	11	22	30-45

Table 4.7: Fodder crops

Turnips are the most common fodder crop, and have similar nutritional characteristics to barley. Their ME levels are relatively high at 12.5-13 MJ ME/kg DM, and their protein and fibre levels are relatively low. This is unlikely to cause problems unless turnips are fed in conjunction with high levels of cereal grain, when protein and fibre levels in the ration as a whole may be below requirements. This situation may be worsened if only limited pasture, silage or hay is fed, particularly if it is of poor quality.

➲ **A SUMMARY OF THE NUTRITIVE CHARACTERISTICS OF COMMON FEEDS APPEARS IN THE APPENDIX OF THIS MANUAL.**

Testing Nutritive Value of Feedstuffs

Information on nutritive value of both pasture and supplements can be obtained by sending a sample away for laboratory analysis.

For any feed testing, it is most important to make sure that the sample is an accurate representation of the feed being tested. For silage and hay, this means taking several small sub-samples from different bales, or different parts of the stack, and mixing them. The same principle applies to sampling grains.

Costing Supplements on the basis of nutritive value

When purchasing supplements, we aim to satisfy cow requirements at the lowest cost. Purchasing supplements on a 'price per tonne' or 'price per bale' basis does not allow a true comparison to be made. Even purchasing on the basis of cost per kilogram of Dry Matter can be deceptive, given the wide range in nutritive value of some supplements.

> *Calculating cost on the basis of nutritive value gives a better indication of the true worth of the supplement.*

When trying to identify the most cost-effective supplement, the following information is required:-

- Cost per unit (e.g. wet tonne or bale)
- Dry Matter%
- Nutrient composition - energy, protein and fibre
- **Which nutrient is limiting** - in other words, are you buying the supplement to provide energy, protein or fibre?

An example of the calculation is presented below.

Example

Silage at $45 per round bale.
Average bale weight is 500 kg
DM% = 45%
Tested feed composition is 9.0 MJ ME/kg DM, 15% Crude Protein, 40% Neutral Detergent Fibre.

FEED:

						(A)
45	÷	500	÷	0.45	=	0.20
Total cost of feed ($)		kg's of feed for price		DM% / 100 *(=DM% ÷ 100)*		$/kg DM

Cost per MJME

				(B)
0.20	÷	9	x 100 =	2.22
(A)		MJME/kg DM		cents/MJME

Cost per gram crude protein (or NDF)

				(C)
0.20	÷	15	x 10 =	0.13
(A)		CP%		Cents/g CP

➲ **FURTHER EXAMPLES WILL FOLLOW IN CHAPTER 9 AND EXERCISES CAN BE FOUND AT THE END OF THE MANUAL.**

5. Nutrition and Production

Knowing the requirements of the cow is important, but from a practical viewpoint it is important to understand the impact of nutrition on a cow's production pattern and body condition. This chapter discusses how nutrient supply affects the pattern of lactation in terms of both production and milk composition. It also discusses the factors that determine how the cow diverts nutrients between milk production and bodyweight.

Impact of nutrition on the pattern of lactation

Early Lactation

Milk yield at peak lactation sets up the potential production for the year. A higher peak means a higher total production.

In feeding the cow to try to maximise the peak, the major obstacle that exists is the cow's voluntary intake.

Remember from Chapter 3 that the cow's appetite at calving is only about 75% of maximum. It takes 10-12 weeks for the cow to reach her maximum intake.

Dry Matter intake 'lags behind' peak milk production, which occurs 6-8 weeks after calving.

What repercussions does this have for managing cows in early lactation?

1. **The cow has to use body reserves to achieve peak yields. Cows MUST have adequate body condition at calving. The cow will not use body condition for milk production if the condition is not there in the first place.**

Cows that are thin at calving will:

- have lower peak yields;
- have lower total yields;
- use more of the available energy for body condition instead of milk production over the whole lactation

> *High feeding levels in early lactation CAN NOT make up for poor body condition at calving.*

Cows which calve at Condition Score 5-6:

- can lose a Condition Score in early lactation and use it for milk production;
- have better fertility

Between Condition Scores 3-6:

Every condition score lost produces an additional 220 litres of milk, 10 kg of milkfat and 6-7 kg of protein over the lactation.

For each additional Condition Score at calving, the time between calving and first heat is reduced by 5-6 days.

The more condition at calving, the more condition available for milk production. **Cows in poorer condition at calving have fewer reserves to lose**. **These cows tend to use energy for gaining weight instead of milk production over the lactation**.

Cows that calve in good condition and produce at high levels can encounter metabolic problems if underfed in early lactation. Because they are forced to rely too heavily on their body reserves, **ketosis** (essentially a dietary energy deficiency) may develop.

➲ **KETOSIS AND OTHER METABOLIC DISORDERS ARE DISCUSSED FURTHER IN CHAPTER 6.**

2. Feed provided to the cow in early lactation needs to be of the highest quality to maximise nutrient intake

If the **quantity** of Dry Matter which the cow can eat is restricted, it follows that the only way to increase overall nutrient intake is to improve the **quality** of the Dry Matter. In other words, a more energy dense diet increases energy available for production.

Example

What happens to milk production when cows are underfed in early lactation?

Slow pasture growth, wet conditions and poor regrowth in early spring often result in the cows encountering a 'feed pinch', particularly on the second round of the farm. **How does the timing of this feed pinch affect production?**

Table 5.0 shows the results of an experiment where cows were fed at high and low levels in various combinations over Weeks 0-5 and Weeks 5-10 after calving. (H = high level of feeding, L = low level of feeding). After Week 10, all cows were fed at the same level and their production and weights monitored.

Feeding Level		Milk Fat produced Weeks 10-20	Live Weight Gain (kg/day) Weeks 10-20	Days to first heat	Days to Conception
0-5 weeks	**5-10 weeks**				
H	**H**	133	0.36	38	82
L	**H**	123	0.55	52	82
H	**L**	113	0.45	38	95
L	**L**	90	0.62	52	95

Table 5.0: Effects of early lactation feeding level on subsequent performance

What does this experiment show?

1. **Cows that are stimulated to milk by good early feeding continue to milk and partition less energy to body condition for some time.** The High/High fed cows produced the most and put on least weight.

2. **Cows that are fed poorly in early lactation respond to good feeding later by putting on weight instead of producing milk.** The Low/Low fed cows produced the least and put on the most weight.

3. **Feeding well in the second five weeks was important.** If you compare the Low first/High second cows with the High first/Low second cows, the Low first/High second group produced more and put on more weight than the others. It seems as though feeding well is particularly important in Weeks 5-10, when intake and milk production are approaching peak.

Mid-late lactation

Energy requirements for milk production during this period are lower, as production starts to decline. **Nutrition is still important because of pregnancy and the need to build up body condition for the next lactation.**

You will recall from Chapter 3 that energy is used more efficiently for weight gain whilst cows are still lactating, compared to when they are dry. This means that:

- It is easier to improve the condition of the herd in late lactation, and then maintain condition over the dry period, than to increase condition when the cows are dry.
- Feeding cows to gain condition whilst still lactating is a more efficient use of available feed.

Table 5.1 compares the requirements for gaining condition in late lactation and the dry period.

Breed/ Size of Cow	kg LWT in a Cond. Score (CS)	Total MJ ME required to gain 1 CS		kg DM (9.5 MJ ME/kg DM) required to gain 1 CS	
		Lactating	*Dry*	*Lactating*	*Dry*
Jersey	26	884	**1118**	93	**118**
JxF	34	1156	**1462**	122	**154**
Friesian	42	1428	**1806**	150	**190**

Table 5.1: Requirements for liveweight gain in late lactation and when dry

The Dry Period

Maintaining (or increasing body condition further if needed) is the key to setting up the cows for the next lactation.

There has been a lot of interest in managing the dry period in recent years, in regard to its effects on production and health in early lactation.

Terms such as ‘transition phase’ and ‘lead feeding’ are commonly used. What exactly do they mean?

‘Transition phase’ refers to the three weeks before calving and the first two weeks post-calving. This is a time of major physiological stress for dairy cows. **As they approach calving, cows reduce their feed intakes.**

Most metabolic problems are linked to low intakes around calving and/or abrupt changes in diet which also cause reductions in feed intakes.

‘Lead feeding’ refers to preparing dry cows for lactation by getting them accustomed to the diet that they will be on once they start milking. It is more commonly used in situations where high producing cows are receiving high levels of concentrate supplement. In these situations, concentrates are fed in the three weeks before calving to get the rumen ‘acclimatised’ to the early lactation ration.

The theory behind lead feeding is that it helps to maintain energy intakes around calving, and that by getting the cow used to the early lactation diet, improves intakes after calving. Better intakes mean that the cow is less likely to encounter metabolic problems such as ketosis. These effects have flow-on benefits for production and fertility.

In addition, gradually accustoming the rumen to concentrates over a three-week period reduces the risk of acidosis (grain poisoning).

As it takes 1-2 weeks for the rumen to make maximum use of concentrates, starting to feed three weeks before calving gives the cow a head start in making best use of concentrates in early lactation.

From a practical perspective, however, it should be remembered that much of this research has been conducted with high producing cows fed high levels of concentrates. As such, it does not apply to all Tasmanian farms. In a pasture-based situation, it is not always possible to feed separate groups of cows different rations in the dry period.

The important thing to remember is that cows close to calving, and in the early weeks of lactation need high quality feed, with adequate quantities of energy, protein and fibre, and that abrupt changes to this diet should be avoided.

➲ **THE INFLUENCE OF DRY PERIOD/EARLY LACTATION NUTRITION ON METABOLIC DISEASE WILL BE DISCUSSED FURTHER IN CHAPTER 6.**

Impact of nutrition on the composition of milk

The fat and protein composition of milk responds to nutrition, fluctuating in response to levels of energy, protein and fibre in the diet. Milk is formed in the udder tissue from substances that the blood delivers to the udder.

What produces milk?

1. The **water** in milk comes from the water in blood.
2. The **lactose** in milk comes from blood **glucose**. **Glucose is formed from propionate**, which is one of the Volatile Fatty Acids produced in the rumen from the breakdown of sugars and starches.
3. **Milk fat** (as well as body fat) is produced from **fats** in the blood. **The main source of these fats is acetate**. Acetate is one of the Volatile Fatty Acids produced in the rumen, with more acetate produced from high fibre diets. Other fat sources are body fat (from losing condition) and dietary fats.
4. **Milk protein** is built from **amino acids** in blood. These amino acids come from **microbial protein and UDP**. The energy source for building the protein is **glucose**.

How does milk composition change?

Lactose — Lactose is formed from glucose. More glucose means more lactose, but also more volume (litres) because water moves with lactose in roughly constant proportions. Therefore, lactose percentage does not change much.

Milk fat — Milk fat test percentage varies greatly, depending on:

- The amount of fibre in the diet. **High fibre diets produce large quantities of acetate, which is then used to produce fats. This means a higher milk fat test.**
- Whether the cow is taking off body condition. **Losing condition in early lactation provides another source of fats for use in milkfat production in the udder, which helps to maintain fat test.**
- **Level and type of energy intake**. High energy, starch-based diets (e.g. with high levels of cereal grain) produce high levels of propionate rather than acetate. This is converted into glucose, which is used to increase lactose, and in turn, milk volume. Not only is milk fat production reduced, but the extra volume tends to dilute milk fat percentage even further.

> *High energy, starchy diets and low fibre levels often go together. The combined effect is to lower milk fat test.*

Protein

Milk protein percentage does not vary as much as milk fat percentage; however it does fluctuate with energy supply.

Lack of dietary energy results in poorer conversion of feed protein into microbial protein, as the microbes need energy to grow and produce their own microbial protein. This reduces the amino acid supply to the udder, and consequently reduces milk protein production.

The energy required to 'build' milk protein in the udder comes from glucose. Low dietary energy also results in less glucose being available for this task, so the amino acids get broken down to provide glucose instead. This is an inefficient use of amino acids, which could otherwise have been converted into milk protein.

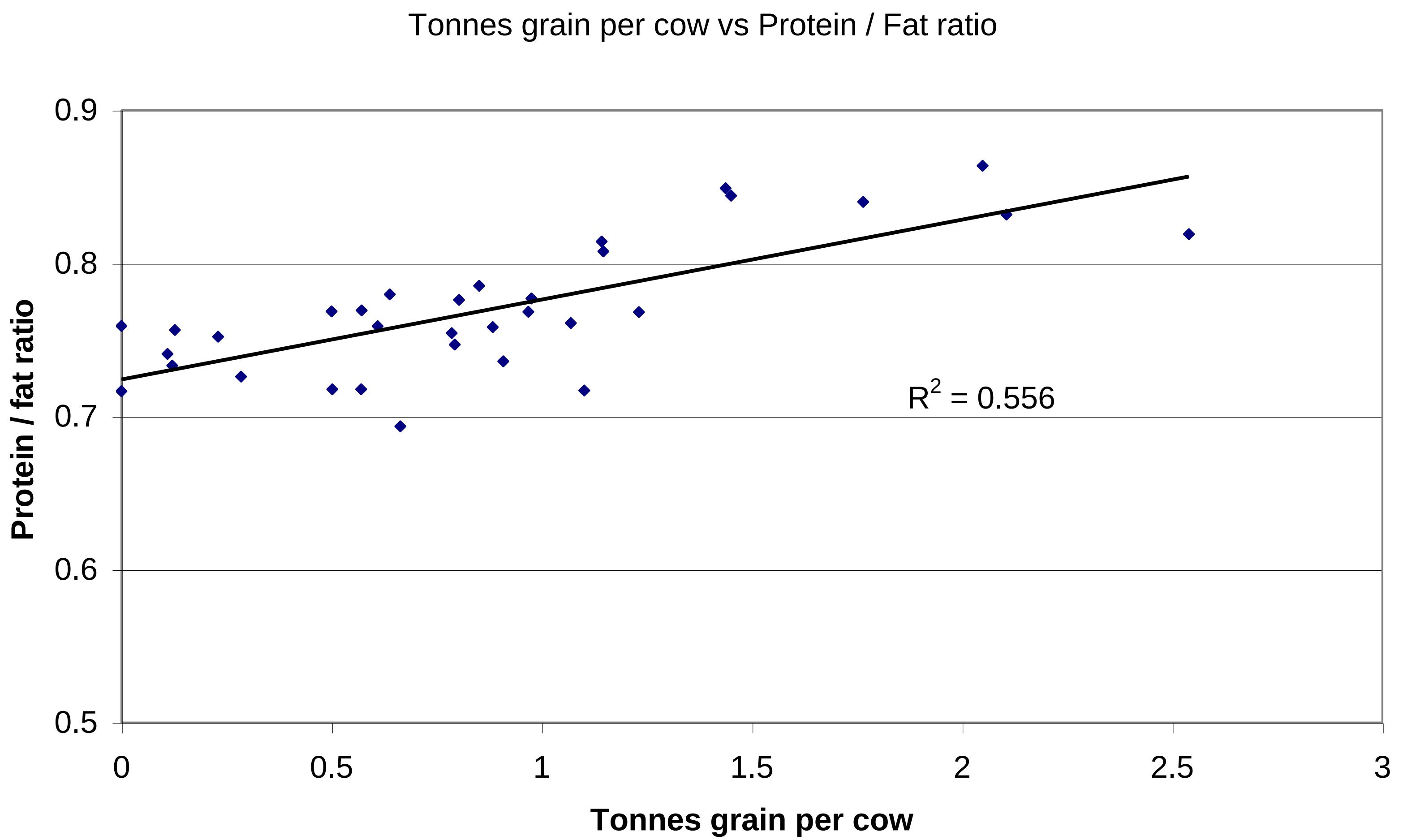
Under most circumstances, providing a higher energy diet will lift protein test.

Protein test will NOT respond to protein supplements unless the cow is truly deficient in dietary protein. If this is the case, microbial growth is depressed and fewer microbes are produced in the rumen. This not only reduces the cow's supply of microbial protein, but means that the energy in feeds is not utilised as well. Consequently, the supply of both amino acids and glucose to the udder is reduced.

Under Tasmanian conditions, a lack of energy is more likely to be the cause of protein test problems than a dietary protein deficiency.

If energy (glucose) is available in excess quantities relative to amino acids, milk protein production will be limited and the excess energy will be converted into body condition instead.

Milk lactose, milk volume (litres) and milk protein are all linked because they are dependent upon glucose supply. **More energy in the diet will lift lactose, volume and protein kilograms all together, so protein percentage tends to be somewhat more constant than fat percentage.**


Tonnes grain per cow vs Protein / Fat ratio
0.9
0.8
0.7
0.6
0.5
Protein / fat ratio
0
0.5
1
1.5
2
2.5
3
Tonnes grain per cow
R2 = 0.556

Impact of nutrition on 'partitioning' between production and liveweight gain

Feed is used by the cow for several purposes, including maintenance, pregnancy, liveweight gain and production. Maintenance is a constant requirement that **must** be met to keep the cow alive.

Once maintenance has been met, however, the cow divides (or **partitions**) nutrients between production and body condition.

Partitioning	*Refers to the division of feed nutrients between different purposes, i.e. milk production, growth and liveweight gain.*

The factors that determine how the cow's nutrient supply is divided up include her stage of lactation, condition, genetics and nutrition.

Changes in body condition over the lactation have already been discussed in this chapter. Basically, in mid-late lactation, cows start to partition more of their intake towards liveweight gain rather than milk production.

Cows that calve in poor condition and/or are underfed in early lactation tend to partition more feed to condition and less to milk over the whole lactation.

