Realistic Rations

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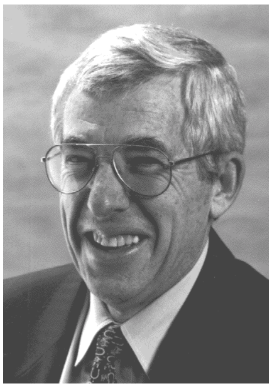
Foreword



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Dairying is one of the most progressive rural industries in NSW. This is evidenced by substantial changes in herd sizes and increases in production by cows and from farms.

An outcome of these increases is that management has become more complex, requiring greater knowledge and technical skills.

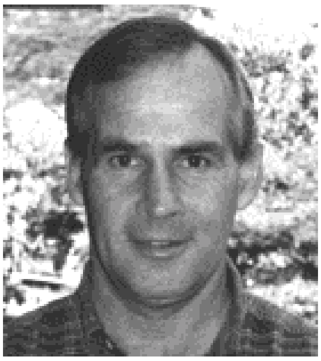
As farmers become more competitive through increases in both production and productivity, they will require even better technical information and management skills. Most important, they will need to know how to use the information in improving whole-farm performance and profits. This statement is supported by results of various Dairy Research and Development Corporation workshops and NSW Dairy Farmers' Association surveys, which have clearly indicated that farmers require technical packages that are current and relevant.

DairyLink is a series of integrated information packages that look at aspects of pasture, herd and feed management, and suggest practical ways of getting the best from your cows and pastures. The DairyLink series is a result of collaboration between NSW Agriculture officers, agribusiness and farmers.

The packages will be the basis of workshops and meetings for NSW dairy farmers.

DairyLink has much to offer the NSW dairy industry in helping improve farm productivity and profitability. We encourage farmers to attend and participate in the DairyLink workshops and meetings.

Preface



DairyLink is an innovative concept that introduces you to some important technical areas to help improve farm productivity and profits.

The modules in the series are of value to farmers, students, consultants and extension service providers.

DairyLink consists of the following information packages:

Establishing Pastures
Managing Pastures
Growing Heifers
Realistic Rations
Conserving Feed

The modules have been developed as technical manuals and farmer-friendly booklets, and are linked to the Tocal Dairy Home Study course.

I would like to take this opportunity to acknowledge and thank the various technical teams for doing an excellent job. I also appreciate the funding and support provided by DRDC.

Alex Ashwood
DairyLink Series Coordinator

Contents

Introduction

When we are feeding a dairy cow, we are trying to achieve an aim. We want the cow to produce a certain amount of milk, to get pregnant and keep healthy. If the cow is a heifer, we want her to grow and be a productive cow in her maturity.

The feeding system we use to achieve our aims should be based on both scientific and practical knowledge. We should have a good understanding of the relationship between the cow and her feed. We should understand what makes up a cow's diet and how it can be manipulated.

Realistic Rations is one of a series of DairyLink publications sponsored by the Dairy Research and Development Corporation. It is a practical step-by-step guide that will take the mystery out of ration formulation. It assumes that you have a good background in pasture establishment and management, grazing management and the conservation of forages; these subjects are covered by the companion volumes of DairyLink.

NSW Agriculture has worked closely with agribusiness, farmers and research officers to produce this publication.

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Understanding the dairy cow & her feed

Aims of this section

Feeding a dairy cow means more than presenting adequate food. The dairy cow has special requirements which her diet has to provide. Today's dairy farmers need to be aware of these requirements; when you are determining how your cows will be fed you should know what feeds are the best to use.

Completing this section will give you a greater knowledge of:

- how a cow breaks down feed for her body to use
- the importance of the rumen and its bacteria
- how to determine the value of a feed
- the different components measured in feed and what they mean
- how much a cow can eat
- what nutrients are needed by the cow
- how much of these nutrients is required by the cow for health, growth, pregnancy and milk production
- what feeds supply different nutrients
- practical tips for getting good results when feeds are sent away to be analysed.

Knowledge level required

To understand this section you need a practical knowledge of dairy cows and dairy farming. Reading the DairyLink manual *Conserving Feed* will give you some valuable background on the types and values of different silages and hays.

Information in the DairyLink manuals *Establishing Pastures* and *Managing Pastures* provides details of pasture costs and grazing management, both of which affect ration formulation.

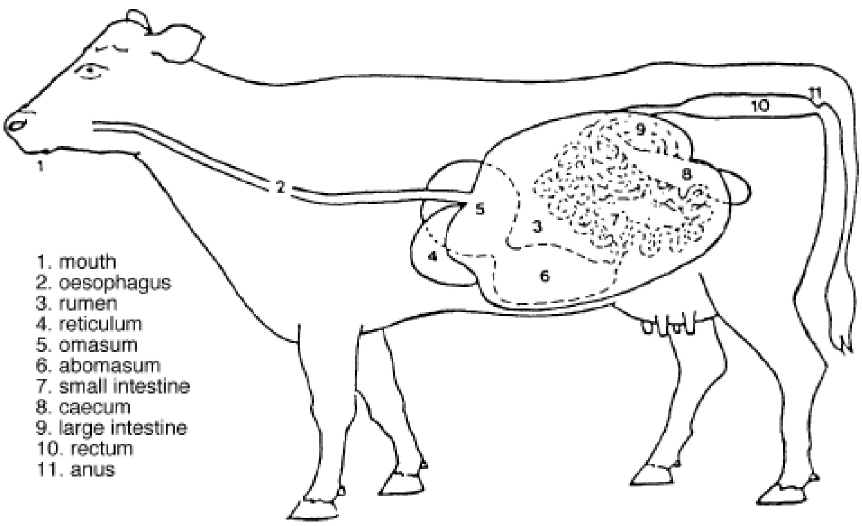
How do cows use feed?

What is the cow's digestive system and how does it work?

Anatomy of the digestive system

The digestive system of ruminants (for example, cows, sheep and deer) differs from that of other animals because it has a

Figure 1.1: The cow's digestive system



four chambered stomach, not a single stomach. Figure 1.1 shows the cow's digestive system.

The digestive system starts at the mouth and ends at the anus. It is a continuous tube that has special functions along its length, and has a number of accessories, called glands, which help it work.

The digestive system's main functions are intake of food, breakdown of food into compounds which can be used by the body (digestion), transport of the compounds into the body (absorption) and elimination of waste.

The **mouth** of the cow is well designed for ripping pasture and grinding feed.

The **tongue** is extremely movable and has a covering of sharp, backward-pointing projections that help direct food towards the throat.

The **teeth** are designed for grinding and chopping. There are no upper front teeth (incisors)—instead, there is a dental plate which the lower incisors come into contact with.

The dental pattern for an adult cow is:

	Upper Jaw		**Lower Jaw**	
	Left	Right	Left	Right
Incisors	0	0	4	4
Canine	0	0	0	0
Premolars	3	3	3	3
Molars	3	3	3	3

There are six glands which produce saliva to aid the initial digestion of food (**salivary glands**). Two glands are situated below the ear (parotid), two near the back of the throat (mandibular) and two under the tongue (sublingual). These glands produce 70–180 litres of alkaline (pH 7.7–8.7) saliva each day. The volume of saliva produced depends on the diet.

The **pharynx** is the cavity between the mouth and the opening of the **oesophagus**. The oesophagus is the muscular tube from the pharynx to the stomach. Food can be moved either up or down the oesophagus by muscular contractions.

The **stomach** has four chambers. It fills the left-hand side of the abdomen, pushing the rest of the digestive tract to the right-hand side.

The four parts of the stomach are the **rumen** ('paunch'), **reticulum** ('honeycomb'), **omasum** ('bible') and **abomasum** (which is similar to the single stomach of non-ruminants). The rumen contains microbes which aid digestion of food.

In the young ruminant, a groove formed by two muscular folds runs along the top wall of the rumen area, connecting the oesophagus with the abomasum. This **reticular** or **oesophageal groove** is stimulated by the action of suckling and allows colostrum and milk to bypass the immature rumen. If the calf has access to hay and grain from the first week of life, the rumen-reticulum begins to function and should be fully functional and able to digest forages by the third or fourth week of life.

The **small intestine** leaves the abomasum and sits in the right-hand side of the abdomen. It is about 40 metres long and has three parts, the **duodenum**, **jejunum** and **ileum**. The **gall bladder** and **pancreas** are two glands along this part of the digestive tract; they provide secretions that help digestion in this section of the gut.

The **large intestine** sits in the upper right part of the abdomen. It consist of the **caecum** (similar to our appendix), **colon** and **rectum**. The caecum and colon, similar to the rumen, contain microbes that aid digestion.

How digestion works

Food consists of chemical compounds (such as proteins, starch and fibre) which cannot be used by the animal unless they are broken down into smaller components.

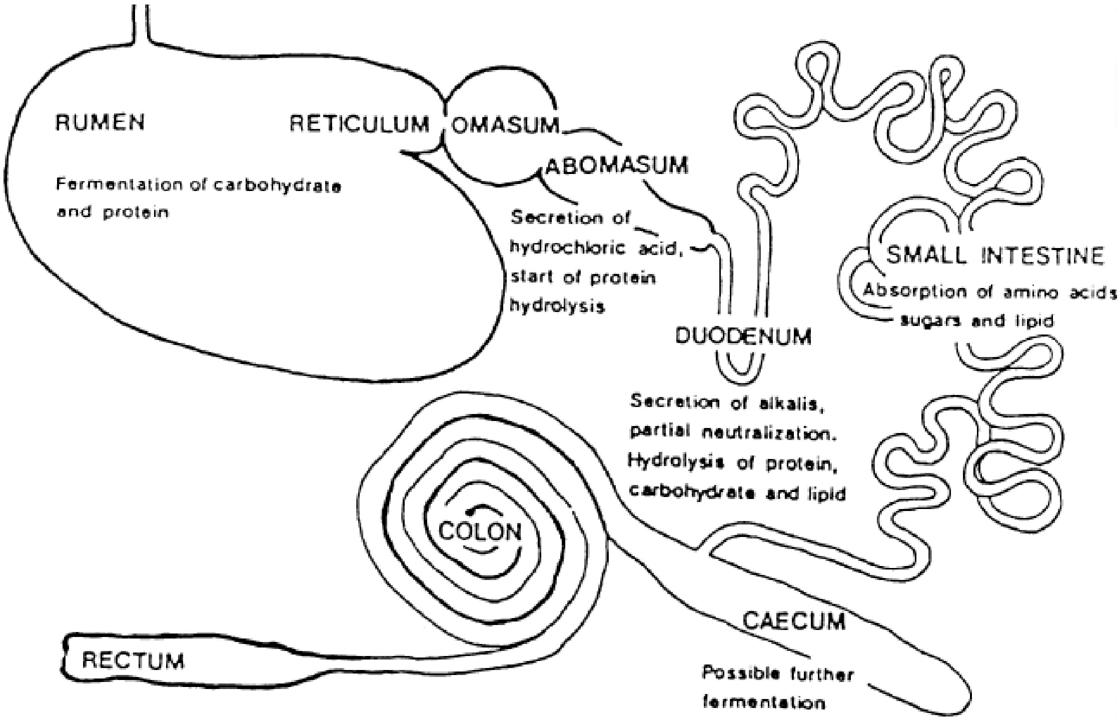


Figure 1.2: How the cow digests food

These components are transported into the blood system and circulated throughout the body to be used by the different organs. In the organs, the components can be rebuilt into other compounds which the body can use. For example, compounds reaching the udder by the blood can be made into milk fat and milk protein. Figure 1.2 shows how the cow digests food.

This process of breaking down and rebuilding components is known as **metabolism**.

Enzymes are special proteins which help drive the chemical reactions involved in breaking down or rebuilding compounds. In single-stomach animals, such as dogs and cats, glands associated with the digestive system are the main source of the enzymes needed for digestion. In ruminants, enzymes released by microbes in the rumen digest about 65% of food.

How the cow's stomach digests food

Ruminants digest feeds primarily by fermentation by microbes in the rumen. These microbes have specific functions. One group (anaerobic bacteria, protozoa and fungi) break down carbohydrates in the diet. Another group (anaerobic bacteria and some fungi) break down the structural fibre of plants. There is a working relationship between the microbes: the fungi might start the fermentation process by attacking the plant cell walls, then other microbes break down the products released into smaller compounds which are absorbed by the cow or else are used by the microbes for their own growth.

The **rumen-reticulum** first receives the food entering the stomach complex. It is similar to a large fermentation vessel. The feedstuffs and the rumen microbes are continually mixed by muscular contractions of the wall of the rumen. The feed may be digested by enzymes produced by microbes or present in the saliva. Because many compounds produced during digestion are acid, the saliva helps buffer the rumen, maintaining the 'neutral' (pH 5.8–6.8) environment needed by the microbes. Some of the digested product (ammonia and volatile fatty acids) may be absorbed through the rumen wall into the blood. Gas (methane and carbon dioxide) may be produced during the digestion process and is belched out of the rumen.Energy, in the form of the molecule Adenosine Triphosphate (ATP), is taken up by the microbes for their growth.

Fibrous feed is regurgitated up the oesophagus to the mouth to be more thoroughly chewed and reduced in size before it is reswallowed; this is known as rumination or ‘chewing the cud’. On a grass-based diet, twice the amount of dry feed material as was originally eaten passes through the cycle of rumination. The small particles of food then pass on to the reticulum and omasum. The valve between the reticulum and omasum keeps feed particles in the rumen until they are less than 1–2 mm in size.

The **omasum** absorbs 30–60% of water leaving the rumen-reticulum. The water contains products of digestion such as volatile fatty acids and minerals.

The **abomasum** is the equivalent of a non-ruminant’s stomach. It has acid secretions that break down escaped rumen microbes and other compounds so that they are ready for digestion by the small intestine.

The **small intestine** digests and absorbs any fat or protein not digested by the rumen, as well as some of the soluble carbohydrate. Escaped rumen microbes are digested and their protein absorbed.

The indigestible products pass into the **large intestine**, where they undergo a second fermentation. Only 5–10% of the total digestion of feed occurs in the large intestine. It contains microbes that attack the insoluble carbohydrates and starch. Any volatile fatty acids produced (together with minerals and water) are absorbed. The microbes from the large intestine pass out with the undigested material in the faeces.

Feeding the rumen

The fibrous pasture and forages in a cow’s diet must be digested through the activity of microbes. Without these microbes, the cow will die. Feeding too much grain can cause certain microbes to break down the carbohydrates in the grain, in preference to microbes which break down fibre. If the excessive amounts of acid produced from the breakdown of the grain cannot be neutralised by the cow’s high pH saliva, the pH of the rumen decreases (becomes acidic). Certain microbes that are not suited to the acidic conditions may be killed. Damage can occur to parts of the rumen wall—especially the folds, which are important for absorbing compounds into the blood. Carbon dioxide gas can build up in the top of the rumen and can ‘bloat’ the rumen unless it is able to be ‘burped’. At one extreme the end result is poor digestion of fibre-based feeds; at the other extreme the cow becomes sick and dies.

It is important to make sure the rumen is functioning properly when you start feeding a cow. To do this, you must understand how to get a proper balance of feed types in the ration.

How do we measure feed value?

The value of a feed and its usefulness to an animal are determined by what it contains and how much of it is eaten. The **nutritive value** of a feed is determined by the following:

- what is in the feed
- how it is digested by the rumen microbes and by the cow
- the physiological state of the cow.

Feed analysis

Feed analysis determines what is present

Table 1.1: Brewers' grain—proximate analysis

Component	Value
Dry matter (DM)	26.0%
Nitrogen	3.2%
Crude protein	19.8%
Acid detergent fibre	30.1%
Digestible dry matter	67.1%
Metabolisable energy	10.1 MJ/kg DM

in a feed—it measures only one part of a feed's nutritive value. Feed analysis is done with special equipment in a laboratory, although in the future it will be possible to do analyses on-farm.

Proximate analysis is the chemical analysis of feed to assess its nutrient content. Table 1.1 shows the results of a proximate analysis of a feed.

Dry matter, **metabolisable energy**, **crude protein** and **digestibility** are some of the components determined. What do these components mean? In this section, the following components which make up the proximate analysis of feed will be explained.