High genetic merit cows continue to partition more feed into milk production rather than body condition. These cows require high levels of feeding in mid-late lactation if they are to replace condition reserves.

The major nutritional factors influencing whether the herd will use feed for milk production or gaining condition are the levels of energy and protein in the diet.

This can be summarised as follows:

High energy, low protein:

This means that less microbial synthesis occurs, as there is less ammonia for the microbes to build into more microbial protein. In this situation, total protein supply to the cow is reduced, milk protein kilograms and milk yield decrease. **The excess energy is diverted into body condition instead of milk production**.

High protein relative to energy:

If there is insufficient energy entering the rumen, the microbes' efficiency of ammonia use decreases and instead of being converted to microbial protein the ammonia is transported to the liver, where it is converted to urea. Urea is then excreted in urine. This conversion of ammonia to urea also costs energy.

Potentially, this means greater liveweight loss in early lactation. If energy levels are low enough, milk volume and milk protein may also be reduced.

Low fibre, high starch diets can cause cows to gain condition at the expense of producing milk fat. This dietary combination results in more propionate and less acetate being produced. This in turn reduces milk fat test, but also causes increased weight gain.

Exercise 5.0 – Page 119

'Efficiency' of herd production - what does it mean?

As stated above, the cow's maintenance requirement is the 'fixed cost' of milk production - it has to be met regardless of the level of production. Once this has been accounted for, however, the rest can be used for condition and production.

In cows with low intakes and levels of production, the daily maintenance cost is a higher proportion of their total intake. The maintenance component of intake as a percentage of total intake is reduced at higher levels of production. This is demonstrated below in Table 5.2.

Example: ***Consider three 500 kg cows, with no significant requirements for pregnancy, and all maintaining liveweight (neither gaining nor losing weight)***

Cow	Daily ME intake	Maintenance requirement	Litres produced/day	Percentage of intake spent on *maintenance*	Percentage of intake spent on *production*
1	81	54	5	67%	33%
2	135	54	15	40%	60%
3	181	54	24	30%	70%

Table 5.2: Energy spent on maintenance and production

Obviously, at higher intakes, less of the total energy is spent on maintaining the cow, and more goes to producing milk. The **efficiency** of production is higher at higher levels of cow performance.

However, on a pasture-based dairy farm, the major profit driver is direct utilisation of pasture - in other words, running a stocking rate which ensures that as much grass as possible is directly eaten by cows.

This presents a potential conflict between cow efficiency and efficiency of pasture utilisation. In practice, the most profitable situation is a compromise between the two. This 'balancing act' will be dealt with in more detail in later chapters.

6. Nutrition, Health and Reproduction

This chapter outlines some of the principles behind maintaining herd health and reproductive performance through nutritional management.

Effects of nutrition on health

Metabolic Disorders

Metabolic disorders can be present in clinical or sub-clinical form. Even at sub-clinical level, they can cause decreases in intake and production losses.

Metabolic disorders such as ketosis and acidosis are usually linked to low intakes around calving and/or abrupt changes in diet.

Nutritional management in the dry period and in early lactation is the key to preventing or minimising their occurrence. The aim is to**:**

- maximise nutrient intake around calving and in early lactation by providing adequate quantities of high quality feed
- avoid decreases in intake as a result of sudden changes to the ration as cows calve and start milking

Nutritional management in this period also plays a major role in minimising milk fever and grass tetany.

Milk Fever

Milk fever is caused by a sudden and severe decrease in blood calcium levels at the onset of lactation, due to large increases in demand for Calcium for milk production. The incidence of milk fever increases with cow age and number of calvings.

The cow has mechanisms for adapting to these increased demands for calcium. These mechanisms are:

- increased absorption of calcium from the intestine
- mobilisation of calcium reserves held in bones

These mechanisms are activated in response to low blood calcium, but take some time to start working once the cow calves. When this process does not happen quickly enough, calcium replenishment into the bloodstream cannot keep pace with the output of calcium in milk.

Once calcium levels fall, muscular tremors and paralysis occur, followed by the cow collapsing, and eventually death.

The key to reducing the incidence of milk fever is to stimulate the cow's mechanisms for mobilising calcium from the skeleton and increasing absorption from the intestine prior to

calving, so that she is 'primed' to meet the increased calcium demands after calving.

Management strategies which can be implemented to achieve this are:

1. Feed low calcium diets during the dry period.
In practice, this means restricting fresh pasture and providing grass-based hay instead. If more than 3 in 100 cows (3%) develop clinical milk fever, mineral supplements should be fed. Table 6.0 shows supplementation rates.

	Minerals Required		Mix of Supplementary Ingredients		
	Calcium (g)	Magnesium (g)	Limestone (g)	Magnesium Oxide (g)	Molasses (ml)
Pre-calving	0	15-20	0	30-40	0
Post-calving[1]	70-100	15	150-200	30	0-300
Post-calving[2]	70	10-15	150	30	300

Post-calving[1] = Drench as soon after calving as possible
Post-calving[2] = Mineral mix for colostrum herd

Table 6.0: Supplementation rates for calcium and magnesium around calving and the mix of ingredients to deliver these minerals. (*Source: John Roche TIAR*)

2. Alter the cow's dietary cation-anion difference (DCAD).

Cations are positively charged ions such as potassium and sodium. Anions are negatively charged ions such as chloride and sulphate.

***DCAD** (dietary cation-anion difference) This refers to the difference between positive ions (sodium and potassium) and negative ions (chloride and sulphate). Ideally, negatives should outweigh positives, but this is difficult to achieve in a pasture-based system.*

How does this work?

Feeding higher levels of negatively charged ions produces a condition called **metabolic acidosis**. **It appears that cows can remove calcium from bone more rapidly when they are affected by metabolic acidosis**. Therefore the calcium mobilisation process is encouraged, thus preparing the cow for the increased requirements around calving.

To achieve this result, the diet must be higher in anions than cations. **This means feeding lower levels of potassium, sodium and calcium.**

How can this be achieved?

- **Choose forages carefully, as they can affect this acid-base balance**. Some forages are high in potassium (often due to potash-containing fertilisers). Hays grown on soils with lower fertiliser histories generally contain less potassium.

- **Feed anionic salts (also called acid salts).** These salts include magnesium sulphate (Epsom salts), ammonium sulphate and ammonium chloride. Some of these salts are unpalatable, and there are various methods of feeding them, including commercially prepared pelleted supplements.

  Note that mixing these salts into molasses to improve palatability is not a good idea, as molasses contains potassium, which, being positively charged, tends to cancel out the effect of feeding the extra negatively charged ions.

  The quantity of anionic salts required in a pasture-based system is very variable and can be large. If dry cows are eating a diet composed mainly of pasture, hay or silage, the DCAD can vary between +200 and +1000 mEq/kg. This can make it very difficult to feed the amount of anionic salts that would be required to reduce blood pH.

  Anionic salt mixtures should be discontinued after calving.

Grass Tetany

The symptoms and causes of grass tetany (also known as hypomagnesaemia or grass staggers) were briefly discussed in Chapter 3 (Nutrient Requirements of dairy stock).

To recap, grass tetany is associated with low blood magnesium levels. Since mobilisation of magnesium from stores is slow, the cow relies upon a daily intake of magnesium.

Conditions that reduce magnesium intake and blood magnesium levels include:
- grass dominant pastures with low magnesium concentrations
- pastures which have been fertilised with potash and nitrogen, as potassium interferes with magnesium absorption by the cow
- Short periods of fasting or stress, such as yarding or transportation

Commonly recognised symptoms include excitable/nervous behaviour, muscular twitching, convulsions, collapse and eventually death.

Nutritional management of grass tetany aims to provide supplementary magnesium from 2-3 weeks before calving until October.

Rates of supplementation vary from 5-15 grams elemental magnesium/cow/day, depending on whether there is a high incidence of tetany or not.

Means of supplementation include:

1. Magnesium Oxide (Causmag) delivered in bail feed, dusted onto hay or dusted onto pasture

Rate:	In feed	30-60 g/cow/day
	Dusted onto pasture	50 g/cow/day
	Dusted onto hay	50 g/cow/day

2. Magnesium Sulphate (Epsom Salts) delivered via drinking water or as a drench
   Rate: 60 g/cow/day in a drench, or
   500 g per 100 litres drinking water

3. Magnesium Chloride delivered via drinking water or as a drench
   Rate: 60-100 g/cow/day in a drench, or
   420 g Magnesium Chloride Hexahydrate per 100 litres drinking water

Note: High levels (over 30g per cow per day) of granulated Causmag (Magnesium Oxide) have been identified as a common factor between herds that are affected by severe outbreaks of Salmonella. This needs to be weighed up against the risk of grass tetany. Some veterinarians suggest dropping granulated Causmag levels if a salmonella case occurs**.**

Ketosis

Also known as **acetonaemia**, ketosis occurs when the cow relies too heavily on body reserves to produce extra energy. It is common in cows fed low energy diets in early lactation.

When cows draw on body condition to meet their energy demands in early lactation, fat reserves are broken down to ketones, which are then used to produce energy.

If a low energy diet is provided, the cow relies too heavily on these fat reserves to make up for the lack of energy. Production of ketones then exceeds the capacity of the cow to use them for energy, and ketones build up in the blood.

Symptoms include:
- Loss of appetite
- Lowered production
- Dull appearance and staggering gait
- Acetone, or a sweet smell, evident in the breath, urine or milk

A high percentage of cows in the herd can suffer from this disorder at sub-clinical level, causing reduced production.

Nutritional management to avoid ketosis hinges on providing adequate quantities of energy, particularly in early lactation, so that reliance on body reserves is reduced.

> *Ketosis highlights the need to avoid abrupt changes in the ration which decrease intake in early lactation, and also underlines the importance of maximising nutrient intake with high quality feed during this period.*

Lactic Acidosis

If high levels of cereal grain are fed without any buffers, large amounts of lactic acid are formed in the rumen. When this occurs, the lactic acid build-up is so rapid that the bacteria which use lactic acid cannot cope.

The build-up of lactic acid causes the rumen to become more acid. You may recall from Chapter 2 that the fibre-digesting microbes cannot function with low pH, i.e. more acid conditions. When these microbes stop working, fibre digestion is interrupted and feed intake drops.

At clinical levels, this disorder is also called **'grain poisoning'.**

Nutritional management to avoid acidosis involves:

1. **Introducing starchy, rapidly fermentable feeds such as cereal grains gradually** over time to give the rumen microbes time to adjust.
2. **Including buffers** when high levels of cereal grain are being fed

> ➲ **THE USE OF BUFFERS AND THE DIFFERENT TYPES OF BUFFERS AVAILABLE WILL BE DISCUSSED IN CHAPTER 9.**

3. **Maintaining fibre levels in the diet**, which stimulates saliva production and helps to buffer rumen pH.

Mineral Deficiencies

Mineral deficiencies are an extremely complex area of dairy cow nutrition. As depicted in Figure 6.1, the mineral status for any given mineral depends on the balance between **requirements**, the level of **intake** in feeds, the animal's ability to **absorb** the mineral from the intestine and the ability to **store** it in the body.

Requirements are affected by stage of lactation, age, pregnancy etc. Requirements for any given mineral also vary with its efficiency of absorption and the presence of other minerals that interact with it.

Intake is affected not only by the amount of each element in the feed, but also on the amount of each feed eaten. Mineral concentrations in pasture often depend on the pasture species, as well as soil and fertiliser history of the paddock. Selective grazing can also affect the actual amount eaten, making it quite different from the 'average' concentration in the pasture. Eating soil can also affect daily intake of some elements.

Absorption of some elements from the gut is affected by the amount of other elements present. For example, copper absorption is reduced when molybdenum and sulphur levels are high.

Storage of many of these elements is nature's way of having animals cope with short periods of low intakes.

Details of the major macro- and microminerals required by dairy stock are presented in Tables 6.1 and 6.2. These tables include the functions of each mineral, likelihood and signs of deficiency, means of diagnosing the deficiency and major sources.

As previously noted in Chapter 3 in relation to mineral requirements, **responses to trace element supplementation in terms of production or fertility have been inconsistent in pasture-based dairy cows.**

Minerals and trace elements need to be considered for individual farms, taking into account known deficiencies in certain areas, history of deficiencies on the property, management system including fertiliser applications, etc.

Supplementing stock without knowing their mineral status can be counter-productive. Monitoring, to assess the effect of supplementation should follow diagnosis and supplementation.

Trace element deficiencies need to be kept in perspective as a cause of reduced performance. Generally, level and quality of feed intake play a much greater role in determining animal productivity.

Mineral	Interfering factors	Function/Features	Major Sources, incl. supplementary sources	Likelihood of Deficiency	Signs of Deficiency	Means of diagnosing deficiency
Calcium (Ca)	Phosphorous, Vitamin D	Component of bone & teeth, involved in heart, muscle and nerve function and blood coagulation. Essential for milk production.	Bone reserves mobilised during mild dietary deficiencies, legumes, grasses.	Deficiency (not milk fever) is rare.	Calves: dental abnormalities, soft bones Cows: off feed, reduced production, fertility and weight gain. Weak bones.	Blood sample Bone ash
Phosphorus (P)	Calcium, Vitamin D, Phytic Acid	Needed for sound bone & teeth. Vital component in protein, also the buffer in saliva.	Legumes, grasses with good fertiliser history. DCP	Uncommon in dairy cattle but is seen here.	Infertility, post-calving red water, bone chewing, poor condition, poor condition, poor production, lame.	Blood Sample compact bone thickness of 12th rib (biopsy)
Magnesium (Mg)	Potassium, high levels of rumen ammonia	Nerve & muscle function, carbohydrate & lipid metabolism, calcium level regulation.	Clover Causmag, epsom salts or magnesium chloride.	Very Common, seen as grass tetany	Lowered production, tetany, collapse, death.	Blood sample Urine sample
Potassium (K)		Essential for metabolism, and muscle & nerve function.	Grasses Note that high K and low Na reduce Mg absorption.	Very rare. Unlikely.		saliva
Sodium (Na)		Na necessary for absorption of sugar & amino acids from the digestive tract.	Pasture generally contains plenty of Na.	Rare, as the body can recycle Na.	Lower production craving (pica) for salt, low appetite grass tetany.	Urine
Chlorine (Cl)		Cl plays a role in gastric digestion in the abomasum. Involved in regulation of acid-base balance.	Salt licks.	Very rare. Unlikely.	Lower production craving (pica) for salt, low appetite grass tetany.	Urine
Sulphur (S)				Unlikely	Lower DMI and production.	Diet analysis

Table 6.1: Macrominerals required by Dairy Cows

Mineral	Interfering factors	Function/Features	Major Sources, incl. supplementary sources	Likelihood of Deficiency	Signs of Deficiency	Means of diagnosing deficiency
Copper	Molybdenum, Zinc, Iron, Selenium.	Required for haemoglobin synthesis, some enzyme & nerve formation. Also required for hair and cartilage.	Higher levels in clover. Also feed additives, bullet and injection.	Common, esp on sandy and peat soils. High Mo levels in plants decrease Cu uptake.	Lowered production rough dry coats, with pale bands in black hair, diarrhoea.	blood, liver
Cobalt		Component of Vit B12 synthesised in rumen. Needed for enzymes.	Feed additives, bullet or injection of Vit. B12.	Common. Vit B12 is often low in spring or with lush autumn growth.	Lowered production, low condition.	blood, liver
Selenium	Vitamin E, Iron	Important in microbial enzymes & tissue protein as well as immune system.	Higher levels in grasses than clover. Bullets and drenches.	Common	Lowered production, retained afterbirth, muscular weakness post- calving, white muscle disease in calves.	blood, liver
Zinc		Component of many enzymes & involved in many cellular functions.	Zinc oxide or Zinc sulphate if deficient.	Rare?	Lowered production & fertility, skin problems, lesions, poor growth.	dietary analysis, blood
Iodine	Manganese, Cobalt, Calcium, Goitrogens	Required for synthesis of thyroid hormones that regulate rate of energy metabolism.		Not very common	Enlarged thyroid in newborn, weakness & mortality in newborn. Abortions.	Milk iodine. Section on newborn thyroid gland.
Iron	Calcium, Phosphorus, Copper, Zinc	Major component of haemoglobin required for transport of oxygen in the blood.	Pasture, soil	Very rare	Anaemia	blood test for anaemia.
Manganese		Required for formation of bone & cartilage & fat & carbohydrate metabolism.		Very rare at pasture	Poor growth & fertility Skeletal abnormality & ataxia of calves.	
Molybdenum	Interferes with copper, reduces copper availability			Very rare	Reduced growth.	

Table 6.2: Microminerals required by Dairy Cows

Effects of nutrition on the reproductive performance of dairy cows and heifers

The national InCalf study, involving nearly 40,000 cows, found that cow body condition and nutrition were one of 6 key factors impacting on herd reproductive performance.

Effects of nutrition on the reproductive performance of dairy cows

The importance of body condition at calving

The target condition score for cows at calving is 4.5 to 5.5 (1-8 scale). Cows that calve within this range have 6 week in-calf rates that are 12% higher than cows calving below 4.5. This is because cows calving at a body condition score lower than 4.5 generally take longer to start cycling after calving than cows in the target condition score range. As cows that are inseminated at their second heat have conception rates 7-8% higher than cows inseminated at their first heat, the faster that cows start cycling after calving, the higher the likelihood that they will get in calf to the first insemination and subsequently calve earlier in the calving period.

Body condition loss at calving

Cows that lose more than one body condition score between calving and mating can be expected to have lower reproductive performance than herd mates with more moderate losses. Cows most likely to lose excessive body condition after calving are those in body condition score above 5.5. For this reason it is not recommended to calve cows down at a condition score above 5.5. In addition, calving cows that have excessive condition can lead to nutritional disorders in early lactation.

Feeding to maximise reproductive performance

1. Ensure cows calve in the target body condition score range of 4.5 to 5.5. At calving, the herd should not have more than 15% of cows below condition score of 4.5 and not more than 15% of cows above condition score of 5.5. As mentioned before it is better to gain the required condition score during lactation. If this has not happened then to reach target body condition scores, cows must be dried-off with enough time to gain the required weight. What needs to be kept in mind is that enough energy must be fed to meet maintenance, pregnancy and liveweight gain requirements. A useful strategy is to split the herds into two groups based on body condition score. Cows with lower body condition can be fed a higher energy diet to help them reach target body condition scores.

2. Minimise body condition loss in early lactation. Ensure that cows are not above condition score 5.5 at calving as cows that are ‘overweight’ are most likely to lose excess condition in early

lactation. Cows should be fed the highest quality pasture after calving and through early lactation to make sure energy and protein requirements are met. If there is not sufficient pasture cover to meet requirements, supplements should be fed.

Monitoring body condition score

There are three key times to condition score cows during the year:

- 8-10 weeks before drying off;
- just before calving; and
- two weeks before the start of mating.

Condition scoring at these times allows adjustments in the diet to be made in time to make sure cows reach target body condition scores at the critical times of calving and mating.

InCalf recommends that at least 70 cows are condition scored to estimate the herd body condition score and the percentage of cows below condition score 4.5 and above condition score 5.5. Cows should be randomly selected and should not be the first 70 cows or last 70 cows through the dairy.

Other factors that impact on herd reproductive performance

Body condition and nutrition is one of 7 key factors found to be important in herd reproductive performance. The other factors are:

- calf and heifer rearing
- heat detection
- AI technique and sire selection
- bull management
- cow health;
- calving pattern.

Table 6.2 gives indicators of reproductive performance and suggests when help should be sought.

		Performance	
	Measure	**Seek help**	**Top farmers achieve**
Seasonal calving herd	6-week in-calf rate	<60%	71%
	Not-in-calf rate (15 week mating period)	>17%	10%
	10-day submission rate	<36%	41%
	3-week submission rate	<75%	86%
	Conception rate	<49%	53%
Year-round calving herds	100-day in-calf rate	<45%	58%
	200-day not-in-calf rate	>19%	13%
	80-day submission rate	<61%	73%
	Conception rate	<43%	51%

Table 6.2 Reproductive performance - what can be expected. (*Source: The InCalf Book for dairy farmers.)*

7. Nutrition for Dairy Replacements

In the last chapter, it was noted that heifer management can have a major impact on herd calving spread and reproductive performance. Producing well-grown heifers in good condition at mating and calving is one of the most important factors under management control. This chapter discusses the nutritional management of replacements from birth to calving.

Nutritional Management

There are three major periods of different nutritional demands required by the replacement heifer. These periods are birth to weaning, weaning to mating and mating to calving. Obviously these periods flow into one another but it is convenient to think of them as three distinct periods each with its own unique nutritional requirements.

Birth to weaning

The newborn calf is born with all four stomachs**. However, the abomasum is the only truly functional stomach**. The other three stomachs are concerned with the digestion of pasture and therefore are not required for the new born calf, as milk is its sole diet in the first few days of its life.

The newborn calf must be fed colostrum. This is milk reinforced with blood proteins and vitamins. The concentrations of vitamins, particularly A, D and E, and proteins are about five times those of whole milk but fall rapidly over the first two days to have little difference to whole milk. As well as providing these blood proteins, or **immunoglobulins**, which transfer passive immunity from the mother to the offspring, colostrum contains a factor which allows the calf to utilise its own fat reserves to provide additional energy.

The rumen is a very small organ in the newborn calf, some 1-2 litres in capacity. It quickly develops to a capacity of 25-30 litres by 3 months of age if given the correct stimuli as part of good feeding management. **The development of the rumen coincides with the increase in the intake of solid foods**. Rumination can occur from two weeks of age.

Calves require three main ingredients for good growth. These are water, energy and protein. In addition to these main ingredients, fibre, vitamins and minerals are also required.

Water	Water is obtained from milk (87% water) during the first few weeks of life and is supplemented with drinking water supplied during the rest of the calf's life
Energy	Energy is required to support bodily functions and to maintain a constant body temperature, this is known as the maintenance energy requirement. Any surplus energy taken in by the animal allows for growth and as growth occurs (i.e. as the animal gets bigger) maintenance requirements increase.
Protein	Protein is required by the calf for the manufacture of blood, tissue and bone. Proteins supply the building blocks from which the calf develops.
Fibre	Fibre is required to stimulate the rumen and to help generate saliva which aids the calf in swallowing and digesting its foodstuff. Around 10-20% of a calf's DM intake should be in the form of roughage i.e. fibre. The fibre should not be too fine as the fibre intake may become too high. High fibre intake will occur at the expense of energy and protein intakes.
Minerals and vitamins	Minerals and vitamins are also required by calves. **The two most important minerals are calcium and phosphorus**. Both are required for bone development and muscle function. Other important minerals are sodium, potassium and magnesium. Calves are born with low levels of vitamins A, D and E and these are generally supplied in both the colostrum and milk that is fed to the pre-weaned calf. Pasture sources of these vitamins replace the milk source in the weaned calf. Vitamin B is also supplied to young calves via the milk, as the young calf is unable to synthesise vitamin B until the rumen is functioning. Pasture will generally supply adequate vitamin B, although in extremely dry summers the calf may have trouble synthesising enough vitamin B and injectable supplements may be required.

Weaning

Calves should be weaned at a minimum weight that is breed dependent, and signals that the physical properties of the calf are sufficiently developed to survive on a pasture diet.

Recommended target weaning weights are as follows:

Breed	Weaning Weight (kg)
Friesian	100+
Jersey	80+
FriesianxJersey	90+
Red Breeds	100+

NOTE: Target weights for Jerseys throughout this chapter are for the heavier-framed animals

In some cases, calves can be weaned from milk at a much lighter weight if their DM intakes are sufficient to allow adequate growth without milk. Although the calf in these cases is technically weaned, i.e. off milk, it is not ready to be self-supporting on a pasture diet alone. The methods of getting calves off milk at an early age are often referred to as the fast rumen development methods and are commonly practised in regions where pasture is of low quality.

Weaning to mating

The period from weaning to mating is the most critical period in the young heifer's development.

It is during this period of growth that the future capacity for size, production and, to a certain extent, reproductive performance, is determined.

In most cases the weaned heifer is given a grass diet to eat that may or may not be supplemented with a concentrate**. For the heifer to have adequate daily weight gains it must be fed the right diet with the right levels of protein, energy and fibre**.

The heifer should also be free of parasites and inoculated against clostridial diseases such as black-leg and pulpy kidney.

Recommended target mating weights are as follows:

Breed	Mating Weight (kg)
Friesian	310-330
Jersey	240+
FriesianxJersey	290+
Red Breeds	310++

		Liveweight (kg)		
		80	**140**	**200**
Maximum DM intake (kg/day)		**2.4**	**3.6**	**4.8**
ME requirements (MJ/day)				
Maintenance		15	23	30
M + 0.25 kg/day gain		18	27	36
M + 0.5 kg/day gain		22	32	42
M + 0.75 kg/day gain		26	38	48
M + 1.0 kg/day gain		31	43	55
Minimum dietary ME content (MJ/kg/DM)				
0.5 kg/day gain		9.2	8.9	8.7
1.0 kg/day gain		12.9	11.9	11.5
Crude protein requirement (g/day)				
0.5 kg/day gain	RDP	170	250	330
	UDP	130	120	110
1.0 kg/day gain	RDP	240	335	430
	UDP	200	180	150
Minimum dietary crude protein content (%DM)				
0.5 kg/day gain		12.5	10.3	9.2
1.0 kg/day gain		18.3	14.3	12.1

Table 7.0: Requirements of weaned calves for energy and protein at different weights *(after Webster 1984)*

Dietary requirements

Table 7.0 indicates the dietary requirements of dairy heifers at the liveweights of 80 kg, 140 kg and at 200 kg with daily liveweight gains of 0.5 and 1.0 kg.

From Table 7.0 it can be seen that the young heifer at 80 kg liveweight requires a feed source with a minimum of 9.2 MJ ME per kg of DM if it is to have a liveweight gain of 0.5 kg per day. The feed source is also required to have a crude protein content of 12.5% and the calf must consume 2.4 kg of DM per day.

During early spring, and even into early summer, a ryegrass white clover paddock can easily supply the calf with feed at or better than this quality.

It is important to note that the young calf is a very inefficient grazer when compared to a mature cow. For the calf to have satisfactory intakes there must be at least 40% more feed on offer than is required by the calf.

As the calf matures, the excess that needs to be offered can be decreased. **However a 20 month-old heifer will still need to be offered 10% above her actual needs.**

During summer and even into autumn, it is common for dryland pasture quality to fall to a level where they cannot supply the minimum requirements as shown in Table 7.0.

Dryland pasture in summer will often only have ME contents of 7 - 8 MJME/kg DM and crude protein levels of 8 -10%. **At these low levels of energy and protein the calf will still fail to make adequate weight gains, even with excessive quantities on offer.**

It may become necessary to supplement the calf with a feed source rich in protein and energy. If a straight grain such as barley or wheat is used there is a chance that the diet may become too rich in energy that may lead to fatty udder syndrome.

Fatty udder syndrome

The object is to get as much size and weight onto the heifer after weaning so that it will become reproductively active and have a frame size which will enable it to produce to its genetic capabilities providing the feed is supplied.

Working against this objective is the **fatty udder syndrome**. Research conducted overseas, particularly in the Northern Hemisphere, has shown that heifers grown too quickly during a critical period of their development can develop fatty udders, which limits their future milk production.

Although there is some debate about the period during which fatty udder syndrome can occur, most researchers agree it may occur in Friesians between the liveweights of 90 kg - 200 kg and between 70 kg -150 kg for Jerseys. **Fatty udder syndrome will only occur if the heifer is gaining liveweight at more than 0.7 kg per day for Friesians and more than 0.5 kg per day for Jerseys, during the critical period.**

Recent research conducted in Australia also indicates that it is the diet, in particular the ratio of energy to protein, that may be the cause of fatty udder syndrome. Diets rich in energy and low in protein may more readily cause fatty udder syndrome than diets that are higher in protein. This is because excess energy is stored as fat in the young animal.

In a pasture-based system it is unlikely that fatty udder syndrome will occur, even at the higher growth rates.

Autumn - winter period	During the late autumn and winter period the pasture quality improves and has adequate levels of energy and protein for adequate weight gains. **However, quantity may be a limiting factor in achieving minimum liveweight gains of 0.5 kg/day.** Supplements of fodder crops, good quality hay or silage and even concentrates may alleviate the feed deficit that is common during this period.
Early spring	During early spring the grass is growing quickly and is of very high quality. With no dietary restrictions heifers will often record liveweight gains in excess of 1.0 kg per day.

Mating to calving

For the spring-calving heifer the period just after mating i.e. early November, is when the greatest weight gains are made. By summer the pasture quality is falling and weight gains begin to taper off. **Table 7.0 indicates that the requirements for crude protein and energy per kg of DM are less for the heavier animal. Therefore the more mature heavier heifer is still able to put on adequate weight gains during an average summer even though the quality of the pasture on offer has fallen.**

During very dry summers there may be a need to supplement the mated heifers with silage or a fodder crop but this is usually required not so much to boost falling protein and energy levels but to provide the large amounts of DM needed by the growing heifer.

A heifer weighing 400 kg and gaining weight at 0.5 kg/day requires 8.2 kg DM/day or 77 MJME/day. In late summer and going into winter it can be very difficult to supply this amount of DM to the heifer.

It is for this reason that is a mistake to put pregnant heifers together with the mature dry cows prior to calving. The dry cows are usually on a restricted diet of around 6-8 kg DM per day but the heifer at 450 kg is requiring closer to **10 kg DM/day**.

By mixing the two groups, the mature cows will compete for the food and the heifers will lose weight. **A weight loss occurring close to calving will create calving difficulties and may slow down the heifer's recovery period from negative energy balance once calved which may add to reproductive stress.**

Recommended target calving weights are as follows:

Breed	Mating Weight (kg)
Friesian	480-550
Jersey	380-420
FriesianxJersey	460
Red Breeds	500

8. Pasture Based Nutrition

Pastures are the basis of cow diets in Tasmania. Dairy farmers are fortunate to be able to provide the majority of their herd's feed from grazed pasture rather than high cost supplements that need to be harvested, transported and stored.

From earlier chapters on feed composition, we have seen that quality pasture usually provides a well-balanced base for milk production. Relative to cow requirements, some deficiencies or excesses may arise at different times of year.

However, on many Tasmanian farms, the major nutritional limitation to pasture is not related to its composition.

The major limitations to pasture are that, for a variety of reasons:

1. **We are not providing enough of it at certain critical times of the year.**
2. **We are not utilising it well enough at other times, and consequently its quality is reduced.**

*This chapter firstly examines the factors that affect **nutrient intake by grazing cows**. Then, it discusses the **management factors that affect pasture availability and suitability for milk production**.*

Factors Affecting Nutrient Intake of Grazing Cows

The effects of bodyweight and stage of lactation on a cow's potential intake has already been discussed in Chapters 3 and 5.

However, nutrient intake of cows grazing pasture is also affected by:

- Grazing Behaviour
- Pasture allocation (*quantity*)
- Pasture *quality* and palatability
- Selection
- Substitution

Skilled grazing management is needed to get the best from pasture. As the cow is the 'harvester' we need to relate to how the cow views pastures and grazing. It is worthwhile to take time to explore what a cow looks for in a pasture and how to manage it to get the best result.

The Ability to Harvest Pasture - Grazing Behaviour

The intake of pasture is determined by:

- time spent grazing (**grazing time**)
- number of times that the cow bites (**rate of biting**) and
- the amount of pasture harvested in each bite (**intake per bite**)

The grazing habit of animals has an element of heritability (some animals appear to be better grazers than others). As grazing managers, it is possible to exert some control over the factors that determine intake, i.e. grazing time, rate of biting and intake per bite.

Grazing Time

The grazing day is divided into 3 activities - grazing, ruminating and resting (Figure 8.0). Most grazing takes place during daylight hours. Short periods of night grazing are not uncommon and in fact are most likely to be the main period of grazing on days with extremely high temperatures (greater than 30^{o}C).

The pattern of grazing is undoubtedly affected by regular activities such as milking or movement of stock onto different pasture types. In the case of the diagram below the average time spent grazing is 8.6 hours with an average of 7-8 hours spent ruminating.

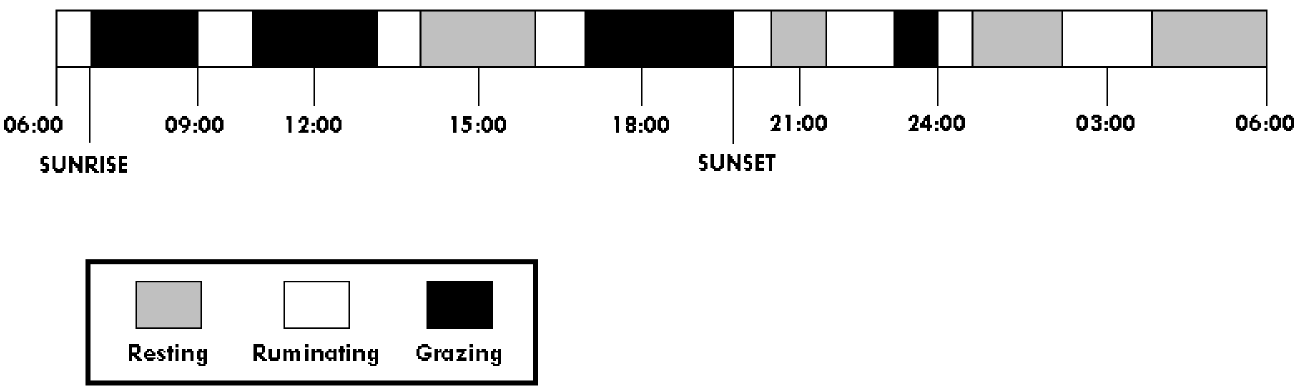


Figure 8.0: Typical grazing and ruminating activity of a dairy cow. *(Adapted from Hodgson, 1990)*

Grazing time varies between 6-12 hours per day. Shorter grazing periods could be achieved if the feed was cut and delivered to housed animals. **It is unlikely that a cow will extend her grazing time beyond 12 hours**.

A rough rule of thumb is that if a 500 kg cow is offered quality pasture, then she would be able to consume about **17 kg of DM in 24 hours**, with a grazing time of approximately 8.5 hours.

Practical Implication:

Cows don't eat for 8.5 hours solid but tend to graze for blocks of time. **This needs to be considered when using stand-off areas in conjunction with short periods of time grazing wet paddocks.**

Rate of Biting

At different stages of plant development, grasses have different amounts of structural carbohydrate (stem material). The 'toughness' of this carbohydrate increases as the grass matures.