Dry Matter (DM)

- Dry matter intake (DMI)

Energy

- Gross Energy (GE)
- Digestible Energy (DE)
- Metabolisable Energy (ME)
- Net Energy System (NEl, NEm, NEp)
- Total Digestible Nutrients (TDN)

Protein

- Non protein nitrogen (NPN)
- Rumen Degradable Protein (RDP)
- Undegraded Dietary Protein (UDP)
- Bypass Protein
- Protein degradability (Pdg%)

Carbohydrates

- Fibre
  - —Neutral Detergent Fibre (NDF)
  - —Acid Detergent Fibre (ADF)
  - —Lignin
  - —Crude Fibre (CF)
- Non-structural carbohydrates (NSC)
- Non-fibre carbohydrates (NFC)

Fats and oils

- Crude fat

Digestibility

- DMD

Dry matter

Dry matter (DM) is the feed material remaining after a feed sample is dried so that all moisture is removed. Water, which is present in all feeds, does not provide any nutrients or energy needed by the cow. Dry matter is used as a measure of the quantity of feed that is fed to a cow.

Dry matter intake is the quantity of moisture-free feed consumed by a cow in a 24-hour period.

Some nutrients in a feed (such as crude protein, neutral detergent fibre, acid detergent fibre and minerals) are calculated as a percentage of the ration's dry matter; others (such as energy) are calculated as a value per kilogram of dry matter.

The values of different feeds can be

compared by relating them to their dry matter content. **It is important to know the dry matter content of feeds when you are changing from one feed to another in a ration.**

There are a number of laboratory methods for measuring dry matter in feeds. A practical way of using a microwave oven to determine dry matter percentage is described in Appendix 1 at the end of this manual.

Units of measurement

The **dry matter percentage** is the dry matter content of a sample of feed, expressed as a percentage of the wet sample. It is based on the difference in weight after the sample is dried. Appendix 1 explains how to calculate dry matter percentage.

The amount of water present in a feed is the inverse of the dry matter percentage. So if a feed has a dry matter percentage of 20%, then 80% of the feed is water (100 - 20%).

Feeds may be described on a fresh, wet weight (**'as fed'**) basis rather than a dry matter basis.When you are determining a ration for a herd it is important to know the **as fed** weight, as this is important for weighing feed before mixing. To convert from a dry matter percentage to an **as fed** value, multiply the amount of feed on a dry matter basis by the inverse of the dry matter percentage.

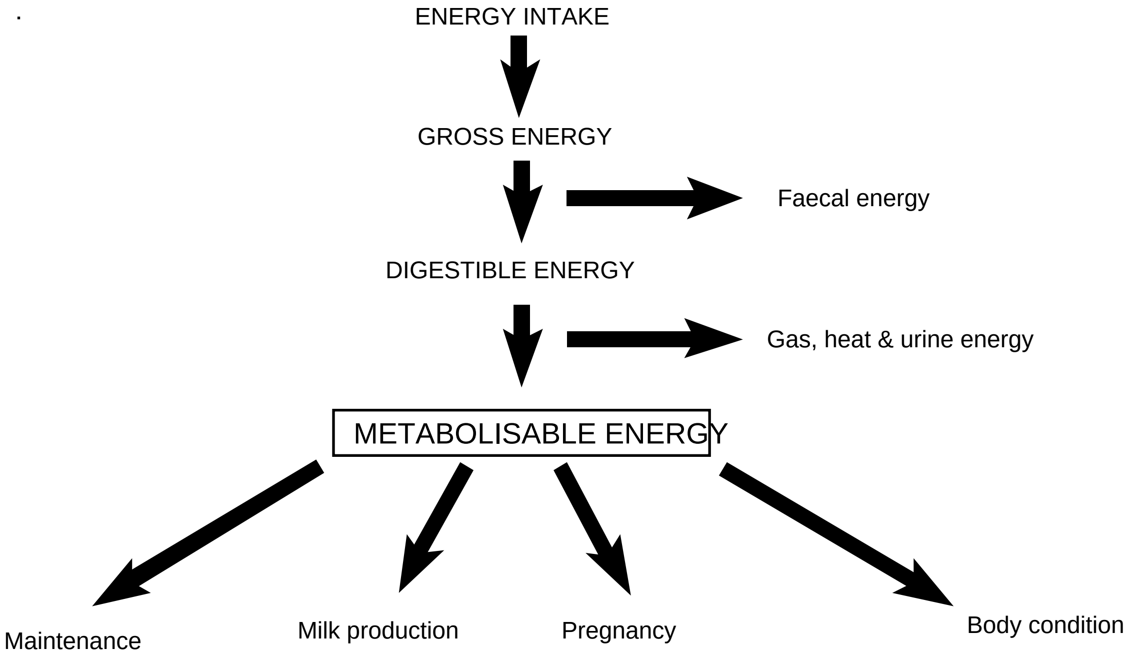
For example, if 100 kg DM of a feed is to be added to a ration mix, and the feed has a **dry matter percentage** of 50%, then the total weight of the feed to be added is 100 kg × 100/50 or 200 kg on an **as fed** basis.

Energy

Energy is needed for the normal body functions of the cow. It is the most important nutrient for driving milk production. Energy is also needed for walking, putting on body condition and nourishing the developing foetus if the cow is pregnant. Cows get their energy from the digestion of feed.

The total energy in a feed is called its **gross energy**. Not all of this energy is available to the cow—some of it will be lost in the faeces. The remaining energy is called **digestible energy**—the portion of

Figure 1.3: Metabolisable energy is the energy available for use by the cow (adapted from Agriculture Victoria, 1994)



energy from the feed which is available for digestion.

During the process of digestion, energy is lost in the manufacture of waste products which leave the body in the urine or as gas belched from the rumen (methane), and through excess heat production by the cow. The remaining energy is now available to the cow for body maintenance, milk production, pregnancy and body conditioning. This energy is called **metabolisable energy** (see Figure 1.3).

Feeds may have similar gross energy contents but may vary in the total energy available for milk production and body maintenance. Only the energy available for use by the cow (metabolisable energy) is determined for different feeds. This energy is expressed as **megajoules of metabolisable energy per kilogram of dry matter** or **MJME/kg DM**.

The higher the MJME in a feed, the greater the energy the feed provides to the animal.

Units of measurement

The basic unit of energy is a joule, which equals 0.239 calories. One megajoule is one million joules.

The **metabolisable energy system** for measuring a cow's energy needs is used in Australia. The results from any Australian Feed Analysis laboratory express the metabolisable energy of the feed as **MJME/kg DM**.

In the USA, the **net energy system** is used. In the net energy system, there are three components: net energy for maintenance (NEm), net energy for lactation (NEl) and net energy for growth and weight gain (NEg). Net energy is equivalent to metabolisable energy minus the energy used in the process of digestion and metabolism but includes the energy in the feed used for maintenance and production.

If you are reading an American publication, the NEl value can be converted to a metabolisable energy value by dividing it by 0.62. If a total NE value is given in megacalories, then this figure can be converted to metabolisable energy in MJME by multiplying the value by 6.8.

If the publication expresses the results in megacalories instead of megajoules, convert the result to megajoules by dividing by 4.184.

Another term used in American publications is **total digestible nutrients** or TDN. TDN is a feed value calculated from the total analysis of a feed. It is commonly used to represent the digestible energy in a diet and is expressed as a percentage of gross energy. TDN can be converted to a metabolisable energy value by multiplying the value by 0.1476.

Protein

Feed contains the element **nitrogen**, which is normally found in the protein part of the feed. **Protein** is usually 16% nitrogen. Feed can also contain nitrogens from other sources; these are **non-protein nitrogens (NPNs**), such as urea.

The percentage of **crude protein** in a feed is calculated by multiplying the nitrogen content by 6.25 (because protein contains 16% or 16 in 100 parts nitrogen). This value contains both true protein and non-protein nitrogen sources.

The nature of a protein and its passage through the rumen (see Figure 1.4) can affect the following:

- the amount of protein digested and absorbed in the rumen
- the amount of protein that passes through the rumen for digestion and absorption in the small intestine.