The grazing animal finds it harder to harvest stem than leaf. Mature stem is harder to harvest than young stem. It follows that if an animal puts equal effort into harvesting pasture, more leafy pasture will be eaten than stemmy pasture with very mature pasture being at the bottom of the scale.

> *If you want to get high bite rates from your cows, present them with a pasture that doesn't tire the jaw muscles too much!*

Intake per Bite

Intake per bite is influenced by the amount of pasture made available at each grazing.

Pasture Allowance & Availability

The ability of cows to maximise feed intake from pasture is dependent on how the pasture is 'presented' to the cow.

Allowance

This is simply the quantity of pasture (kg DM) made available or allocated to each cow. Limited trial work indicates that in order for a grazing cow to be well fed on pasture, an allowance of double her requirement needs to be made.

Offering less sees the cow limit her intake. This is because a lot of the pasture on offer is close to ground level where it is more difficult to harvest by grazing. While grazing time may increase to harvest closer to ground level, the extra grazing time does not fully compensate for the reduced bite size and intake is reduced.

As cows are offered more pasture, their intakes increase but their utilisation of available feed declines.

Cows need to be offered around 1.5 - 2 kg DM to increase pasture intake by 1 kg DM from 7 to 8 kg DM, but need to be offered around 4-5 kg DM more to increase intake from 11 to 12 kg DM.

> *Each additional kg DM intake requires more and more pasture to be offered.*

Availability

How available is the pasture allowance to the grazing cow? A 10 cm tall pasture spread over one hectare will more easily satisfy intake per bite compared to 1 cm tall pasture spread over 10 hectares. **In other words it is easier to get a mouthful of long pasture than short pasture!**

Pasture Quality and Palatability

Effect of quality on DRY MATTER INTAKE

It is not possible to laboratory test all pasture on a farm each day to determine its likely value for milk production. Therefore, physical terms can be used as a means of quantifying what should be a good quality or a poor quality pasture.

High quality pasture tends to be more leafy, has less stem material and little to no dead plant material at the base. **The rumen microbes easily break down such pasture.**

On the other hand, stemmy, dead plant material, has a higher fibre level which is either not digested or only slowly digested by the microbes.

One of the main effects of pasture quality is to determine the rate at which pasture is broken down by the rumen microbes. The quicker pasture is processed and moved on out of the rumen, whether to be absorbed or passed out as faeces, the sooner more pasture can be eaten in order to fill the rumen again.

Effect of quality on NUTRIENT INTAKE

Whilst higher quality pasture will result in higher intakes, there is another benefit from quality pasture. **Higher quality pastures offer more nutrients per kg of dry matter than lower quality pastures.**

Whilst differences in the energy levels of pasture species may only appear small, it should be remembered that a 1 MJ increase in energy density over an average intake of 15 kg DM/day will supply sufficient energy to produce an additional 2.5 to 3.0 litres of milk!

Therefore, not only will higher quality pasture result in increased intake, but also in more nutrients (in this case energy) being available. **In other words, cows not only eat more, but more of what they eat will be of value to them.**

Thus the effect of quality has a multiplying impact on the total amount of nutrients that potentially will be available to the animal for maintenance, production, pregnancy or liveweight gain.

Palatability	Cows eat more of what they like and less of what they don't. Thus in practice it is important to find ways to offer your cows pastures which are: • leafy (highly digestible), • moderate to tall height (easy to harvest) and • very palatable (uncontaminated young succulent plants). **Consequently they will have high intakes, digest more of the nutrients and produce more.**

Selection

The ability of the cow to select a better diet than what is on offer in the paddock is another factor that influences her intake of nutrients.

Unless pasture allowance is low, cows selectively graze the high quality areas in the pasture and leave the low quality areas.

For example, in a pasture with an average energy content of 10.5 MJ ME/kg DM, the cow starts off by selecting a 12 MJ diet, then moves on to slightly lower quality material of 11.5 MJ, and so on until her potential intake is reached.

The cow's ability to select is higher when there is plenty of feed available and stocking rates are low.

On average, it is commonly assumed that cows will select 3-4% more Crude Protein and 0.5-1.0 MJ more ME than what is available across the pasture.

Substitution

Substitution is the term used to describe how intakes of grazed pasture alter when supplements are fed.

A cow can only eat so much. If she gets more than she can eat, something goes uneaten. If a supplement is fed in the shed before pasture, then it is the pasture that goes uneaten. If it is fed in the paddock (e.g. silage or hay) then the cow makes a choice between pasture and supplement.

Pasture Substitution:	*The decrease in pasture intake that occurs when cows are offered supplementary feed. Substitution reduces the expected increase in intake when feeding supplements.*

Substitution Rate	*The reduction in pasture intake per kg of supplement offered. Substitution rates have been measured at different pasture intakes.*

Example *A substitution rate of 0.25 means that for every kg of supplement eaten, pasture intake will fall by 0.25 kg DM.*

This means that if 3 kg of grain is fed, pasture intake will fall by 0.25 x 3 = 0.75 kg DM.

The extent of substitution depends on a number of factors that are discussed below.

Pasture allocation

The closer the cow is to maximum intake, the greater the substitution.

This is demonstrated in Table 8.0 below.

Level of pasture intake (kg DM/cow/day)	Substitution Rate
16	0.75
14	0.6
12	0.25
6	0

Table 8.0: Substitution rate at different levels of pasture intake

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***Example**:*

Cow pasture intake = 16 kg DM/cow

Cows were also offered 4 kg DM/cow in grain

Substitution rate is 0.75

Therefore reduced pasture intake is 0.75 x 4 = 3 kg DM

Pasture intake = 13 kg DM/cow
Grain = 4 kg DM/cow
Total intake now = 17 kg DM/cow

Cost implications

Assuming a pasture utilisation cost of 12 cents/kg DM and grain at 25 cents/kg DM:

*Cost of feed on pasture alone = 16*12 cents = $1.92 per cow per day.*

*Cost of feed with grain = (13*12) + (4*25) cents = $2.56 per cow per day. This is an extra 64 cents per cow per day.*

Obviously one expects extra production from the increased intake that will offset the extra cost of feeding. If the 1 kg DM extra intake gave an extra 2 litres of milk per cow per day at 35 cents/litre then the extra income will be 70 cents. This is a 6% return on investment.

Pasture Quality — If the quality of the pasture is the same or lower than the quality of the supplement, the supplement will be eaten first.

With high quality supplements on high quality abundant pasture, almost complete substitution occurs (i.e. cows eat 1 kg less pasture for each 1 kg of supplement eaten)

Supplement type — Substitution is greater when roughage (hay, silage) supplements are fed than when concentrates are fed. This reflects the volume that supplements occupy in the rumen and the fact that these supplements are more slowly digested. Hence, they do not make room for more feed to enter the rumen as quickly as concentrates, which are digested faster. High rates of substitution have been recorded for silage when cows were grazing dry summer pasture.

Dietary balance — If the supplement corrects dietary imbalance there is less substitution, and in fact there can be an increase in intake over that provided by the supplement. However, if an imbalance is made worse, there may be a further reduction in total intake.

What substitution rates can be expected on pasture?

Where ample pasture provides the base ration, substitution rates of concentrates have ranged between 0.3 - 0.9. **If the substitution rate is less than 1.0 then concentrate feeding increases total intake.**

Substitution rate is greatest (i.e. closer to 1.0) where there is plenty of highly digestible pasture and large amounts of concentrates are fed.

Substitution rate is lowest (closer to zero) where there is little pasture available and small amounts of concentrates are fed.

The stage of lactation and season of the year do not appear to affect substitution.

Why does substitution occur?

Reasons for substitution are not fully clear. In part, it occurs because the digestion of starch in the rumen makes the rumen more acidic, which causes a decrease in the number of fibre-digesting bacteria. This slows fibre digestion and causes a longer retention time of undigested matter in the rumen, so pasture intake decreases.

Other factors that may contribute to substitution are decreased grazing time and rumen capacity. **Experimental work suggests that under reasonable grazing conditions the cow might spend 10 or 15 minutes less grazing for every kg of concentrate supplement eaten**.

Management factors affecting pasture availability & suitability for milk production

From the section above, **pasture allocation, availability and quality** are some of the most important factors affecting the nutrient intake of grazing cows.

Pasture growth rates vary throughout the year and will affect the quantity of pasture on hand. Depending on season, stocking rate and calving pattern, pasture will generally be available in excess quantities in spring and there will be a deficit in summer/autumn and winter.

This section discusses some of the management factors that affect pasture availability and quality, and how they can be manipulated to get the most out of our pastures.

Stocking rate, grazing pressure and utilisation

Farm stocking rate and calving pattern influence farm feed requirements and availability. It is generally accepted that higher stocking rates allow more of the spring surplus to be utilised whilst 'exaggerating' the seasonal feed deficits.

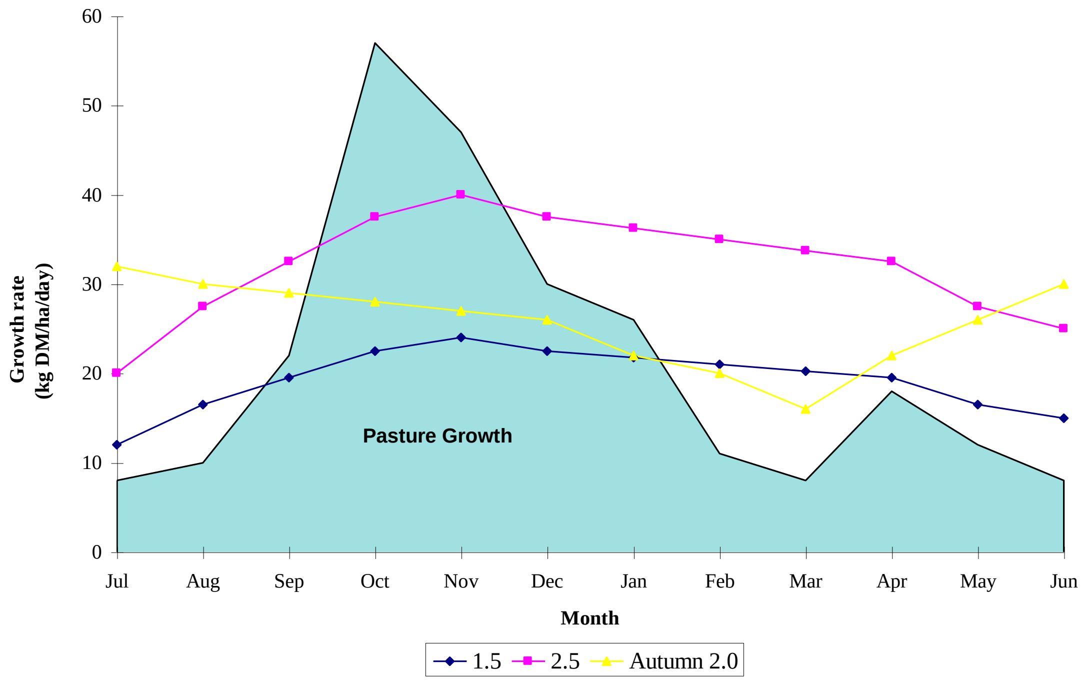


Figure 8.2: Cow requirements vs dryland pasture growth, at stocking rates of 1.5 and 2.5 cows/ha (spring calving) and 2.0 cows/ha (autumn calving).

However, stocking rate does not just affect the quantity of pasture required at different times of year. It also plays an important role in determining the quality of that pasture.

At lower stocking rates, cows tend to be offered much more than they can eat. This means that they have the opportunity to select, and to achieve higher intakes per cow. **It also means that they leave a large amount of feed behind**.

The quality of the pasture left behind is reduced when the next grazing round occurs. Cows prefer not to graze these unpalatable clumps and unless they are removed by some other means such as topping, they remain uneaten. The overall quality of the pasture declines and nutrient intake will not be as high from subsequent grazings. **Importantly, pasture that we have already paid for is wasted, and additional money is spent on maintaining production, usually by feeding supplements and/or pasture topping.**

How can this be avoided?

After grazing, pastures need to be in a state where there will be good quality feed at the next grazing. This requires grazing pressure to be increased so that less feed is left behind.

On a day-to-day level, this could mean offering the herd a smaller area. **At the farm level, it means adjusting the effective stocking rate to match the feed demand to what is available**.

Note that this does not necessarily mean increasing cow numbers. On your farm, it may mean running the heifers at home to clean up after the cows, or reducing the area available to the milkers.

However it is achieved, increasing grazing pressure maintains higher quality pasture over the season and increases overall utilisation.

As high rates of pasture utilisation are strongly linked to profitability in pasture-based dairying systems, grazing pastures to optimise utilisation and maintain high pasture quality is the most profitable strategy.

Because of the seasonal limitations to pasture growth, higher grazing pressure could be expected to enlarge seasonal feed deficits and make them last longer.

In practice, the improvement in pasture quality and regrowth may partially compensate for this higher requirement in the initial stages. This is why per cow production can often be maintained or sometimes even increased when cow numbers are increased.

However, as stocking rates and pasture utilisation increase further, the need for supplements to fill feed deficits also increases.

Grazing management and pasture management

Pasture growth is maximised and decay minimised if plants are allowed to grow to their three-leaf stage, and then grazed to leave a residual cover of 1400 - 1600 kg DM/ha. **Grazing management aims to maintain pastures within this range, so that cows are presented with pasture that is readily available and of high quality.**

To maintain this range of pasture height it is important to allocate appropriate areas to the cows each day, which determines the rotation length around the farm. If the aim is to give the paddock time to grow back to the 2200-2400 kg DM/ha level before the next grazing, the rotation length (and hence the area allocated to the cows each day) will depend on how quickly the pasture is growing back after grazing.

Rotation length and QUANTITY

Rotation length plays a major role in manipulating pasture availability and cow performance from pasture.

You may recall from Chapter 5 the results of an experiment which demonstrated how underfeeding in early lactation reduces cow production over the rest of the lactation.

Research work carried out at Ruakura in New Zealand demonstrates this within the grazing management context.

Example

What is the effect of early spring grazing management on intakes and cow performance?

Four herds with the same stocking rate, calving date, calving spread and condition score were calved onto farmlets with the same level of pasture cover in mid-July.

Rotation length was varied between calving and the middle of September, but all herds were on the same rotation length by early October.

Table 8.1 presents a summary of the findings of the farmlet trial.

Management	Herd Number			
	1	**2**	**3**	**4**
Number of times around the farm from calving to mid-September	1	1.5	2.5	4.1
Rotation Length (days)				
21 Jul. to 3 Aug.	100	58	41	33
4 Aug. to 17 Aug.	60	37	26	20
18 Aug. to 31 Aug.	52	35	21	14
1 Sep. to 15 Sep.	42	28	14	7
DM Intake (kg/cow/day)				
Jul./Aug.	6.1	8.1	8.4	10.9
Sep.	13.0	14.7	12.0	10.6
Oct.	15.8	15.2	12.7	8.3
Production per cow (kg MF) from calving until early Feb.	**142**	**153**	**148**	**141**

Table 8.1: The effect of early spring grazing management on per cow performance. (Deane 1993, after Bryant 1990)

Nitrogen fertiliser

A highly productive pasture will always require more nitrogen (N) than can be supplied naturally through legumes and ongoing plant decay. Pastures growing at 30-50 kg DM/ha/day require about 1-1.5 kg of N per day above the nitrogen that is supplied naturally. The correct use of a nitrogenous fertiliser will increase the quantity of dry matter grown in a given period as well as lifting the crude protein levels of the pasture.

Response from Nitrogen

Nitrogen will only increase the growth of pastures that are actively growing. If pasture is not growing due to low temperatures or lack of rain, there will be no response to the application of nitrogen. The best responses to nitrogen are from healthy pastures growing on soils with good fertility status.

During spring, and to a lesser extent autumn, when pasture is growing rapidly and moisture and temperature are not limiting then the nitrogen applications should result in a minimum response of 10:1. This means that for every kilogram of nitrogen applied 10 kilograms of dry matter will be grown.

As soil temperatures cool the plant response to applied nitrogen is reduced. It is generally accepted that if soil temperatures are below 4° Centigrade then pasture response to nitrogen is negligible. Nitrogen will also be susceptible to high rates of leaching in cold wet soils.

How much Nitrogen to use

Tasmanian research has shown that although the response to nitrogen can be considered linear, that is, the more nitrogen applied the better the response will be, there is an upper and lower limit. Generally it has been found that it is uneconomic to apply less than 25 kg of N in a single application, unless the application is by fertigation (carried by irrigated water) when amounts of 1-2 kg are used on an irrigation rotation cycle. The upper limit is considered to be around 60 kg of N in a single application. Soils have trouble retaining amounts greater than 60 kg per hectare if applied as a single application and losses to the environment rapidly increase once applications are greater than 60 kg/ha. As nitrogen can both leach into the waterways and escape to the atmosphere as ammonia and more seriously as nitric oxide (a very serious greenhouse gas) sensible usage of this product is required

When to apply Nitrogen

Nitrogen is rapidly taken up by actively growing plants. Once nitrogen has been applied, it is useful to allow the plant to grow out to its three-leaf stage to best capture the boosting effect of N.

Nitrogen is best applied 3 to 5 days after grazing when the pasture is about 50 mm long (1600 - 1800 kg DM). If extra time is needed because of short rotations, nitrogen can be applied 1-3 days prior to grazing. If applying prior to grazing always allow at least one day before grazing for the nitrogen to fall to the base of the plant to prevent stock eating the fertiliser. The pasture will be safe to graze (have low nitrate levels) once it has grown two leaves after application. If the nitrogen is applied some time after grazing, it is wise to check leaf stage at application time and ensure that it is not grazed until a further two leaves have grown. If nitrogen has been applied to short rotation ryegrass, then waiting for these two leaves to grow is very important as short rotation ryegrasses can store higher amounts of nitrates than perennial pastures.

What type of Nitrogen to use

If nitrogen is the only nutrient required, urea is most likely the cheapest fertiliser to use.

If both nitrogen and phosphorus are required, Di-Ammonia Phosphate (DAP) is usually the cheapest source of nitrogen.

If other nutrients are required specific blends can be made.

It is important to remember that, whatever type of nitrogen is used, it should be applied at the rate of 25 to 60 kg N/ha.

Animal health and nitrogen use

Excess nitrogen in pasture can cause animal health problems. Table 8.2 shows the level at which nitrate in a plant can become a problem.

Plant nitrate level	**Effect on stock**
Above 0.65%	Potentially dangerous
Above 0.90%	Potentially fatal
Above 1.2%	Will cause death in unadapted stock*

**These limits apply to unadapted or hungry stock – ruminants can tolerate excessive nitrate in their diet if adapted first.*

Table 8.2: Toxic Nitrate levels. (*Source: The effect of nitrogen fertiliser use on dairy cow health and production by Richard J Eckard)*

Nitrate levels in pasture

When nitrogen is applied to pasture, it usually takes 4 to 5 days for it to dissolve into the root zone to be taken up by the plants. Nitrate levels in the plant peak around 7 to 14 days after the nitrogen application. Protein levels usually peak slightly later at around 16 to 18 days. By 18 to 21 days after the nitrogen application, nitrate levels have usually dropped to acceptable levels. However, by waiting for two leaves to grow after application, the plant content of nitrate will always be at the lower levels.

Nitrate toxicity

Nitrate is a normal plant product. When cows eat pasture, the nitrate in the plants is converted to nitrite when it enters the rumen. At low levels this nitrite is converted to ammonia and is used by the rumen microbes. However if the nitrite levels are high, or the production of nitrite happens too rapidly, the excess nitrite moves into the bloodstream and competes with oxygen for uptake by haemoglobin. Cows that are suffering from nitrate toxicity may show the following symptoms: anaemia, chocolate brown blood, frothing at the mouth, and muscular spasms leading to paralysis.

There are certain plants that are more prone to causing nitrate toxicity because they accumulate nitrates. Perennial ryegrass/white clover pastures are NOT known to cause nitrate toxicity but annual and short-rotation ryegrasses may. Table 8.3 lists plants and their relationship to nitrate toxicity.

Plants which are KNOWN to accumulate potentially toxic levels of nitrate	Plants which are NOT KNOWN to accumulate potentially toxic levels of nitrate
Annual ryegrass	Perennial ryegrass
Short rotation ryegrass	White clover
Oats, rye, wheat and barley	Red clover
Maize	Cocksfoot
Millet	Timothy
Kikuyu	Brome grass
Cape weed	
Brassica tops (e.g. turnips, pasja)	

Table 8.3: Plants that are known, and are not known to accumulate potentially toxic levels of nitrate. (*Source: The effect of nitrogen fertiliser use on dairy cow health and production by Richard J Eckard.)*

Plants are more prone to accumulate nitrate if there is excess nitrate in the soil, and/or the plants are stressed (water stress, herbicide applications, frost, and 4-5 days of continuous cloud cover combined with high temperatures and low soil moisture).

Cattle that are most likely to suffer from nitrate toxicity are those that are hungry, dry cows and heifers, cows with low energy in the diet and cows that are unadapted to the forage on offer.

Avoiding animal health problems caused by nitrogen:

- Do not graze pastures 7 to 14 days after applying nitrogen, or 14-18 days after application if protein problems are suspected.
- Preferably wait until two leaves have grown after applications to prevent animal health problems.
- Do not apply more than 60 kg/ha of nitrogen in one application.
- Be careful of rapid changes in the diet from low nitrate accumulating plants (e.g. perennial ryegrass) to high nitrate accumulating plants (e.g. pasture containing large amounts of capeweed or volunteer brassicas) especially with cows that do not have a lot of energy in their diet (hungry or dry cows).

Irrigation

Irrigation is used to maintain soil moisture status at a level that is adequate for either pasture or crop production, at times of the year when soils would normally be too dry to sustain high growth rates. The amount of pasture or forage grown under irrigation will vary from season to season and with the efficacy of applications. An average response of pasture to irrigation is around 1000 kg DM/megalitre (ML), of water. However, recent surveys have shown that with correct scheduling and efficient systems, over 2000 kg DM/ML can be obtained.

Importantly, this extra production occurs at a time when both availability and quality of unirrigated pasture is low. Therefore the effect of irrigation on pasture quality as well as growth rates should not be ignored.

Irrigation is only profitable if:

1. The extra feed grown is fully utilised. This will usually mean increasing the stocking rate on the irrigated area to a level that utilises all the extra feed grown.
2. Allowing the pasture to grow. This means maintaining a grazing rotation based on the 2.5-3 leaf stage for ryegrass pastures to maximise the effect of the water and fertiliser applied.
3. Water use is optimised through efficient irrigation scheduling.

Scheduling means applying the right amount of water at the right time, so that maximum benefit is obtained. Overwatering and underwatering is avoided. If soils are allowed to dry out to a moisture level where less than 20 mm of water remains in the root zone (top 300 mm of soil), plant growth is severely affected. Research conducted in Tasmania has demonstrated that the potential pasture loss from allowing soils to dry out to these low levels is at least 50% of potential production for a period of 40 days. Putting water on after this stress level has been reached will not reduce the time of recovery or lessen the potential loss but will enable the plants to begin growing closer to potential once the recovery time has elapsed.

Soil moisture status should be measured using either field tensiometers or some of the gypsum block based soil moisture measuring devices. These while seeming to have a high initial cost will return the value many times over in a single season.

Drainage

Drainage involves removing excess water from the soil to allow oxygen to penetrate the surface for pasture growth. All soils should be capable of going through a partial-drying phase as this allows plant roots to obtain air and the soil to breathe. Soils that are permanently waterlogged do not contain enough oxygen for ryegrass and the pasture will become overgrown with sedges and poor quality weeds.

Developing a drainage scheme:

1. Assess the costs (including ongoing maintenance) and benefits
2. Design the scheme in winter when it is wet (a couple of days after a good soaking rain is the best time).
3. Install the drains when the soil is at a moisture content suitable for cultivation (not too wet, not too dry). The exception to this is putting in mole drainage. This should be done when the soil is drying out and plastic at depth (soil will mould rather than fall apart when rubbed between fingers)
4. There are many types of drains that can be installed including open arterial drains, grassed waterways, hump and hollow drainage, pipe drains, mole drains and deep ripping. Each of these types of drainage has a specific purpose and the correct system needs to be chosen for maximum results.
5. If sub-surface pipes are installed, prepare a detailed plan of their location as the work is completed. This will help with future maintenance.
6. Fence stock out of major drains as this will lengthen the life of the scheme

9. Supplementary Feeding

Tasmania's pasture-based dairying system means that even if high amounts of concentrates are fed (e.g. 1 to 2 tonnes/cow/yr.); pasture will still account for 70-80% of the cow's diet. On average across the industry, it is estimated that 90-95% of the diet of Tasmanian cows consists of pasture and pasture-based supplements.

Given these conditions, managing pasture utilisation and quality through feed planning remains an important focus of dairy cow nutrition. Using supplements to increase milk production must not happen at the expense of pasture utilisation and quality.

This chapter discusses how supplements fit into the annual feed plan and those decisions relating to the use of supplements. It also addresses some practical and nutritional considerations involved in the use of different supplements. The final section explains how to check whether the proposed ration is balanced for energy, protein and fibre.

Feed planning and the decision to use supplements

Day-to-day feed management should be centred around three key elements:

- pasture growth
- pasture consumption or demand, and
- the amount of feed on the farm (average pasture cover).

The day-to-day situation varies and can swing from periods of excess growth to periods of excess demand.

The importance of Average Pasture Cover (APC)

The APC is a measure of the amount of feed on the farm in kg DM/ha. It can be likened to the amount of money in your bank account. The pasture growth is a deposit and pasture demands are withdrawals. If you take more money out of the bank than you put in each month then you run your balance down. This is fine if you know there will be large deposits in the next month, but you soon find yourself in trouble if withdrawals are more than deposits for an extended period. **The same can be said for the average pasture cover.**

The average pasture cover is measured in kg DM/ha; and is worked out by multiplying the cover on each paddock by its area, then adding up the total, and then dividing by the total number of hectares measured. It is not the average over one paddock.

For example: What is the APC for the five paddocks below?

Paddock No.	Area (ha)	Pasture Cover (kg DM/ha)	Total Pasture (kg DM)
1	1.4	2500	3500
2	1.1	2200	2420
3	1.6	1900	3040
4	1.3	1700	2210
5	1.0	1400	1400

The APC for these five paddocks is:

(3500+2420+3040+2210+1400)/(1.4+1.1+1.6+1.3+1.0) = 1964 kg DM/ha

Estimating APC quickly

APC can be estimated quickly by taking the average of the three paddocks with the most feed (usually the next three to be grazed) and the three paddocks with the least feed (usually those most recently grazed). This method usually provides a reasonable approximation of APC.

Through slow growing months this may need to be done once per month, while in spring every 12-15 days may be more appropriate.

Monitoring APC

Knowing your APC means you know how much pasture feed you have. **Monitoring APC lets you know when you are increasing the amount of pasture feed on the farm or eating into what you have.**

Monitoring APC tells you one of three things.

- **if APC is not changing,** the stock requirements from pasture are equal to the growth rate. *If you know the stock requirements you then know the growth rate.*
- **if APC is falling,** the stock are eating the pasture faster than it is growing. The rate at which it is falling tells you how much greater the feed requirements are. To stop the APC from falling supplements can be introduced and/or the rotation extended.
- **if APC is rising**, feed is building up so the pasture must be growing faster than the stock are eating it. The decision to stop supplementing and/or drop out paddocks for silage can be made early.

Average pasture cover targets

It is useful to have targets for the average pasture cover so that you can work towards them and make sure that there is enough quality pasture on the farm at all times.

One important target is the APC at break-even date i.e. that time in early spring when pasture starts to grow faster than the cows are eating it. The time when this occurs in Tasmania is usually around late September but will vary from farm to farm depending on district, climatic conditions, fertility and stocking rate.

The target APC for break-even date should be about 1800 kg DM/ha.

The aim is to start the season's milk production when there is a sufficient quantity of good-quality pasture for the milkers. In most herds, the cows start calving before the period of rapid pasture growth. This creates a short period where demand can exceed supply. The amount of this excess will vary depending on the date that calving starts, the calving spread and climatic conditions. The saved winter pasture covers will help meet this extra demand until the spring growth kicks in and a genuine surplus follows

If APC at break-even ends up below the target level, then the pasture quality leading up to break-even will be good but pre-grazing covers will be lower than desired. Unless more area is grazed, daily intakes will be lower. Increasing the area to offer more feed to the milking cows will result in the rotation speeding up but this is not good practice before the period of rapid growth occurs. In addition cows will probably graze down harder and this will affect pasture recovery post-grazing and possibly delay the onset of peak spring growth.

If the APC at break-even ends up higher than the target level, then the likelihood is that the cows would have started lactation on pasture of reduced quality owing to high pre-grazing covers. Whilst intakes could be high, the cows will struggle to eat down to the optimum residual of 1400-1600 kgDM/ha. Higher residuals will compromise quality on the second milking round.

A second important target is the APC at calving and this should be higher than 1800 kg DM/ha. This is because pasture demand is normally higher than growth in the period between calving and break-even. Therefore the APC will fall until break-even.

The APC at calving should be somewhere between 1800 and 2200 kg DM depending on stocking rate, calving date, calving spread and the farm system.

If the APC at calving is above the target then this will normally result in lower quality feed being offered to the milking herd during the first round of grazing as well as wastage of feed during the first round.

Once supply exceeds demand in spring, the average pasture cover should be kept between 1800 and 2200 kg DM/ha. This should result in the cows being well fed on good quality pasture. If it falls below 1800 kg DM/ha, daily intakes will be lower. Putting in supplements will offset the lower pasture intakes and assist in raising the APC. If the APC exceeds 2200 kg DM/ha then pasture quality and utilisation will be compromised. Paddocks should be dropped out of the grazing round for conservation in order to maintain the grazing pressure on the rest of the farm.

Achieving APC targets through feed planning

The advantage to having a planned approach to feed management, as opposed to merely reacting to circumstances, lies in the fact that getting in early gives you a better choice of options.

Supplements tend to follow the general law that states that whenever you need something in a hurry, it's going to cost more. As an example, the cost of additional pasture boosted with nitrogen fertiliser is estimated at about 14c/kg DM (Cost of urea at $655 per tonne and a 10:1 response), whereas a kilogram of Dry Matter as pellets may be anywhere between 20 to 45c/kg DM depending on availability. The major difference is that using nitrogen fertiliser to fill a feed gap requires several weeks forward planning, whereas pellets to fill the same feed gap can be sourced within days.

Knowing where you stand in relation to your target APCs at calving and break-even gives you time to source the cheaper options. Obviously these will vary, but identifying a potential feed gap earlier rather than later can make a big difference when trying to obtain cheaper agistment or purchased hay.

The decision to use supplements – the seasonal approach to feed planning

In this context, the word 'supplement' is used in a broad sense to include agistment, nitrogen-boosted pasture and fodder crops, as well as silage, hay and concentrates.

Achieving break-even pasture cover target

The break-even APC target is important for setting up the farm in terms of pasture quality and quantity for the season. From previous chapters, you may recall the importance of feeding level as the herd approaches peak-yield in terms of production over the season. **The break-even pasture cover has a major impact in determining how well the herd is fed during this period**.

An important determinant of the break-even APC is the balance between pasture growth and demand between calving and break-even. The feed budget will give this picture and allow you to set the APC at calving that you need to achieve the required break-even APC.

What if the feed plan indicates that the only way to achieve an APC of 1800 kg DM/ha at break-even is to calve onto a very high pasture cover (e.g. above 2200)? Because very high pasture covers at calving will have detrimental effects on quality and regrowth in early lactation, it would not be best practice to have these high covers at calving. **It is better to manipulate feed intakes with supplements after calving.**

To manipulate pasture cover between calving and break-even, the options include:

- using **nitrogen fertiliser** during the first round of the farm in late winter/early spring to grow more pasture
- using **grain, pellets or high quality silage** as a means of reducing feed demand from pasture
- a combination of the above

Nitrogen fertiliser after calving can greatly increase pasture growth rate and decrease the need for a high APC at calving.

The decision is essentially one of assessing the size of the feed gap, taking expected responses into account and comparing the relative costs.

Achieving pre-calving targets

To achieve the target APC at calving, we need to manage the APC leading up to calving. Management decisions that affect pasture demand in late autumn and winter will influence the APC at calving. These include:

- Drying off dates and strategy (e.g. how many and when)
- Getting rid of culls/empty cows
- Use of nitrogen
- Wintering strategies
- Feeding of supplements to both milkers and dry cows

The pressure that farmers face at this time is the requirement to carry on milking to maintain cash flow and increase profitability. Milk responses to supplements can be good when pasture intakes are low or of low quality but these responses need to be offset against the cost of the supplements. Under tight circumstances it might be necessary to feed purchased supplements to the dry cows then it might pay to feed these to milking cows and to delay drying off.

Example:

Assume that baled silage costs $60 per bale. This equates to about 20 cents per kg DM for a 650 kg wet weight bale with a DM content of 45%.
Assume that pellets cost $400 per tonne. This equates to a cost of 45 cents per kg DM.

1. *Assume a daily DM intake for dry cows of 3kg silage, 1kg pellets and 3kg pasture. Cost of feed = (3*20)+(1*45) cents = $1.05 per day for no milk income. Essentially a loss.*
2. *Assume a daily intake of 13.5kg DM for milkers doing 1.0kg MS/day. DM intake of 5.5kg silage, 5kg pellets and 3kg pasture. Cost of feed = (5.5*20)+(5*45) cents = $3.35 per day. Milk income at $4.20 per kg MS = $4.20. Aside from other costs associated with milking this represents a gain of 85 cents per cow per day.*

N.B. The above calculations have not factored in feed needed to regain condition score.

When making the decision to milk on longer, the impact on next season's pasture cover at calving needs to be considered. **Constructing a feed plan or budget allows the effects of this decision on average pasture cover to be evaluated**.

If milking on means running pasture cover down to a level where target APC at calving cannot be met, a decision needs to be made between introducing a supplement in order to maintain APC at the desired level, or drying off some or all of the herd earlier.

Alternatively, the decision can be made to eat further into the APC whilst milking, but to reduce feed demand over the dry period through supplement inputs. This may involve

- wintering some, or all cows off
- nitrogen fertiliser
- purchasing more brought-in feed

Again, this decision essentially involves comparing the costs of the various options to the expected returns from the longer lactation.

The decision to use supplements - day to day level

Logical day-to-day management requires considering pasture growth, pasture demand and APC to determine how much feed can be consumed. This is then related back to what is in the paddock.