Most protein entering the rumen can be broken down by microbes if it is in the rumen for long enough. A small amount of protein is **indigestible** by both microbial

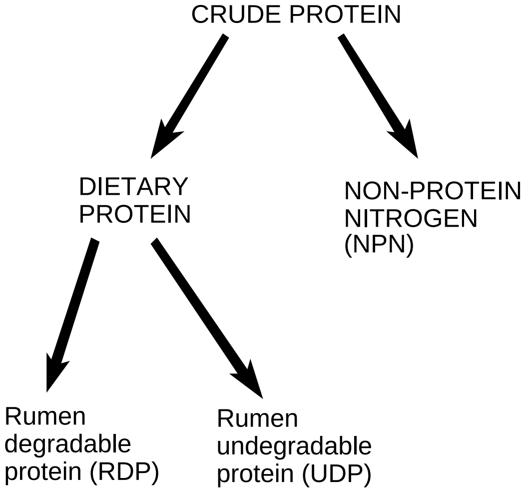


Figure 1.4: The components of crude protein (adapted from Agriculture Victoria, 1994)

and animal enzymes and will pass intact from the animal. No part of this protein will be absorbed or used in metabolism.

Protein entering the rumen is broken down by the microbes into amino acids. Most amino acids are further broken down to form **ammonia**, which is used by the microbes to produce their own protein for their reproduction and growth. Protein which is broken down in the rumen is **Rumen Degradable Protein (RDP)**.

Non-protein nitrogen is 100% degradable in the rumen. The excess ammonia from NPN and protein breakdown is absorbed through the rumen wall into the blood and travels to the liver to be detoxified by the formation of **urea**. Urea is excreted from the body in the urine.

Some microbes will pass out of the rumen into the abomasum. The proteins they contain are digested and absorbed by the cow in the small intestine. Microbial protein is the major source of protein for the cow.

Protein which passes through the rumen without being attacked by the microbes will pass into the small intestine to be digested and absorbed. This protein, called **Undegraded Dietary Protein (UDP)**, is not modified from its original state in the feedstuff. The amino acids it contains are released to the cow when the protein is digested in the small intestine.

In any feed, the protein will be a combination of RDP and UDP. Feeds with a high percentage of their protein as UDP are called **bypass proteins**. Slowing the passage of a feed through a rumen can affect its UDP percentage. The longer time a feed is in the rumen, the greater the chance of microbial attack and digestion.

Units of measurement

The feed test will normally show the protein content in the feed as crude protein. Crude protein is normally expressed as a percentage of a kilogram of dry matter content (**CP%**).

To calculate the total amount of crude protein as grams per kilogram of dry matter in the feed, simply multiply the percentage figure by 10.

For example, a feed can have 12% crude protein or 120 g/kg DM.

Sometimes the nitrogen value of a feed is given instead of a crude protein percentage. To convert the nitrogen value to a crude protein percentage, multiply the nitrogen value by 6.25. Remember that not all nitrogen will be part of protein; some of the nitrogen might be non-protein nitrogen such as urea. The nitrogen from protein and that from urea are not measured separately when a feed sample is analysed.

The protein degradability (Pdg%) is not given on a feed test result. The test used to determine this value is very expensive (about $1000) and is usually requested by feed companies when evaluating one of their products. However, you can find protein degradability percentages for a number of feeds in the literature (NRC, 1989).

The RDP value is often given as a percentage of the total crude protein. For example, the protein in a cereal grain may be 90% degraded in the rumen.

The feed requirements for RDP and UDP are often expressed as grams per kg DM. If a feed has a CP of 12% or 120 g/kg DM and an RDP of 90%, every kilogram of feed dry matter will contain $120 \times 90/100$g or 108 g of RDP.

Carbohydrates

The components of the feed that do not contain nitrogen (and so are not included in the crude protein determination), and all fibre components, are the **carbohydrates**. Carbohydrates make up about 75% of a plant's dry matter.

Fibre

Fibre provides the structural support for plants and cell walls. Feeds high in fibre are called roughages or forages. There are a number of measures of a feed's fibre content.

Neutral detergent fibre (NDF) is a measurement of the amount of plant cell wall or 'fibre' in forages. When a forage is boiled in a detergent with neutral (pH 7) detergent, all the contents of the cell dissolves except for the cell wall or NDF.

NDF contains carbohydrates (cellulose and hemicellulose) that are partly digested by the rumen bacteria but are not digested by the cow's intestines.

Acid detergent fibre (ADF) is the residue of lignin and cellulose remaining when the plant cell wall is treated with an acidic detergent solution. ADF is a useful measurement of the minimum fibre level in a ration, and is used to help calculate the energy value of a forage.

Lignin is the least digestible portion of the plant. It binds together the other carbohydrates in the plant and gives the plant rigidity.

Units of measurement

The fibre content in a feed will commonly be expressed as ADF, because this value is used by the laboratory in the calculation of energy. Some laboratories will provide the NDF value of the feed. Lignin can be measured in the feed, but it is not as useful for balancing rations as ADF and NDF.

Some publications use the term **crude fibre** (**CF**). Crude fibre includes the lignin and most of the cellulose in the feed. To get an approximation of CF, divide the ADF value by 1.15.

Soluble carbohydrates

Non-structural carbohydrates (NSC) are the carbohydrates that are not part of the plant cell wall (NDF). They are present in the cell contents. NSC are also called **non-fibre carbohydrates** or **NFC.**

NSC include **soluble sugars**, **starches** and **pectins**. Sugars are an instant energy source for the rumen microbes. Starches and pectins are storage carbohydrates that are fermented more slowly than sugars. NSC are more completely and rapidly digested in the rumen than the NDF carbohydrates. They can also be digested in the cow's intestine. The ration should contain 30–40% NSC in its total dry matter content.

Units of measurement

Direct measures of non-structural carbohydrates are not carried out in normal feed analysis. NSC is usually calculated by subtracting all the other components in the feed from 100. These components are fibre (NDF or CF), crude protein (CP), fat and oil (ether extract or EE), water content (100 - DM%) and mineral content (ash). Ash is the portion of feed remaining after it has been combusted at 650°C; it is the inorganic or mineral part of the feed.

In other words, the percentage of NSC in a feed can be calculated by the following equation:

NSC = 100 – (CP + CF + ether extract + ash + water content)

where all components are expressed in grams.

Fats and oils

Fats and oils are sources of energy. They have a similar structure to carbohydrates, except that they contain three fatty acid chains. For this reason they are called **triglycerides**. During breakdown (oxidation), they liberate 2.5 times more energy than carbohydrates of the same weight.

Units of measurement

The **crude fat** of a feed is estimated by the ether extract method. This method determines all the components in the feed that are soluble in ether—all the fats and oils as well as gums, resins and waxes. Ether extraction is not usually done in the feed analysis laboratory unless it is requested. For this reason, the true metabolisable energy of a feed may be higher than that reported from feed analysis if the feed contains fats or oils (for example, oilseed meal).

Digestibility

The organic part of the feed consists of everything except the mineral component (ash). The organic matter contains the energy of the feed, and there is a direct relationship between feed organic matter and gross energy. A proportion of the organic matter of the feed is indigestible—it contains lignin and some cellulose.

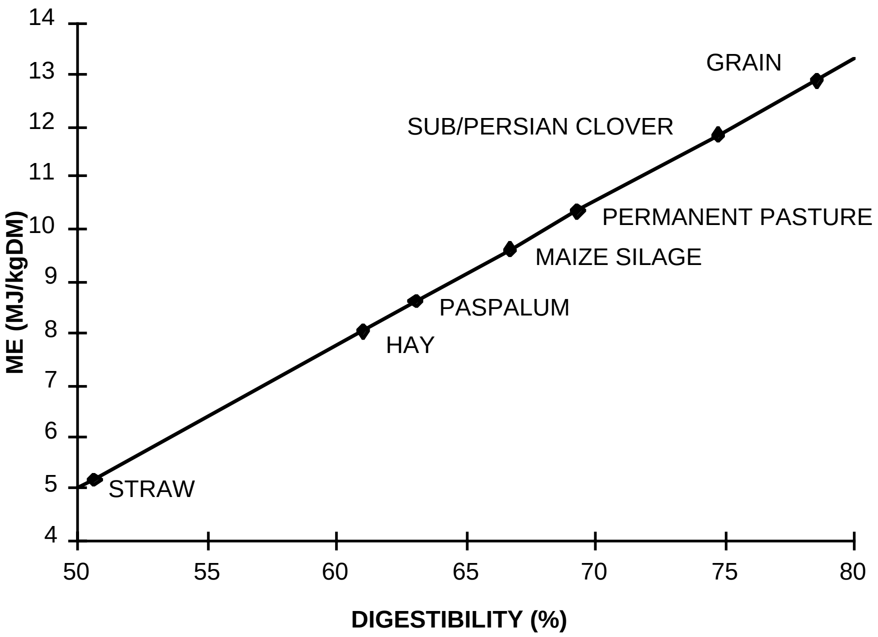
The **digestibility** of a feed is the proportion that can be digested by an animal. Digestibility is a guide to the energy value of a feed. It is commonly measured as a percentage (%).