***Example**:* *It is January, and we have 300 cows running on 110 ha (2.7 cows/ha). The average pasture cover is 1800 kg DM/ha (grazing from 2100 kg DM/ha to about 1500 kg DM/ha). The cows are back to 20 litres/day and maintaining weight.*

The cows require 16 kg DM/day. The per hectare requirement is 16 x 2.7 = 43 kg DM/day. This is our break-even growth rate. The average pasture growth rate for January is 30 but because it is a bit drier, assume it will be 25 kg DM/ha/day. Thus, the difference between pasture growth and demand is 18 kg DM/day (43 - 25). This means that the APC will fall by 18 kg DM/day every day. If this went for 30 days the APC would fall by 540 kg DM (18 x 30) to 1260 and we are effectively out of feed. ***What do we do?***

Option 1: **Fill the feed gap with a supplement.**

We need 18 kg/ha of supplement (6.6 kg/cow) so over the whole farm we need 2000 kg DM (18 x 110) supplement to cut the pasture demand back to 25. If a roll of silage contains 250 kg DM, we need to feed eight bales/day or 240 bales for the month. Alternatively, we could feed other supplements, such as a combination of silage and grain.

If we feed this level of supplement we can also cut the grazing area back (i.e. extend rotation length). The cows are going into paddocks with 2100 kg DM on them and could graze down slightly harder to about 1400 kg DM. Thus, there is 700 kg DM/ha available. The cows need about 9 kg DM from pasture and so the 300 cows will need a total of 2700 kg DM per day. They will need 3.9 ha/day (2700/700), which means a rotation length of 28 days (110/3.9).

Option 2: **Reduce feed demand by restricting cows.**
It is possible to decrease the area cows get for a day **without** feeding supplement. This will cause milk production to fall and cows to lose condition - not the most desirable option.

Option 3: **Dry off some cows.**
Another more permanent option is to decrease demand by drying off problem cows, low producers or thin cows. **Other options include running the pasture cover down until, for example, a turnip crop is ready to graze, or a combination of all of the above.**

Note: We have not considered OAD options here. Typically OAD milking is not designed to reduce daily intake but to assist with gaining condition score. Less ME/cow/day is required for milk and exercise, which should result in energy being made available for condition recovery.

Choice of Supplement

There are a number of supplements that can be fed to dairy cattle. The decision to use a certain supplement is determined by a combination of factors, including:

- **The purpose for feeding the supplement** - is it to increase per cow production from the existing herd? Is it to increase cow numbers and per cow production? Is it to fill feed deficits? Is it to calve earlier or in a tighter spread? Is it to extend days in milk? Is it to change from a seasonal calving system to a split calving system? Is it to supply a limiting nutrient such as energy, protein, fibre, or a combination of all three? These could be limiting due to low pasture intake or poor pasture quality.

- **What supplements are available? What is their nutritive composition?**

- **What are the relative costs?**

- **What practical considerations should be taken into account** (i.e. facilities, machinery, labour, reliability of supply etc.)?

- **What nutritional considerations should be taken into account** (i.e. how will the supplement affect the ration balance? Could problems such as acidosis arise?)

In a pasture-based system, energy is normally the first limiting nutrient. **Therefore, in most cases, supplements should be compared on the basis of cents/MJ ME.** The lower the cost per Megajoule supplied, the cheaper the supplement. It is also possible to cost supplements on the basis of cents/g Crude Protein supplied, or cents/g Neutral Detergent Fibre.

Typical costs per MJ ME for a variety of feeds appear in Table 9.0.

Feed Type	MJ ME/kg DM	Cost (c/kg DM)	Cost (c/MJ ME)
Nitrogen-fertilised pasture (10:1 response)	11	14	1.3
Maize silage	10	16-20	1.6-2.0
Round bale silage (250 kg DM bales bought for $45)	8.5	18	2.1
Pit silage	8.5	8-14	0.9-1.6
Round bale hay (300 kg DM bales bought for $40/bale)	7.5	13	1.7
Barley at $180-$260/tonne (as fed)	12	20-29	1.7-2.4
Pellets at $250-$330/tonne (as fed)	12	28-37	2.3-3.1
Turnips - @ $600/ha with 75% utilisation, yield range 6-14t/ha	12	13.3 (6 t) - 5.7 (14 t)	1.1 (6 t) - 0.5 (14 t)

Table 9.0: Typical costs per MJ ME for a range of available supplements.
Source: Adapted from DPIF Intensive Pasture Management (In press)

In practical terms, the supplement with the lowest cost (c/MJ ME) may not always be available, or may not be feasible because of a lack of facilities/machinery/labour.

➲ **COSTING SUPPLEMENTS ON THE BASIS OF THEIR NUTRITIVE VALUE WAS DISCUSSED IN CHAPTER 4, AND WILL ALSO FORM PART OF THE RATION BALANCING EXERCISES WHICH APPEAR AT THE END OF THE MANUAL.**

Practical and nutritional considerations when using supplements

Choosing a supplement does not stop at identifying a feed source that supplies the right nutrient at the right cost**. Several practical and/or nutritional considerations usually complicate the issue.** These may be related to machinery, facilities and labour, such as the availability of grain handling and crushing equipment.

Alternatively, they may relate to the nutritional implications of feeding the supplement. For example, a feed plan may indicate a deficit of 10kg DM/cow/day, and cereal grain may be the cheapest supplement available in terms of MJ ME. However, from earlier chapters, we know that cows have requirements for fibre and crude protein, and that low fibre/high starch diets can lead to severe metabolic problems and a lower fat test. For this reason, we would avoid feeding a combination of 5kg DM as grass and 10kg DM as barley!

Some of these considerations are discussed below in relation to the most commonly used supplements.

Milk Response The milk response to supplement together with the cost of supplement is a key factor affecting returns to feeding supplements.

In theory on an energy basis the maximum response to feeding supplements can be calculated as follows:

Assume that the supplement contains 12.5 MJ ME/kg DM. About 80 MJ ME are needed for a Friesian to produce 1kg MS (C. Holmes and J. Roche, 2006). 12.5 MJ ME would therefore give 1000/80*12.5 grams of MS = 156 grams MS/kg DM. In practice a number of factors affect milk response. Wastage of feed, the way the animal partitions energy and substitution of pasture all reduce response rates.

A number of short-term experiments have demonstrated responses in the order of 30-60g MS/kg DM particularly when supplements are added to meet short-term pasture feed deficits in spring when pasture quality is high. In situations where supplements complement diets that are low in pasture quality and quantity, the responses can be in the 70-100g MS/kg DM range. When used to extend lactation when pasture intakes are low or of poor quality, responses as high as 140g MS/kg DM are possible.

The extra milk from feeding supplements may or may not be profitable.

Example:

*Assume an average response rate of 80g MS/kg DM for a supplement costing $400 per tonne delivered and with a DM content of 90%. The cost of the supplement on a DM basis = $400/(1000*90%) per kg = $0.44 = 44 cents/kg DM. The 80 grams of milksolids will return 34 cents at $4.20/kg MS. The feeding of the supplement would need to be justified on other grounds for it's continued use.*

Nitrogen Fertilised Pasture

Nitrogen fertiliser as a means of increasing pasture availability was discussed in the last chapter. To recap, **the average response which can be expected to Nitrogen fertiliser is an extra 10 kg DM for every kilogram of elemental Nitrogen applied**. However, if soil temperatures are below 4 C, responses are likely to be negligible. Higher responses would be expected in the peak of spring and also in summer, *providing that moisture is not limiting*.

A late July/early August nitrogen application of 46kg elemental N/ha (100 kg urea/ha) could therefore be expected to provide an additional 500 kg DM/ha. This could assist in reaching break-even APC targets, by increasing pasture availability post-calving.

Nutritional Considerations

Nitrogen use at the rates discussed in Chapter 8 is unlikely to produce adverse nutritional effects, however, to minimise risk:

- **Do not graze a pasture within 18 days of an application of N fertiliser, slightly longer if higher than recommended rates of N have been applied at peak season (early spring), or when using slower-release products**
- **Never allow hungry, unadapted animals unlimited access to nitrogen-fertilised pasture in spring or autumn.**

Practical Considerations

When considering nitrogen as a supplement, remember that:

- responses are better on paddocks with **higher fertility and better composition** (i.e. mainly ryegrass/clover)
- Nitrogen needs **soil moisture** to produce a growth response (not a problem in spring - but a consideration in summer)
- Nitrogen needs **time** - it is not an 'instant' supplement. Nitrogen needs to be used 4-6 weeks ahead of a potential feed gap. **Successful nitrogen use requires forward planning**. One of the benefits of feed planning is that it allows you to identify a potential feed gap and take action before it occurs.

Hay and Silage

The wide range in quality observed in silage and hay means that the suitability of these supplements for milk production varies considerably.

Silage and hay are commonly used to fill summer/autumn and winter feed gaps - essentially as a source of additional dry matter, and hence energy. They can also fill a specific requirement for fibre in certain situations. High quality silage can provide the additional protein and fibre needed to balance the feeding of low fibre/low protein feeds like turnips.

The most important nutritional consideration when feeding hay and silage is QUALITY. Particularly in early lactation, feeding silage and hay can depress intakes of Dry Matter. This is because, being fibrous feeds, they take longer to break down in the rumen, and so intake of additional feed is reduced. Low quality silage with a high NDF content will reduce intakes more than better quality silage.

In practice, the combination of high fibre and relatively low energy content in hay and most silages means that they are not suitable feeds for milking cows in early lactation, if the aim is to maximise nutrient intake.

However, if pasture availability and intakes are low, they are a means of increasing overall intake. **In this situation, they can also be a necessary source of fibre if used in combination with high levels of energy supplements such as grain.**

Maize silage generally has a higher energy content than pasture silage, averaging 10-10.5 MJ ME/kg DM. It is also low in crude protein and this needs to be taken into account if it is to be fed in combination with low quality pasture during dry summers.

Lucerne hay is occasionally fed to milking cows, and generally has a higher crude protein content than pasture hay or silage. The heat involved in the hay-making process means that more of this crude protein is in the undegradable form (UDP). However, as discussed in Chapter 3, supplementary UDP is generally considered unnecessary for pasture-based herds producing 30 litres or less. Therefore, the energy content and cost/MJ ME should still be the primary determinant when considering lucerne hay as a supplement.

Turnips

Summer fodder crops, usually turnips, have become widely used as part of pasture renovation programs in Tasmania in recent years.

Nutritional Considerations

Turnips are a common fodder crop, and have similar nutritional characteristics to barley. **Their ME levels are relatively high at 12.5-13 MJ ME/kg DM, and their protein and fibre levels are relatively low. In contrast to barley, they are a high moisture supplement (10-11% DM) and have a relatively high concentration of the macro-minerals Calcium, Magnesium, Sodium and Potassium.**

Protein is probably the major nutritional component of turnips that is inadequate for the dietary requirements of lactating cows. Trial work has demonstrated that applying nitrogen fertiliser to the crop after germination can increase crude protein levels in turnips. It is suspected that much of the additional crude protein produced is in the non-protein nitrogen (NPN) form, and the nutritional implications of this have yet to be fully investigated.

The low fibre and protein content of turnips is unlikely to cause problems unless turnips are fed in conjunction with high levels of cereal grain, when protein and fibre levels in the ration as a whole may be below requirements. This situation is worsened if only limited pasture, silage or hay is fed, particularly if it is of poor quality.

Silage is commonly fed in combination with summer turnips to provide additional dry matter, as pasture availability and quality is low on most dryland farms during this period. In practice, the combination of silage and summer pasture usually 'balances' the deficiencies of protein and fibre.

It is generally recommended that intake of turnips should not exceed 5 kg DM/cow/day (1/3 of the diet).

Practical Considerations

- Being a readily fermentable feed (like cereal grains), **turnips need to be introduced gradually** to milking cows to avoid digestive upsets and health problems. Survey work in Tasmania and Victoria has found that disease risk is higher during the period when the first 25% of the crop is grazed, **highlighting the importance of gradual introduction of brassica crops.**

Turnips should first be offered at about 2 kg DM/cow/day, and then built up gradually to the 5 kg DM level over 7-10 days.

- Cows can eat 5 kg DM of turnips in about 3 hours. During the first week, access time should be restricted.

- **To measure turnip yields**, mark out a square metre in the crop and pick all the turnips (tops and bulbs) in that square metre. Weigh tops and bulbs and record. Repeat several times to get a representative sample of the crop and average. The average wet weight in kg per square metre equates to the average yield in tonnes DM/ha. (**kg wet turnip/m^2 = t DM/ha)**

Example

For example, if the average wet weight of turnips per square metre is 10 kg, the crop averages 10 t DM/ha. This also means that each square metre contains 1 kg DM, as turnips are approx. 10% DM.

To allocate 5 kg DM, each cow needs 5 m^{2}.
If the crop was a 5t/ha crop, then each square metre would contain 5 kg wet turnips and 0.5 kg DM. To still allocate 5 kg DM/cow, each cow would then need 10 m^2.

- Check the electric fence unit to ensure good stock control.

- Watch out for bloat and choking on turnip bulbs. Other health problems which may occur when cows graze fodder crops include redwater, photosensitization and nitrate poisoning, but they are relatively uncommon.

- Utilisation of turnips is improved if cows graze the crop off from a long access face with a narrow strip of crop. Two faces are better than one wide strip in terms of minimising trampling and fouling. Using two faces also improves access for younger, smaller cows.

Concentrates

This section discusses the nutritional and practical considerations involved in feeding concentrates (grains and pellets), buffers and mineral pre-mixes.

Choosing a concentrate

As with any supplement, concentrates need to be compared on the basis of their cost and nutritive value.

Cereal grains and grain legumes (e.g. lupins) have a Dry Matter content of 90%, protein meals about 85%, whereas by-products such as brewer's grains are more variable.

When considering which grain, pellet or by-product to purchase:

1. First consider your options based on cost per tonne Dry Matter
2. Then consider **cost per unit of nutrient which is limiting**
3. **Consider the nutritional/practical implications of the supplement**

Example

If barley costs $220/tonne delivered, pellets cost $320/tonne delivered and oats cost $200/tonne delivered, which should I buy?

	DM%	Energy (MJ ME/kg DM)	Crude Protein	Cost ($/t) delivered	Cost fed*		
					c/kg DM	c/MJ ME	c/g P
Barley	90	12.5	11	220	27	2.2	0.25
Oats	90	11	9	200	22	2.0	0.24
Pellets	90	12	12	320	36	3.0	0.3

If energy is limiting, the first cost to look at is cost per unit of energy. **If protein is also limiting, you would look at both cost per unit of energy and per unit of protein.**

In this example, oats is cheaper per unit of energy and slightly cheaper per unit of protein. **It should be remembered that the nutritive value (ME and CP) of oats tends to be more variable than that of barley.**

Other specific farm-related issues to consider are:

- Can grain intake by individual cows be controlled? If intake cannot be controlled (e.g. no trough dividers), what is the risk of acidosis? What is the cost of controlling this risk?
- Is fibre in the diet a problem at this time of year? Would buffers (at additional cost) be needed?
- Is the equipment to mill the barley available on the farm?

Know how much concentrate your cows are being fed!

Many of us take for granted that we know how much grain cows are actually eating. **If you have in-shed feeders it is recommended that you check them at least once per year**. It is not uncommon for individual feeders to be a kilogram out when dispensing 4-5 kg of grain.

If acidosis occurs with only a few cows affected, check the feeders before you do anything else!

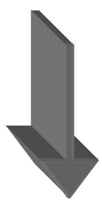
What is the risk of grain overload (acidosis)?

Rumen pH is a key factor in any discussion on acidosis. Acids produced during the fermentation of feeds high in readily digestible carbohydrates (e.g. grains) keeps rumen pH below 7.0. How far below neutral depends on the rate of production and total amount of acid produced, the rate of absorption of acids out of the rumen, and the amount of salivary secretion released to neutralise the acids. Dry cows are typically on high fibre forages and the rumen microorganism population adjusts to this diet. In addition the lower energy dry cow ration results in a lowered capacity for the rumen to absorb acids. If the cow is suddenly offered a high energy lactating ration comprising a high level of grains, she is at risk of developing rumen acidosis owing to the fact that the lactate producing bacteria respond quickly to the diet and produce large amounts of lactic acid. However those bacteria that utilise lactic acid respond slowly to the increased lactic acid levels. They require 3-4 weeks to cope with the lactic acid production. It is this time lag that sees a build-up of lactic acid in the rumen. It is not so much lactic acid on its own that is the problem but the total VFA production and the build up of these acids.

➲ **FOR MORE INFORMATION AN ACIDOSIS, SEE CHAPTER 6 (HEALTH AND REPRODUCTION)**

The risk of acidosis varies, depending on the grain being fed.

Greatest risk ***Wheat***



Triticale

Barley

Lowest risk ***Oats***

Processing of Grains

Can I feed whole grain or should it be rolled or milled?

In order to maximise digestion, and hence milk production responses, **most grains should be rolled or milled rather than fed whole.**

The exception is oats. **When fed at low rates (e.g. 2-3 kg/cow/day), the increase in milk production arising from feeding processed oats (as opposed to whole grain) is not economic.**

Processing can add $20-30/tonne to the price of purchased grain.

How finely/coarsely should grains be processed?

Cracking or milling grain into 3-4 pieces is sufficient. It is not uncommon to see some grain in the manure of cows fed grain once or twice a day**. Finely grinding grain is counter-productive** - you may not see grain in the manure, but fibre digestion in the rumen will be reduced.

Regardless of whether you have a hammer or roller mill, grain of the right consistency can be obtained by varying either the screen size or the roller settings.