Dry matter digestibility (DMD)

$$= \frac{\text{feed DM} - \text{faeces DM}}{\text{feed DM}} \times 100\%$$

As grasses mature, the organic matter content becomes more indigestible because the lignin content increases. For this reason, cows obtain greater energy from younger grasses; there is more feed

Figure 1.5: The relationship between digestibility and metabolisable energy (after MAFF, 1984)



available for digestion for every unit of weight of the plant.

The digestible organic matter in the dry matter portion of a plant (DOMD) gives information about the stage of growth of a plant and can be used to predict the energy the plant can supply (see Figure 1.5). This figure can be given as a percentage.

How much feed can a cow eat?

An important constraint of any dairy cow ration is how much the cow can eat. If you formulate a ration to supply the nutrients for body maintenance, walking, pregnancy and milk yield you must be able to supply it in amounts that the cow can eat.

A number of factors can affect a cow's dry matter intake.

Cow factors

- size and age
- physiological state
- genetics
- disease
- social interaction
- heat stress

Feed factors

- digestibility
- nutrient supply
- palatability

Physical factors

- ability to harvest pasture
- grazing time
- intake per bite
- access to feed

We will consider these factors in greater detail.

Cow factors

Size and age

The maintenance requirement of a cow is determined by her age, live weight and body surface area. A young heifer will eat more than an adult cow as a percentage of her body weight. A heifer will eat the equivalent of 2.3% of her body weight daily, and an adult dry cow will eat the equivalent of 1.5%. As an example, a 300 kg heifer can eat up to 7 kg dry matter. An adult dry cow weighing 470 kg will eat a similar amount.

The size of the rumen and its ability to expand are limited by the size of the body cavity where the rumen is situated. Distension of the rumen (**'gut fill'**) depends on the rate of breakdown of feed roughage and the flow of small particles from the rumen. Fat cows can have lower intakes because of the effect of fat deposits in the rumen and because they have lower energy requirements.

Physiological state

Milk production and stage of lactation can drive a cow's intake. Before a cow calves, her intake is reduced because of the physical restriction on the size of the rumen by the developing foetus and because of the hormonal changes associated with pregnancy.

After a cow calves, milk production begins; it reaches a peak yield at about 5–7 weeks after calving. The cow's metabolism has to adapt to this demand on her body reserves; her intake is initially depressed, but it gradually increases until she reaches full appetite at 8–20 weeks after calving.

This delay in reaching full appetite while the cow is producing peak yield means that the cow is in a **negative energy balance** for this period. She cannot eat enough to supply the nutrients needed for body maintenance, milk production and fertility. Weight loss usually occurs after calving.

The period between peak yield and full appetite can be shortened if the cow's rumen is encouraged to expand before calving. Medium quality forage, at least 11 mm in length, can provide the 'scratch factor' needed to stimulate rumen capacity. The cereal component of the lactating diet, **without the mineral mixes or buffers**, can be fed in small amounts to the cow for a month before calving to adapt the rumen microbes to the new diet.

Making changes to the early lactation diet and calving your cows in good condition will benefit the early lactation cow. These factors will be discussed later.

The intake of a lactating cow can be 30–60% greater than that of a non-lactating cow. There are numerous ways of predicting how much a cow will eat, but they are not as practical as an on-farm method. One simple **rule of thumb** for predicting dry matter intake is that a lactating cow will eat 2.5% of her live weight if given low quality forage, 3% of live weight if given a medium to good quality diet and 3.5% of live weight if given a high quality diet. Intakes as high as 4%, 4.5% and 5% of live weight can occur on well balanced rations, especially in Jersey cattle.

Another quick **rule of thumb** for determining the intake of a lactating cow requires you to know both her live weight and milk production. Her dry matter intake will be about (2.2 × live weight + 20 × daily milk production in litres) /100.

Example: What is the dry matter intake of a 500 kg cow producing 20 litres of milk a day?

Dry matter intake = (2.2 × 500 + 20 × 20)/100
= (1100 + 400)/100
= 1500/100
= 15 kg DM.

Genetics

Dry matter intake can be influenced by the cow's genetics. High breeding value cows can eat more. In these cows, a 5% increase in intake can result in a disproportionate increase in milk production (up to 30%).

Disease

A drop in appetite is a common sign of many diseases. The first sign of disease can be decreased in milk production, because the cow has reduced her feed intake.

Decreased intake can be caused by:

- metabolic changes in the cow as a result of disease (for example, milk fever or low blood calcium)
- physical changes in the rumen stimulating gut fill (for example, bloat)
- tumours and wounds in the mouth, pharynx or oesophagus
- diseases of the feet that physically restrict the ability of the cow to graze.

Social interaction

Cows are very social animals and have an established hierarchy or 'pecking order' within the herd. They form social groups, which may be family groups or their heifer group. The introduction of new animals to a herd can interfere with this structure until the hierarchy is re-established. Normal grazing patterns can become disrupted, resulting in lower feed intakes.

Mating groups can also form, especially in seasonally calving herds or in large herds where there is a significant number of cows on heat. Increased walking activity and behavioural changes can result in decreased feed intakes.

Heifers are most affected when they are introduced to a dairy herd. Many heifers can calve when they are only 75% of their mature weight. Individual heifers are on the lowest rung of the pecking order, especially if they are small and can be bullied by the more dominant cows. Heifers are disadvantaged at feed bunks if space is limited or at grazing if pasture feed is limited. Heifers grazed in groups separate

Table 1.2: Relationship of dry matter intake (DMI) to temperature

Mean day temperature (EC)	Mean night temperature (EC)	% reduction in DMI
25ñ30	20ñ25	10
30ñ35	20ñ30	20
35ñ40	25ñ30	30

from the adult herd have both higher feed intakes and milk production.

Heat stress

Dairy cows originated from cool, temperature climates and prefer environmental temperatures less than 25°C. Dry matter intake declines as the ambient temperature increases, as table 1.2 shows.

Heat stress caused by high temperatures can be increased if:

- there is poor access to cool, clean water
- there is high humidity—this prevents evaporation of heat; cows can show heat stress at relatively low temperatures if the humidity is high
- stock have to walk long distances
- stock do not have shade.

Feed factors

Digestibility

Dry matter intake increases by up to 65–80% with increasing digestibility of feed. Highly digestible feeds such as young pastures have comparatively less structural fibre (lignin) and are digested rapidly, allowing fast passage through the rumen. Gut fill is slower. Feeds with low digestibility (such as very mature pastures) limit intake by slowing the digestion and rumen passage and by accelerating gut fill.

Nutrient supply

Dry matter intake can be affected by:

- the quantities of nutrients absorbed by the rumen and small intestine
- the proportions of the different nutrients absorbed
- the type and level of nutrients in the feed.

Amino acids, from the breakdown of protein, stimulate intake. Volatile fatty acids, from the breakdown of fibre, can inhibit intake.

If the nitrogen content of the diet (crude protein content) meets the needs of the rumen microbes, intake will increase with increasing digestibility, providing the products produced during digestion have no adverse effect on the rumen or the cow.

Example: Grain has high digestibility (about 80%), but too much grain can cause acid conditions in the rumen which affect the digestion of fibre and reduce total intake. In acid rumen conditions, there is less nitrogen made into microbial protein, leading to fewer amino acids passing into the small intestine, reducing intake. If bloat occurs from eating too much grain or from eating clovers or lucerne, the distension of the rumen is sensed as 'gut fill' and intake reduces.

If two feeds have the same digestibility, intake will increase with increasing nitrogen (protein) intake. Feeds with low digestibility usually have a low nitrogen content. Increasing nitrogen in the diet (but only up to 10–12% CP) will provide greater nitrogen to the rumen microbes, allowing greater microbial growth and a greater ability to digest fibre. Intake increases in response to the improved fibre digestion.

Example: White clover – ryegrass pasture and ryegrass pasture have the same high digestibility. The higher milk production seen on white clover

– ryegrass pastures occurs because cows on these pastures have a greater nitrogen intake, which stimulates more microbial activity and a higher intake of pasture than occurs in cows grazed on ryegrass alone.

Palatability

Palatability is the cow's immediate response to the feed. The sight, smell, touch and taste of a feed can affect whether a cow will eat or refuse a feed. The palatability of poor quality roughages has a greater influence on intake than the palatability of better quality forages.

Exposing a calf to a variety of different feeds can influence how it accepts them in later life. One practical way of doing this is to feed small amounts of the milkers' ration to heifers.

Physical factors

Ability to harvest pasture

The pasture intake of a cow can be defined by a number of physical factors:

- the time spent grazing (grazing time)
- the number of times the cow bites the pasture (rate of biting)
- the amount of pasture harvested at each bite (intake per bite).

The total daily intake of pasture can be calculated by multiplying the grazing time (in minutes) by the rate of biting (bites per minute) by the intake per bite (kilograms per bite).

Both the grazing time and the intake per bite can be influenced by farmer management. The rate of biting is an individual character of a cow.

Grazing time

When a cow is at pasture, she can be either eating, ruminating ('chewing her cud') or resting. Cows graze mainly during the day, but night-time grazing increases if the day temperature is hot and humid. The average time most cows can spend grazing is 7–8 hours. Another 8 hours may be spent ruminating.

Farm management practices can severely limit grazing time. Excessive time spent in the milking yard and walking to and from pasture at milking time, as well as poor access to water in the paddock (requiring the cows to seek out a water trough in another place) will reduce the amount of time available to the cow for grazing.

Intake per bite

The amount of pasture available can determine how much a cow will eat at each bite. A cow will eat her requirement in pasture if she is provided with twice the dry matter content of pasture she needs. Cows are selective grazers and will seek out the more digestible (and higher energy) pasture in the longer pasture. If the cow is offered less than this, she will still eat the pasture but to a lower height. Her intake of the shorter pasture will be less. She will also be unable to select pasture and will take in less digestible parts of the pasture as well.

Access to feed

Cows should be allowed sufficient access to feed. In a pasture, the presence of weeds, dead plant material and manure pats can hinder the cows' ability to graze.

At a feed bunk, there should be sufficient space for each cow to eat without competing with another cow. Access is very important if most of the cows' feed requirement is fed at the bunk. There should be at least 76 cm of feeding space for each cow. Headstalls or self-locking stalls can allow cows adequate access to the feed.

In herds feeding on partly or totally mixed rations, separating the herd into different lactation group can benefit feed intake. Early lactation cows should have unimpeded access to the bunk area, and there should be sufficient space for every cow. High-producing cows should be presented with 10% more feed than they require. For mid- to late lactation cows, space should be sufficient for only 50–75% of the group to be eating at any one time.

The feed bunk should be cleaned out regularly, especially if feed with high moisture content is fed. If these feeds are left, moulds can build up and make the feed unpalatable, even when new feed is added.

Cattle fed in feedlots or on feed pads have a higher intake and milk production than pasture-fed cattle. Feedlot rations have a higher dry matter content than pastures, but the fibre content is usually lower. Pastures with a high dry matter content also have a high fibre content, which limits feed intake (the digestibility is lower). The rate of eating is faster in the feedlot, because highly digestible feed is presented to the cow—it doesn't have to search for it in a pasture. Pasture-fed cattle have to walk longer distances when grazing and use more energy in this activity than feedlot cattle.

What nutrients does the cow need?

The nutrients needed by the cow (in descending importance) are water, energy, protein, fibre, macro minerals, micro minerals and trace elements and vitamins.

Water

This is the most important nutrient required.

As saliva, water serves as an important lubricant for swallowing and regurgitation. It is needed for the process of digestion and absorption.

A lactating dairy cow needs a lot of water. Her body is 70–75% water, and the milk she produces is over 85% water. Inadequate water will markedly reduce milk production.

Usually a large proportion of the cow's water intake is supplied by pasture. When you supplement the cow' diet with grain and hay, the need to supply extra water increases.

As the environmental temperature and the cow's milk yield increase, so does the water requirement. Table 1.3 overleaf shows the water intake of 600 kg Holstein cows at different temperatures and milk yields.

How much water do your cows need? Use table 1.3 as a guide. For example on a cool spring day (14°C), a 600 kg cow producing 30 litres a day would need 103 litres of water. This would be supplied by water in the feed and drinking water. On a warm day in spring (24°C), the same cow would need 133 litres of water from the feed and the trough.

Dry cows and heifers need less water. For each kilogram of dry matter eaten, dry cows and heifers need 5–7 litres of water, again depending on the environmental temperature. If a dry cow on a warm spring day was eating 10 kg dry matter of grain and hay, then she would need about 70 litres of drinking water at the trough.

In dry, hot weather the requirement for water increases.

Energy

Energy is the next important nutrient and is the chief limiting nutrient of most feeds (although it is not an actual substance like protein or minerals). When complex substances are broken down, energy is released and becomes available to the animal. Carbohydrates such as sugars and starches (non-structural carbohydrates) and cellulose, hemicellulose and lignin (structural carbohydrates or fibre) are the main energy sources in a cow's diet. Fats (and to a lesser extent, protein) also provide energy.

Table 1.3: Water intake of 600 kg Holstein cows at different temperatures and milk yields

Milk yield	Environmental temperature (EC)			
	I 17 to 10	11 to 15	16 to 20	21 to 25
10	78	81	92	105
20	88	92	104	119
30	99	103	116	133
40	109	113	128	147

From *The Nutrient Requirements of Livestock* 1980

The structural and non-structural carbohydrates are converted to **volatile fatty acids** in the rumen. **Acetic**, **propionic** and **butyric acids (acetate, propionate** and **butyrate)** are the main volatile fatty acids formed. The starches and pectens which escape the rumen are converted to glucose in the small intestine.

The proportion of volatile fatty acids produced depends on the original diet. If the diet mainly contains structural carbohydrates (forages such as pasture and hay), the cellulose-digesting bacteria will predominate and large quantities of acetate will be produced. **Acetate is the immediate precursor of milk fat**. A deficiency of acetate can result in low milk fat percentage.

If the diet contains a large proportion of non-structural carbohydrates that are rapidly fermentable in the rumen (such as cereal grains) different bacteria will be favoured and a higher proportion of propionate will be produced. **Propionate is converted in the liver to glucose. Glucose provides the energy for the production of lactose and synthesis of protein in milk**. Lactose secretion is the main determinant of milk yield. A deficiency of propionate can result in decreased milk yield and milk composition. **Glucose provides the energy needed for live weight gain.** If the cow has a deficiency of propionate she can start to mobilise her own body tissue and lose weight.

Butyrate, another volatile fatty acid produced in the rumen, is metabolised in the liver to **ketone bodies**, the source of energy for fatty acid synthesis, skeletal muscles and other body tissues. Ketone bodies are also produced when body fat is mobilised; they are used as an alternative energy source for the cow.

Fats are degraded in the rumen or, if in a protected form, pass to the intestine. Fats and oils are modified in the rumen into **saturated fat** and absorbed. They are either converted to a specific animal body fat (usually a triglyceride) or oxidised to a gas if they are used as an energy source. Every lactation a cow goes through the process of accumulating and oxidising her body fat.

If there is too much fat in a cow's diet, fibre particles become coated with fat, making the surfaces difficult for microbial attack. Large amounts of fats can:

- depress the digestion of forages
- reduce the total feed intake
- lower the acetate to propionate ratio
- reduce the availability of calcium
- reduce the production of microbial protein.

Cows can tolerate as much as 900 g of fat a day in their diet (or 5–7% of the ration's total dry matter).

Protected fats escape microbial digestion and can be used to overcome the problem of increased breakdown of fat in the rumen.

How much energy is needed by the cow?

The metabolisable energy in a feed has to be partitioned to the different body functions. In decreasing order of importance, energy will be partitioned to maintenance, activity, pregnancy and milk production. If the energy in the feed is insufficient for all body functions, milk production will be the first function affected.

Maintenance

How much energy does a cow need for her body maintenance? Table 1.4 shows the energy required daily for maintenance at different live weights.

Table 1.4: Energy needed for maintenance

Live weight (kg)	Energy required (MJ of ME)
350	40
400	45
450	49
500	54
550	59
600	63
650	68
700	73

Activity

Cows need energy for walking. If the topography of the dairy is flat, a cow will need an extra 1 MJ of ME for each kilometre walked. If the topography is hilly, more energy is used and a cow may need up to 5 MJ of ME per kilometre.