Introducing grain/concentrates to cows

In cows fed grain after calving, many gut upsets are due to too much concentrate being introduced too quickly. If relatively high levels (e.g. 5-6 kg/cow) are to be fed post-calving, consider feeding a small quantity (1-2 kg/cow/day) during the 2-3 weeks prior to calving *if practical*. This 'lead feeding' allows the rumen bacteria time to adapt to the concentrate, hence diets can be changed more readily after calving.

If only 2-3 kg of grain (or less) are to be fed after calving, feeding prior to calving is probably not warranted.

If introducing concentrates during lactation, do so gradually. The speed at which concentrates can be introduced depends on:
- the type of concentrate
- the quantity to be fed
- whether the cows can 'steal' grain from each other
- whether a buffer is included or not.

If in doubt, err on the side of caution! Start at 1-2 kg/cow/day and increase by about 0.5 kg/day.

Buffers	***What is a buffer? Should I add it to grain?***
Definition	*A general term applied to additives that minimise fluctuations in rumen or intestinal pH (i.e. level of acidity).*

Cows produce a natural buffer in the form of saliva. When low fibre and/or grain diets are fed, the production of saliva may be reduced due to a lower fat content in the diet and less rumination (cud-chewing). The result is that rumen pH falls are not buffered as effectively as with diets higher in fibre. In order to maintain rumen pH and thereby help prevent a reduction in milk fat, buffers can be used. There have been widespread studies on the use and efficacy of dietary buffers for dairy cows. What is interesting is that responses to feeding buffers range from some to none. There is a lack of a strong relationship between feeding buffers and the acid-base status and there is little support that these compounds actually function as ruminal or metabolic buffers.

In general, however, buffers will be of greatest benefit to the cow:

- during early lactation
- when large amounts of rapidly fermentable carbohydrates are fed
- when cows are fed at infrequent intervals
- when maize silage is the major forage feed in the diet
- when concentrates and forages are fed separately
- when particle size of the total diet has been reduced to the extent that chewing activity is reduced
- when the milk fat test is low
- when the NDF of the ration is lower than recommended.

The common buffers used by the dairy industry appear in Table 9.1.

Buffer type	Action	Level to use
Sodium Bicarbonate (Bicarb)	* alters rumen pH	* **add to grain at 1.0-1.5% (10-15 kg per tonne of grain)** * Higher levels can be unpalatable to stock, and may reduce grain intake
Magnesium Oxide (Causmag)	* alters rumen pH * has a specific action on udder metabolism increasing the uptake of fatty acids * source of magnesium to prevent grass tetany	* **add to grain at up to 1% (10 kg per tonne**) * as there is an association between high levels of magnesium oxide and Salmonellosis in dairy cattle, **the total amount fed in grams/cow/day should not exceed label recommendations**
Combination of Sodium bicarbonate and magnesium oxide		* A combination of these two additives can be used. The recommended rate is 1.5% sodium bicarbonate and 0.8% magnesium oxide (15 kg sodium bicarbonate and 8 kg

		magnesium oxide per tonne of grain)

Table 9.1: Buffers and their recommended inclusion levels

When do I add buffers?

> *If feeding 5 kg/cow/day or more of cereal grain, consider using a buffer.*

If you feed slightly smaller quantities of grain, but:

- grain intake cannot be controlled, i.e. cows can steal grain from each other

then a buffer is also recommended.

Minerals

Do I need to worry about minerals if I feed grain?

From earlier chapters in this manual, we have seen that macromineral levels in well-managed ryegrass/white clover pastures can fulfil most of the requirements of pasture-based cows, providing that intakes are sufficient. Some marginal dietary deficiencies may arise from time to time, but the cow has mechanisms (such as mobilisation from bone reserves) which allow her to cope with these periods.

However, if pasture mineral levels are marginal-low and/or pasture intakes are low, **feeding high levels of cereal grains can aggravate the problem. This is because cereal grains are low in most minerals**.

If feeding high levels of grain, a mineral supplement containing additional Calcium and Phosphorus, such as DCP, may be required.

This point is illustrated in Table 9.2.

Example

Two cows at differing levels of production, on the same pasture. Mineral levels are taken from those in perennial ryegrass/white clover pasture over spring-summer at Elliott Research and Demonstration Station. ***Note that these levels are not intended to be representative - they are used for example purposes only.***

To illustrate how high grain levels can 'tip the balance' in terms of minerals, the 'high producing' cow represents an extreme. She is assumed to be eating 5 kg barley as well as 14 kg DM/day pasture - a high level of intake that would not always be achieved by the 'average' Tasmanian cow.

	'Medium' producing cow eating 15 kg DM/day pasture			'High' producing cow eating 14 kg DM/day pasture + 5 kg barley		
	Recommended allowance	From Diet	Difference	Recommended allowance	From Diet	Difference
Macrominerals (g/day)						
Phosphorus	**57**	**48**	**-9**	**72**	**59**	**-13**
Calcium	**90**	**86**	**-4**	**114**	**83**	**-31**
Magnesium	30	37	7	38	48	10
Sodium	27	78	51	34	74	39
Sulphur	30	51	24	38	48	10
Potassium	155	349	214	171	346	175

Table 9.2: Example of grain feeding changing the balance between mineral supply and demand.

Note that Phosphorus and Calcium levels are 'marginal' for the medium producing cows on pasture only, and are likely to be made up by mobilisation from the skeleton whilst this level of production is maintained.

When barley is eaten by the high producing cow, the marginal supply is compounded.

As discussed in previous chapters, the requirements for minerals and trace elements vary between farms, and are complicated by a number of factors unique to individual farms, such as known trace element deficiencies.

However, it is important to be aware of the potential for high levels of supplementary feeding to alter the herd's mineral requirements.

What to look for when purchasing a mineral mix or pre-mix?

If purchasing a mineral mix or pre-mix, consider:

* **Form**, i.e. is it available in loose or pelleted form
* **Composition** (what does it contain)
Price per cow per day (determined by cost per bag, bag weight and the rate fed per cow)

Form - loose vs pelleted minerals

Pelleted mineral mixes or pre-mixes are generally more expensive than those available in the loose form.

If you don't have a mineral dispenser as part of your feeding system, however, pelleted pre-mixes are the only way to ensure that every cow receives the mineral mix. In some feeding systems, additives 'fall out', resulting in high mineral levels at the first hopper and almost negligible levels at the last.

Composition

Take care when reading the label - BUYER BEWARE.

Are the quantities of trace minerals sufficient if the farm has a known trace mineral deficiency and you are relying on the mix as the only form of supplement? Does the price include Rumensin? If feeding high levels of grain, does it contain enough calcium? Does it contain a buffer in the required quantity?

A wide variety of mineral mixes and pre-mixes are on the market. For example, some of these mixes have been formulated for dairy cattle fed high levels of grain and contain significant quantities of added calcium and phosphorus, whereas other mixes are more suited to cows grazing predominantly pasture-based diets.

'Topping up' a mineral mix with substances such as Di-Calcium Phosphate (DCP), Sodium bicarbonate, Causmag or additional trace elements can be expensive, so it is worth doing the sums before making the selection.

As minerals are present in all feeds, it is *not* essential that the mineral additive contains 100% of the recommended daily allowance for any given mineral.

Price

The dangers of looking at price alone ($ per bag) are no different to those discussed previously when comparing grain prices.

Example

Details of two mixes are given below. Both contain similar levels of the macro-minerals and the major trace elements.

	Mix A	**Mix B**
Price per bag ($)	29.00	20.50
Bag weight (kg)	40	25

At first glance, Mix A appears to be a good buy based on price per bag and bag weight. **However, the mineral mixes are added to grain at different rates**. The rate per cow and resulting prices are shown below.

	Mix A		Mix B	
Grain fed	*Rate/cow*	*Cost/cow*	*Rate/cow*	*Cost/cow*
2 kg/cow/day	80g/day	5.8c/day	50g/day	4.1c/day
6 kg/cow/day	240 g/day	17.4c/day	150g/day	12.3c/day

When grain is fed at 2 kg/day, the difference in cost is less than 2 c/cow/day. This increases to more than 5c/cow/day when 6 kg of grain is fed.

Although their composition is similar, Mix A is in reality more expensive than Mix B.

Using a mineral mix or pre-mix, plus bullets/other additives

If you use copper, cobalt or selenium bullets, or other additives, check the quantity of minerals supplied by **all** sources.

Some mixes and pre-mixes supply 100% of the recommended daily allowance, and if another source of the same mineral is supplied via an additive or bullet, feeding the pre-mix can lead to mineral imbalances.

Making your own 'home brew' - be careful and seek advice

If you prepare your own mineral mix, know what you are doing and why. Add the individual minerals according to label specifications, or seek nutritional advice.

Resist the temptation to add unused portions of bags to the mix. If the label recommends one bag to the tonne and you have a 2.5 tonne mixer, add 2.5 bags, not 3 'just to get rid of it'!

Some minerals absorb moisture and will form clumps if not stored in sealed bags. **Break these lumps up BEFORE adding to the grain, as they are usually not broken up during mixing**.

Feed additives

An increasing number of additives are coming on to the market.

If you want to try an additive, FIRST FIND OUT WHAT IT CONTAINS, AND HOW IT WORKS. That way you'll know whether it is appropriate for your situation, and when is the most appropriate time to try it in your herd. If you want to use a number of additives, find out whether their modes of action will complement each other.

When using additives, use at the recommended rate. MORE IS NOT NECESSARILY BETTER, and less may be the difference between a response and no response. As for mineral mixes, additives which come in a pelleted form are more readily handled, unless you have in-line dispensers.

Additives are generally used to 'fine-tune' nutritional management**. They are not a solution to poor nutrition. Additives may only cost 'a few cents per day', BUT THE CENTS ADD UP!**

Ionophores

Ionophores such as Rumensin (monensin) function as antibiotics and affect what are known as gram-positive bacteria. The aim is to promote populations of useful bacteria and in consequence metabolic performance and responses to feed. The result is the shift in the end-products of fermentation in the digestive system. The effect of a reduction in methane production and an increase in the proportion of propionic acid is to increase the net energy content of the feed. Studies have claimed that these compounds can increase milk production, prevent ketosis, reduce the incidence and severity of bloat and increase milk protein production.

Generally, additives should only be considered
after *energy, protein, fibre or known mineral deficiencies*
are addressed, ***not before***

Balancing a Ration

Earlier sections in this chapter have discussed the decision to use supplements, and how it is necessary to cost supplements in terms of the nutrients which need to be supplied. The range of practical and nutritional considerations which affect the choice of supplement have also been discussed. **It is now necessary to make sure that the proposed combination of pasture and supplements will meet cow requirements, by 'balancing' the ration.**

Ration balancing or formulation is simply a means of meeting financial and production goals by supplying the specific requirements of the herd in the most economic way.

Ration formulation should be seen as the next logical step in the feed planning process, after initially weighing up pasture cover, pasture growth and herd requirements. It should not be viewed in isolation from pasture feed planning.

To check whether the ration is balanced, we need to know

1. **What we need -** the nutrient requirements of the cow or herd
2. **What we have available -** the quantity and quality of feed on hand

In a pasture-based system, there will always be a certain level of inaccuracy when attempting to balance a ration, as the nutrient composition of the pasture cannot be measured on a day-to-day basis.

The most limiting nutrients in most diets are energy, protein and fibre (in order of importance). Therefore, if production is reduced or metabolic problems occur, these are the first nutritional factors that need addressing. Other factors such as mineral deficiencies can play a major role in production and health, but as requirements vary for individual farm situations, it is recommended that specific advice be sought when dealing with suspected imbalances in the ration.

For most practical purposes, ration formulation should be used to check that the basics (energy, protein and fibre) are present in adequate quantities for the level of production that you expect. For simplicity, the Exercise 9.0 deals with these nutrients.

Exercise 9.0 – Page 120

Calculating a ration at the individual cow level and on a day to day basis is only the first step. **In practice, it is necessary to multiply the quantity of supplement required per cow per day by the number of cows in the herd and the number of days of supplementary feeding, to obtain the total supplement requirement.**

The total requirement for supplement over the period of feeding needs to be budgeted against how much supplement is on hand or how much it is possible to purchase.

If supplement supply cannot meet demand, it is time to consider changing the level of demand - i.e. reducing cow requirements. This could be achieved by reducing numbers (drying off culls).

If we were confident that pasture growth rates were going to increase, we could take the option of feeding more pasture, and hence reducing the requirement for supplement. If pasture growth rates stayed the same or decreased, however, we would have eaten into the APC by the time the turnips were ready to graze, and it is likely that additional supplement would still be necessary.

Daily feed planning, ration balancing and seasonal feed budgeting are only useful as management tools when they are re-assessed on a regular basis. Plans need to be updated to take variations in growth and requirements into account

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Using the ration balancing sheets for ‘trouble-shooting’

Earlier chapters have discussed how nutrition can affect milk production, milk composition and herd health.

If problems such as low milk fat test, low protein test or acidosis arise, the Ration Balancing sheets can be used as a checklist to ensure that levels of energy, protein and fibre in the ration are adequate.

10. Interaction of Higher-Cost Feed Options with Pasture - Implications for Farm Profitability

The profitability of using supplements, including agistment, fodder crops and nitrogen as well as conserved fodder and concentrates, is a contentious issue. Unfortunately, there is no simple answer and no single 'recipe' which will produce a profitable result for every farm. Responses to supplementary feeding need to be considered in the longer-term to evaluate their true impact on farm performance and profit.

This chapter briefly discusses the factors which affect responses to supplementary feeding, the vital role of pasture utilisation in determining farm profit, and some of the implications of increasing supplement usage.

Factors affecting responses to supplementary feeding

When responses to supplements are discussed, it is generally assumed to be in relation to concentrate feed inputs. However, the use of any supplement is usually intended to have some effect on production, cow condition or pasture availability.

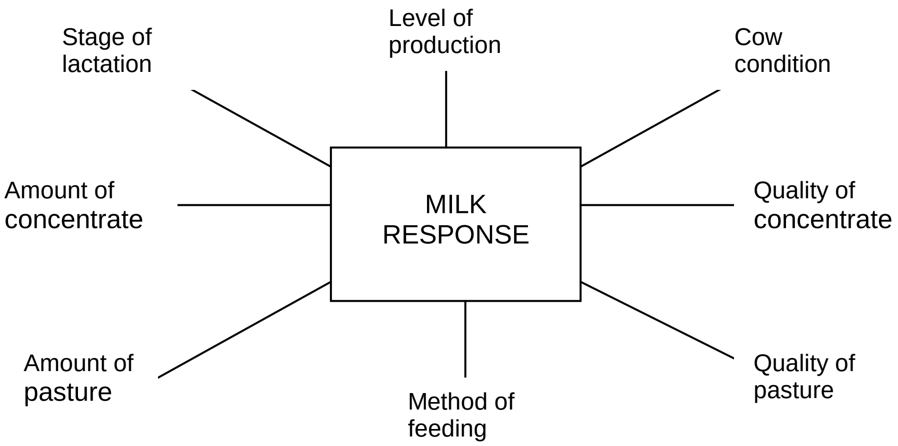
These effects can be difficult to evaluate because they may not appear immediately as profit. In the short-term, response to supplement inputs may be marginal, but if the supplement is used to 'carry the herd over' to a period when pasture availability improves or a lower-priced supplement (such as a crop) enters the system, it may eventually produce a profitable result.

The economic impact of supplements can only be assessed in relation to the overall farm feeding system

Whilst the profitable implications of supplements need to be considered in the longer-term, it is still important to be aware of immediate responses, as it is the short-term response which impacts on cash flow.

Responses to concentrate feeding have been studied in numerous trials, but these have produced widely varying results due to the complex interaction of factors seen in Figure 10.1.

Figure 10.1. Some of the many factors which influence the responses of dairy cows to supplementary feeding.



What response *should* 1 kg of concentrate produce?

1 kg of concentrate has enough metabolisable energy (12 MJ ME) for a little over two litres of milk.

However, the majority of Australian trials have indicated poor immediate responses, ranging from 0.4-1.3 litres of milk per kg concentrate fed.

Where do the losses occur?

By the time you consider **substitution** of pasture for the supplement and the **inefficiencies of converting body fat to milk** it is not surprising that theoretical responses to concentrate do not materialise.

However, many of these results are generated from short-term feeding trials. **The carryover effects of feeding are generally not taken into account, namely:**

1. Improved condition, leading to higher production in early lactation and improved reproductive performance
2. Higher post-grazing residuals. *Remember that higher residuals can have both positive and negative effects on pasture regrowth and quality.*

What response can be expected in practice?

A 'rule of thumb' response to feeding supplement is '0.5 litre milk immediately and 1.0 litre next lactation for moderately fed cows'. *However, this ranges from 0 litres (for cows eating plentiful high quality pasture) to 2 litres (1+ litres immediately + 1 litre next lactation) for severely underfed cows. Of course this relies upon the underfed cows being well fed in the next lactation.*

Judging from the results of numerous trials, the level of pasture availability seems to play a major role in determining the response to supplements. The reason for this is SUBSTITUTION.

How Substitution affects responses to supplements

Substitution was discussed in Chapter 8. **Essentially, it is the reduction in pasture intake that occurs when cows are fed supplements**. Note that substitution is not confined to concentrate feeding situations - silage and hay and fodder crops can also produce a substitution effect.

The net effect of substitution is to reduce overall Dry Matter intake. This means that milk production responses to concentrates are less than would have occurred had pasture intake been maintained, with the supplement as an additional 'bonus' on top.