Pregnancy

What energy is required for a pregnant cow? The growing calf foetus is drawing all of its energy from its mother. In the last four months of pregnancy, the demands of the foetus must be allowed for. Table 1.5 shows the extra energy required by the cow for pregnancy.

Milk production

Energy is the most important nutrient determining **milk production** and **milk protein content**. The amount of energy needed depends on the number of litres produced and the composition of the milk (milk fat and protein content). Table 1.6 shows the amount of energy needed to produce a litre of milk of a number of different compositions.

Body condition

Cows gaining condition require extra energy. For each kg of weight gained, an extra 34 MJ of ME is needed.

When a cow loses condition, energy becomes available to the cow. For each kg of weight lost, 28 MJ of ME is released for the cow to use.

When we assess the condition of a cow, we use a system called ‘condition scoring’ (see later). In Australia, the scoring system we use ranges from 1–8 ‘condition scores’, which are based on the degree of fatness of the cow. For Holstein–Friesians, one condition score is equivalent to 42 kg live weight. For Jerseys, one condition score is about 26 kg live weight.

The energy needed for a Holstein–Friesian to gain one condition score is 42 × 34 MJ of ME or 1428 MJ of ME. This energy requirement is above that already needed for maintenance, lactation and pregnancy.

Rules of thumb

Is there another way of calculating cow energy requirements?

There are a number of **rules of thumb** for quickly estimating how much energy a

Table 1.5: Energy needed for pregnancy

	Month of pregnancy			
	6	7	8	9
Extra energy needed (MJ of ME per day)	7ñ8	10	14	19ñ20

cow needs. One rough guide is to use the maintenance requirement which is typical for the herd, multiply the average milk production by 5 MJ, and add the two figures together to get an estimate of the cow's energy requirement. If the average live weight of a Holstein–Friesian herd is 550 kg then (from table 1.4) the maintenance requirement is 59 MJ. If the average milk production is 15 litres, the energy requirement for milk production will be 15 × 5 MJ or 75 MJ. So the total requirement for the average cow will be 134 MJ. This figure is a quick guide only but it can be useful to help you assess if the energy in the ration is adequate.

Example: What is the energy requirement for a 550 kg Holstein-Friesian cow, in late lactation, producing 15 litres of 3.2% protein, 3.8% fat milk. The cow is 6 months pregnant. The dairy is about 2 km flat walk from the day paddocks. The night paddocks are close to the dairy.

Use Table 1.4 to find the maintenance requirement for a 550 cow: 59 MJ

Use Table 1.5 to find the energy needed for pregnancy: 8 MJ

Use Table 1.6 to find the energy needed for each litre of 3.2% protein and 3.8% fat milk (5.2 MJ) and multiply this value by the daily production of 15 litres: 78 MJ

Calculate the energy needed for walking 4 km per day (from the section on Activity, this will be about 1 MJ per kilometre on flat land): 4 MJ

Total energy needed: 149 MJ

How much energy is needed if the same cow is to gain 0.5 kg live weight a day?

Table 1.6: Energy needed to produce milk of various fat and protein compositions

	Milk protein %					
	2.6	2.8	3.0	3.2	3.4	3.6
Milk fat %	Energy needed for milk production MJME/day)					
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

From the section on Body Condition, for every kilogram of weight gain the cow requires 34 MJ of ME. So to gain 0.5 kg per day, the cow will need an extra 17 MJ per day.

Protein

Proteins are made up of **amino acids**. The cow needs 25 amino acids for body metabolism, growth, milk production and the development of the foetus. Of these amino acids, there are 10 which the cow cannot make. These are the **essential amino acids**, which must be supplied in the diet or can be released after the digestion of the rumen microbes (microbial protein) in the small intestine.

The essential amino acids are:

- methionine
- lysine
- histidine
- threonine
- phenylalanine
- tryptophan
- arginine
- branched chain amino acids

Methionine and lysine are considered the main limiting amino acids in cows for milk production.

Amino acids can come from two sources:

- rumen microbes that pass out of the rumen into the small intestine and are digested.
- dietary protein that escapes the rumen and is digested in the small intestine (UDP).

Rumen microbes use the ammonia and nitrogen released from either dietary protein broken down in the rumen (RDP) or from non-protein nitrogen sources such as urea to manufacture their own protein. RDP could be classified as the dietary protein needed by the rumen microbes, not the cow.

Feeds and microbes vary in their ability to supply the different essential amino acids. Some feeds are unbalanced in the essential amino acids they supply. These unbalanced protein feeds (such as corn gluten meal) are less efficient for the synthesis of milk protein than balanced protein sources (such as soybean meal). Rumen bacteria supply most of the essential amino acid methionine and rumen protozoa supply most of the lysine. The overall diet can preferentially encourage the growth of one species of microbe over another by providing the substrate preferred by one group of microbes.

Too much protein in the diet can cause excessive ammonia production in the rumen, especially if the energy level in the diet is inadequate. If this is the case, the rumen microbes don’t have enough energy to convert the ammonia to protein. The ammonia is absorbed from the rumen and enters the bloodstream and travels to the liver. The liver converts the ammonia to urea for excretion into the urine. Energy is needed for this process. High blood ammonia levels is associated with reduced conception in cows (especially heifers).

If there is not enough protein in the diet or too much dietary energy compared with protein, microbial protein synthesis decreases, resulting in a decrease in the total amount of protein available to the cow. The excess energy is used for putting on body condition rather than for milk production.

If there is not enough energy in the diet, the dietary protein (especially UDP) can be used as an energy source, resulting in a poor milk response.

How much protein does a cow need?

The amount of crude protein a cow needs varies throughout lactation. The amount of protein required per energy unit in the diet is much higher for milk production than for maintenance.

A range of crude protein percentages is given below. The high range value is suitable for high-producing cows and those cows receiving significant amounts of supplements. The crude protein should contain 30–35% of UDP.

- In early lactation, the diet should contain 16–18 % crude protein. If the cow is producing over 16 litres a day, the crude protein percentage should be about 18%, with a proportion of the protein as UDP. According to Kellaway, the UDP requirement for cows producing over 16 litres per day is 93 g for each litre over 16 litres.

Example: How much UDP does a cow producing 30 litres in early lactation need?

The cow needs 93 × (30–16) g or 93 × 14 g of UDP or 1302 g.

- In mid-lactation, the diet should contain 14–16% crude protein.
- In late lactation, the diet should contain 12–14% crude protein.
- Dry cows should receive 10–12% crude protein.
- Springers may need 15% crude protein if they are receiving a special ration.

For some rations you will need more specific information on protein requirements. This is given in table 1.7 and 1.8.

Do cows need UDP?

The answer to this question depends on your farm management, the genetic potential of your cows, and the feed making up the rest of the cows' ration. Early lactation cows with a potential for high milk production will need UDP. In early lactation the cow's appetite is depressed and she may not be able to consume enough nutrients for her potential milk production. She will be 'milking off her back'—using her body energy reserves.

If the ration is deficient in feeds providing sufficient energy for maintenance, growth and reproduction, especially in early lactation, the protein supplement will be used by the cow to make up this shortfall in energy. The minimum UDP and RDP requirements for cows at different live weight and milk production are shown in table 1.9. The assumptions used to calculate these figures are:

- 8–10 g of microbial protein is produced for every MJ of ME consumed
- the 'type' cow used in the table is not pregnant and is producing milk with an

Table 1.7: Protein needed for maintenance

Live weight (kg)	Crude protein needed for maintenance (g/day)
450	400
500	430
550	460
600	490
650	520
700	540

Table 1.8: Protein needed for milk production

Crude protein (g) needed for each litre of milk		
4.5% BF 3.6% P	4.0% BF 3.4% P	3.5% BF 3.2% P
92	87	82

BF = butterfat

P = protein

average composition of 4.0% BF and 3.2% P

Fibre

The source of the fibre and how it is degraded in the rumen is important to the cow. **Cellulose** is the major energy source for rumen microbes. **Acetic acid** is a major breakdown product and is important for the production of milk and milk fat production. The importance of fibre has been explained in the Energy section above.

Not all fibre or fibre supplements are nutritional. (Some can be useful as bulk in high grain diets.) The ADF from mature forages, straws and cottonseed hulls is poorly digested in the rumen because much of it is indigestible.