Substitution is something that most people who feed supplements know about. *However, very few of these people believe that they see the negative effects of substitution on their farm, namely wasted feed.*

Substitution is widely regarded as a tool that can be used to create a higher post-grazing residual during periods of high feed demand, such as early spring. These higher residuals (1450 – 1600 kgDM/ha) can improve pasture recovery from grazing by increasing the rate of regrowth.

Like responses to supplements, the impact of substitution needs to be examined over the longer-term. Monitoring pasture utilisation from season to season gives an indication of whether supplements are being used effectively, or whether substitution is causing a reduction in overall pasture utilisation.

Pasture utilisation was calculated for each year of operation of the 'High Input Farmlets' trial conducted at Elliott Research & Demonstration Station 1994 -1996. Figures for the two Irrigated farmlets are presented in Table 10.1.

		Irrigation Grain	Irrigation No Grain
Stocking Rate (cows/ha)		3.4	3.4
Grain Input/ha		1700 kg (500 kg/cow)	0
Estimated Pasture	**1994/95**	**12.5**	**13.3**
Utilisation	**1995/96**	**12.5**	**13.4**

Table 10.1. Pasture utilisation on Elliott Research and Demonstration Station Irrigated farmlets.

These figures indicate that the grain supplements were **not** being effectively used to increase pasture utilisation. This is not surprising, given that the stocking rates are the same on the two farmlets. **Instead, it appears that a considerable amount of substitution is occurring.**

Therefore, it is also not surprising to discover that the average milk response to supplements on these farmlets ranged from 0.5-0.7 litres/kg grain fed, which at prevailing milk and grain prices did not produce a profitable result.

Increases in concentrate inputs without increases in stocking rate are all too frequently associated with a decline in pasture utilisation.

From the Elliott trial results, it appears the increase in per cow production from cows stocked at the same level but fed concentrates HAS NOT covered the cost of feeding the supplement. **Extra feed inputs need to be matched by extra feed demand if they are to be used effectively.**

The impact of additional feed inputs on profitability

The example below demonstrates the effect of increasing supplementary feed inputs *without increasing pasture utilisation* on farm profitability. **Although it is not based on Tasmanian figures, it is still a useful example, because it illustrates changes over a six-year period, as opposed to taking a short-term approach.**

Example *These figures relate to the 36 ha Swan Hill Irrigation Research Farm. Changes in management and their effects on farm profit over six seasons are detailed in Table 10.2.*

Season	**1985-86**	**1986-87**	**1987-88**	**1988-89**	**1989-90**	**1990-91**
Maximum Herd Size	104	105	112	126	135	143
Stocking Rate (cows/ha)	2.9	2.9	3.1	3.5	3.75	4.0
Total kg MF	18936	18408	20267	25435	25872	31000
kg MF/ha	526	511	563	707	719	860
kg MF/ha from pasture	407	368	352	473	530	625
kg MF/cow	182	175	181	202	192	215
Supplements						
Grain (t)	42	60	110	138	95	170
Hay (bales)	3000	3000	3000	2262	2900	1500
Nitrogen (t)	8	6	10.5	22.4	22.5	22.5
Pasture Utilisation	7.4	6.8	6.5	8.3	9.6	11.3
Profitability relative to base year (85/86)	**0**	**-14%**	**-15%**	**+36%**	**+54%**	**+98%**

Table 10.2: Effects of additional feed inputs over a six-year period.
Source: Dairying and Feed Supplements - how they fit together (1991)

What does this example show?

1. In the first three years, there was an 8% increase in cow numbers with a 160% increase in the amount of supplement fed. Pasture utilisation dropped (attributed to substitution), as did profitability
2. Over the next three seasons, supplement inputs increased, **but so did cow numbers**. Overall, production per hectare and per cow increased. Pasture utilisation and profitability also increased
3. It was concluded that feeding supplements was most profitable when used to carry more cows, which in turn allowed more pasture to be eaten.

The importance of pasture utilisation in determining the profitability of feeding supplements

Why is pasture utilisation so important?

Partly because pasture based dairy farms will only continue to be viable if the cost of feed produced on those farms is at lower cost than purchasing feed off farm. In other words, the feed which forms the basis of the production system needs to be the cheapest source available. **The effective cost of this feed is determined by its utilisation.**

Consider the costs of growing pasture. There are the variable costs, such as fertiliser, seed and irrigation water that are under management control. There are also fixed costs associated with owning the land that you are using for dairy production. These costs will obviously vary depending upon land value, etc.

As a feed source, however, we are not interested in the cost of growing pasture. **Instead, we need to identify the cost per kg of Dry Matter which is eaten by the cow, much as we can calculate the cost per kg of Dry Matter for purchased supplements. In reality we actually need to identify the costs per energy unit (MJME) as this is the only true way to compare feed costs.**

The total costs associated with pasture production need to be divided by the quantity of Dry Matter consumed to obtain an indication of the cost per kg DM UTILISED**. Obviously the higher the utilisation, the lower the cost in c/kg DM of the feed**.

This is illustrated in Table 10.3.

Pasture Utilisation	Total Cost (Variable + Fixed) of Pasture Utilised (c/kg DM)
9300 kg DM / ha (dryland)	12.3
12500 kg DM / ha (irrigated)	11.6
13500 kg DM / ha (irrigated)	10.7

Table 10.3. Effect of increasing pasture utilisation on the effective cost of pasture per kg DM, based on the Elliott Research & Demonstration Station farmlets.

Efficiency of pasture use vs herd production efficiency - striking a balance

You may recall from Chapter 5 how the efficiency of cow production increases at higher levels of production, as proportionally less of the cow's nutrient intake is being spent on maintenance, and more of the feed provided is used for production.

To achieve this level of performance efficiency, high nutrient intakes are necessary. **As previously mentioned, this initially appears to conflict with the aim of increasing profit through maximum efficiency of pasture utilisation**.

Maximising pasture utilisation means matching pasture demand to pasture availability, usually through higher stocking rates. This impacts on the cow's ability to achieve high intakes and high levels of cow performance.

To strike a balance between efficiency of pasture use and efficiency of cow production, we need to achieve moderate to high levels of per cow production whilst maintaining high pasture utilisation. **The strategic use of supplements at critical times plays a major role in creating this result**.

Supplements will not increase the amount of pasture eaten on a day to day basis. In fact, as has already been discussed, substitution can produce the opposite effect. **However, strategic supplement use during pasture deficit periods can increase overall utilisation by allowing you to have more mouths during surplus periods**. It can also increase utilisation and increase cow production efficiency through sustaining a longer lactation.

The profitability of the final result will depend upon the cost of these supplements and the response that results from their use. **Low-cost supplement options that can produce the same result as higher-cost options will improve the bottom line.**

The lowest-cost supplements will vary from farm to farm, however, as discussed in Chapter 9, they will often be those that require forward planning, such as nitrogen or fodder crops.

The more that the farm is 'geared up' to run at higher stocking rates and high levels of per cow production, the more important feed planning becomes.

Increasing supplement use - other implications for profitability

Capital Investment The capital which is invested in machinery such as grain feeding systems, silage-making equipment, etc. represents the 'hidden cost' of supplementary feeding.

Surveys conducted in the Circular Head region during the 1990's revealed that the capital invested in grain-feeding equipment ranged from $1200 for simple troughs to $30 000 for systems incorporating silos, roller mills, mixers and feeders.

The average capital cost of the more extensive systems was $18633, which, assuming depreciation at 10% per year, means that the average annual cost of owning this equipment was $1863.

The average level of throughput amongst those surveyed was 58 tonnes per year. At this level, the capital cost could add $32 per tonne to the cost of grain, before the variable costs associated with milling and mixing grain are included. Obviously as more feed is fed the capital cost per tonne will fall.

Exposure to risk **The more reliant the farm is on purchased supplements, the more it is exposed to fluctuations in the price of these supplements**. To compound the situation, these increases in the cost of supplement generally occur in poorer seasons when the reliance on supplements is higher than usual.

Labour As mentioned above, increasing supplement inputs requires a higher level of planning and managerial input to produce a profitable result. Where higher stocking rates mean larger herds, labour requirements are also increased.

Another factor which is often overlooked is the additional labour required to handle the extra feed inputs, i.e. more time spent milling grain or feeding out in the paddock. Even making the decision to agist out cows and heifers or lease a run-off block means additional time spent travelling to check stock.

In summary, responses to supplements depend upon four main factors:

1. Physical losses of supplement
2. Substitution rate (SR)
3. Partitioning of nutrients to liveweight (and to maintenance if extra cows are carried)
4. Supplement quality

   (Holmes & Roche)

Physical losses of supplement

Energy is often lost in the harvesting, transport, storage and feeding out of supplements. This can have a big impact on milk responses, as less energy is available. For silage the losses during harvesting, fermentation and feeding out can be up to 50% of the total original energy. Poor storage conditions and poor feeding out methods can also cause similar losses with concentrates. Care should always be taken to ensure that the energy available in a feed is adequately captured otherwise the true cost of the energy fed may be more than another feed that originally appeared too expensive to consider.

Substitution rate

Generally substitution rates are highest and milk production responses lowest, at high pasture allowances coupled with low quality supplements. Even when good quality supplements are used there will always be an element of substitution. Substitution can be managed and can even be used as a tool to aid in overall pasture utilisation.

Partitioning of nutrients

During short term experiments the mobilisation of body tissue in early lactation and the amount of energy partitioned to gaining liveweight will influence the milk response to supplements. Feeding supplements to low genetic cows with low body condition scores will inevitably result in energy being diverted from milk production to weight gain, this may not be true of high genetic merit cows. There is evidence that cows of high genetic merit have a greater drive to produce milk at the expense of weight gain. These cows may not be as suitable for pasture only systems as their energy requirements are higher than that offered in a competitive stocking rate on a pasture only system.

Supplement quality

Pasture of good quality will provide all the basic nutritional requirements for milk production. As the genetic ability of cows to produce milk has increased, it is possible that pasture levels of minerals such as magnesium, calcium and some trace elements may now be limiting production. While this may only affect high performing cows it should be recognised that certain times of the year pasture quality may limit production and the judicial use of supplements may be warranted to maintain production. As in all cases the cost of the supplements provided should be balanced against the value of the milk produced and any effects upon cow condition.

Exercise 3.0

What are the daily energy requirements of these cows?
The first one is done as an example.

COW DETAILS							
Size (kg LW)	**500**	**550**	**400**	**600**	**500**	**500**	**500**
months Pregnant	**7**	**Empty**	**6**	**9**	**7**	**7**	**Empty**
Daily milk prod'n (litres)	**13**	**27**	**18**	**0**	**13**	**13**	**13**
Fat Test(%)	**4.4**	**4.0**	**5.2**	**-**	**3.6**	**3.4**	**3.4**
Protein Test (%)	**3.4**	**3.2**	**3.6**	**-**	**2.6**	**3.4**	**3.4**
Lwt gain or loss (kg/day)	**+0.5**	**-1.0**	**0.0**	**+2.0**	**+1.0**	**0.0**	**+1.5**
ENERGY REQUIREMENTS (MJ)							
Maintenance & pregnancy	**64**						
Milk Production	**74**						
Weight gain or loss	**17**						
Total energy requirements	**155**						

What intakes of Dry Matter could these cows achieve on a daily basis?
(Hint: refer to table of potential Dry Matter intakes, page 19)

COW DETAILS							
Size (kg LW)	**500**	**550**	**400**	**600**	**500**	**500**	**500**
months Pregnant	**7**	**Empty**	**6**	**9**	**7**	**7**	**Empty**
Daily milk prod'n (litres)	**13**	**27**	**18**	**0**	**13**	**13**	**13**
Potential Dry Matter Intake	**13**						

What must the energy content (or energy density) of this Dry Matter be if the energy requirements you worked out above are to be satisfied?

Total energy requirements	**155**						
Potential Dry Matter Intake	**13**						
Energy density in MJ ME/kg DM (divide requirements by DMI)	**11.9**						

Exercise 3.1

List the Crude Protein and Neutral Detergent Fibre requirements for each level of milk production. Then calculate what this percentage equates to in kilograms. The first one is done as an example.

Daily Milk production (litres)	Dry Matter intake	% Crude Protein Required	Kgs of Crude Protein required	% Neutral Detergent Fibre required	Kgs of NDF required
26	15	20	3.0	25	3.75
35	18				
33	16				
20	14				
0	10				

Exercise 5.0

How will these dietary changes (some fairly extreme!) affect milk production, fat and protein test, and body condition? Will they go up, go down or stay the same?

Mark each of the factors below with a (↑) *if you think they will increase, a* (↓) *if you think they will decrease, or a* (→) *if you think they should stay the same.*

1. Lift wheat from 1 kg to 4 kg per cow suddenly, whilst on spring pasture:

Litres: *Protein kg:*

Fat kg: *Protein test:*

Fat test: *Body Condition:*

2. Cows on average quality summer dryland pasture, availability is declining, so 1 kg barley is introduced and built up slowly to 2.5 kg:

Litres: *Protein kg:*

Fat kg: *Protein test:*

Fat test: *Body Condition:*

3. Cows are on limited quantities of irrigated pasture, receiving 5 kg DM turnips each day, plus 2 kg grain. Silage is introduced:

Litres: *Protein kg:*

Fat kg: *Protein test:*

Fat test: *Body Condition:*

Exercise 9.0

This exercise is an extension of the feed planning example. To devise your feeding strategy, you will be presented with a choice of possible supplements, of varying nutritive value and price.

Recall that the example farm has 300 cows running on 110 ha (2.7 cows/ha). It is early January, and the average pasture cover is 1800 kg DM/ha. The cows are back to 20 litres/day and maintaining weight. The aim is to maintain this production level.

The herd's requirement in terms of Dry Matter was higher than the pasture growth rate of 25 kg DM/ha/day. To avoid running the pasture cover down, the decision was made to introduce supplements, so that the demand from pasture was reduced. It was hoped that by feeding supplement for the next 3 weeks, pasture availability would be maintained at reasonable levels until turnips are ready to be fed. Depending on growth rates, the turnips should be able to substitute for some of the supplement later on.

If the growth rate is 25 kg DM/ha/day over the farm and we are trying to maintain pasture cover at 1800 kg DM/ha, the herd's demands in terms of pasture Dry Matter per day can be no higher than 25 kg DM/ha/day. ***If we are running 2.7 cows/ha, this means that we can offer 9 kg DM/cow/day as pasture.***

Having reduced the area available to the cows (slowed the rotation) we will need to introduce supplements to maintain milk production and cow condition. ***As Dry Matter Intake is restricted, the first nutrient we need to address is ENERGY****.*

Step 1 - Choose your supplement or combination of supplements, based on cost/MJ ME.

You have a choice of supplements of varying availability, price, and quality. **Compare their cost per unit of energy and work out which supplement(s) best suit your needs**.

FEED:

						(A)
[ ]	÷	[ ]	÷	[ ]	=	[ ]
Total cost of feed ($)		kg's of feed for price		DM% / 100 *(=DM% ÷ 100)*		$/kg DM

Cost per MJ ME

				(B)
[ ]	÷	[ ]	x 100 =	[ ]
(A)		MJ ME/kg DM		cents/MJ ME

FEED:

	÷		÷		=	(A)
Total cost of feed ($)		kg's of feed for price		$\frac{DM\%}{100}$ *(=DM% ÷ 100)*		$/kg DM

Cost per MJ ME

	÷		x 100 =	(B)
(A)		MJ ME/kg DM		cents/MJ ME

FEED:

	÷		÷		=	(A)
Total cost of feed ($)		kg's of feed for price		$\frac{DM\%}{100}$ *(=DM% ÷ 100)*		$/kg DM

Cost per MJ ME

	÷		x 100 =	(B)
(A)		MJ ME/kg DM		cents/MJ ME

Step 2. What are the cow requirements?

Average cow liveweight is 500 kg, and cows are maintaining weight. As yet, they do not have a significant requirement for pregnancy.

Milk production is currently averaging 20 litres/cow, at 4.2% fat and 3.2% protein.

Calculate the daily requirement in MJ ME on the **ration balancing worksheet.**

Step 3. Meeting the daily requirements for MJ ME.

The first step is to fill in the pasture section on the ration balancing worksheet. Just fill in the Energy section to calculate how many MJ ME the pasture is supplying.

Recall that pasture intake is 9 kg DM/cow/day. Assume that the average quality of this pasture is 10 MJ ME/kg DM, with a Crude Protein level of 18% and NDF% (fibre %) of 35%.

This is the base feed supply. Compare the MJ ME supplied by the pasture with the cow's daily energy requirements. **What is the daily shortfall in MJ ME?**

Based on the nutritive value of your supplement(s), decide how many kilograms of supplement Dry Matter you need to feed to meet this energy shortfall.

Fill in the Energy section for each supplement. Then total the MJ ME supplied by all feed sources to make sure that energy intake is high enough to sustain the desired level of milk production.

Step 4. Checking Crude Protein levels

Fill in the protein sections for the pasture and supplements as directed on the ration balancing sheet.

Add up the total intake of protein as directed and divide by the total Dry Matter Intake to calculate the percentage of protein in the diet as a whole.

Check whether this protein level will meet requirements.

Step 5. Checking NDF levels

Fill in the NDF sections for the pasture and supplements as directed on the ration balancing sheet.

Add up the total intake of NDF as directed and divide by the total Dry Matter Intake to calculate the percentage of NDF in the diet as a whole.

Check whether this NDF level will meet requirements.

You have just formulated (and hopefully balanced!) a ration!