How much fibre is needed by the cow?

A minimum level of dietary fibre is needed to promote rumen function and maintain the milk fat test. The fibre content in a diet can be measured as crude fibre, NDF and ADF. In the USA, NDF is used as the main determinant of fibre in the diet. In Australia, NDF is not routinely measured in feeds and, at present, has to be requested as an additional test.

The minimum ADF content in the total ration should range from 19 to 21%.

If NDF values are available for the diet, the following guidelines, although based on US information, may be useful, especially if partial mixed or total mixed rations are fed (routinely or during drought).

The minimum forage dry matter intake (for hays, silages and pastures) is 2% live weight. A 500 kg dairy cow should be eating a minimum of 10 kg DM of forage daily.

The minimum crude fibre content is 17% or NDF content of 25 to 30%. As a rule, 75% of the NDF in the diet should come from forages. If maize silage is fed, the NDF provided by forage should be 30%.

The minimum amount of forage NDF is 0.9% live weight. A 500 kg cow should get at least 4.5 kg NDF from the forage component of the diet. The maximum NDF

Table 1.9: Minimum UDP and RDP needs of cows for various levels of milk production at various weights, and energy (MJME)

Live weight (kg)	Milk production (litres/day)									
	15		20		25		30		35	
	MJ ME	RDP UDP (g)	MJ ME	RDP UDP (g)	MJ ME	RDP UDP (g)	MJ ME	RDP UDP (g)	MJ ME	RDP UDP (g)
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

intake for feedlot cows is 1.25% live weight or, for a 500 kg cow, 6.25 kg NDF daily. NDF levels greater than this can decrease dry matter intake because of accelerated gut fill.

Fibre deficiency does not normally occur in pasture fed cattle. Lack of dietary fibre, especially from forage sources, can occur during droughts. Lush spring pastures can be low in NDF. If these pastures are fed with high levels of cereal grains, the ration can lack adequate fibre for maintaining milk fat percentage.

When low fibre diets are fed, buffers may be needed in the ration, especially if cereal grains are fed at greater than 4–5 kg/cow/day.

The length of the fibre source fed is important. The minimum length of forage should be 2.5–3.0 cm. Hay should be longer than 4 cm to be effective as roughage. For silage chop, 15–20% should be 2.5–3.0 cm long, to provide an effective fibre length of 8–10 mm. A shorter chop length will allow better packing of the silage but will reduce the buffering capacity. For maize silage, which contains substantial amounts of grain, a chop length of 11 mm or longer can provide effective roughage, although its buffering capacity can be less than that of other silages.

You should calculate the forage to concentrate ratio of the diet, as it can have an important impact on the milk fat percentage. The length of the fibre can affect this ratio. Long fibre stimulates chewing and salivation, resulting in increased buffering by saliva. On pasture, the minimum forage to concentrate ratio is 60:40. Lower ratios can result in milk fat depression. Forage to concentrate rations of 30:70 are possible for cattle on a total mixed ration, providing the forage source is long chop hay.

One practical method of determining if there is sufficient effective fibre in the ration is to calculate the percentage of cows chewing their cud. If less than 50% of cows are chewing their cud at any time, then there is insufficient fibre in the ration.

Minerals, trace elements and vitamins

These are essential nutrients needed for normal metabolism and the function of different enzymes. The cow’s need for these nutrients can vary with her live weight, reproductive stage, level of milk production and other stresses. For example, heat stress increases the cow’s requirement for sodium and potassium. The Appendix lists the mineral and vitamin requirements for dairy cattle.

The mineral content of pastures and grain feeds can vary throughout the year, depending on the soil type, irrigation and fertiliser use and the species of pasture or grain grown.

The **macrominerals** required by the cow are calcium, phosphorus, sodium, magnesium, potassium and sulphur. Suboptimal intake of these minerals can result in reduced milk production, reduced fertility and increased incidence of metabolic diseases.

Tropical pastures have a lower mineral content than temperate pastures. This is mainly true for sodium and phosphorus, and for calcium at certain growth stages (see the DairyLink *Managing Pastures* manual); also, different tropical pastures have different levels. The magnesium content in a pasture declines after potash and nitrogen fertilisers are used.

Cereal grains have low levels of most minerals, especially calcium and sodium. Although cereal grains are believed to be a good source of phosphorus, the phosphorus content can vary depending on the level of superphosphate use on the crop.

The **microminerals** required by the cow are cobalt, copper, iodine, iron, manganese, molybdenum, selenium and zinc. The cow needs these minerals in trace amounts. Excessive amounts can be toxic. Deficiencies of these minerals can result in a poor response to infection, especially at calving time. Using micro- mineral supplements can give variable responses in milk production. Supplementing with zinc (as zinc methionine) reportedly improves hoof condition and hardness.

Many of the **vitamins** needed by the cow are supplied by green pasture. When pasture is limited or unavailable, or when the cows are being fed a ration consisting of cereal grains and conserved forage, vitamins A and E will need to be added to the diet. Pastures containing high levels of polyunsaturated fatty acids (such as some clovers) or pastures that have been sprayed with oil or detergent to control bloat can be deficient in **vitamin E** or **tocopherol**.

In the USA, **vitamin A** or **beta carotene** supplementation is required for udder health.

Analysing the diet for minerals and vitamins may not be enough to determine if the cow is receiving adequate amounts. There are many interactions among different mineral and vitamins in the cow, and a deficiency or excess of one mineral or vitamin can affect the function of another mineral and vitamin, even if there are sufficient amounts in the body. Important interactions which can affect the cow's health are the relationships between calcium, magnesium and sodium; calcium and phosphorus; vitamin E, vitamin A and selenium; selenium and copper; selenium and sulphur; and copper and molybdenum. Other components in the diet can affect the levels of minerals and vitamins in the cow. For example, a diet with inadequate protein can inhibit the uptake of selenium even if the diet contains adequate selenium.

Blood, urine and milk testing for minerals and vitamins is a better method for determining if the cow's diet has enough of these components. If deficiencies are found, the mineral or vitamin can be added to the diet as a premix; added to the water supply; directly administered to the cow as an injection or slow release bolus; or included in fertilisers for pastures or crops.

What are the mineral and vitamin requirements of a cow?

The mineral and vitamin requirements of a cow will vary with stage of lactation, the conditions under which she is housed or fed, environmental conditions, the quality of the feed and other components of the feed. Tables 1.10 and 1.11 are recommendations for a 550 kg adult lactating cow producing 25 litres of milk and consuming 20 kg DM daily. They should be used as a guide for the level of minerals and vitamins that should be supplied in the feed.

If supplemental fat is fed, the calcium level may need to be increased to 0.95% and magnesium level increased to 0.30%.

In hot conditions, increased levels of magnesium (0.30%), potassium (1.30–1.50%) and sodium (0.50%) may be of benefit.

Table 1.11 shows the recommended requirements of the fat soluble vitamin A, D and E for a 550 kg cow producing 25 litres per day, consuming 20 kg of dry matter daily. This table would be of use if the ration to be fed was a total mixed ration where the cows had no access to fresh pasture. Vitamin K, another fat soluble vitamin, is not required in the ration because it is synthesised in the rumen.

Table 1.10: Recommended mineral requirements for lactating dairy cattle

Mineral	Recommended range in ration	Maximum level in ration	Estimated amount/day
Macro-minerals			
Calcium	0.43ñ0.77	2.0	116 g
Phosphorus	0.28ñ0.49	1.0	75 g
Magnesium	0.20ñ0.25	0.50	41 g
Potassium	0.90ñ1.00	3.0	184 g
Sodium	0.18		37 g
Chlorine	0.25		51 g
Sulphur	0.20ñ0.25	0.40	41 g
Micro-minerals			
Cobalt	0.10	10	2 mg
Copper	10	100	204 mg
Iodine	0.60	50	12 mg
Iron	50	1000	1020 mg
Manganese	40	1000	816 mg
Selenium	0.10		3 mg
Zinc	40ñ60	500	816 mg

What feeds supply these nutrients?

(Also see the DairyLink *Managing Pastures* manual.) Pasture supplies all of the nutrients required by the dairy cow. This statement might be surprising, but within limits it is true. Unfortunately, the ideal pasture does not occur on all dairy farms, nor does it exist throughout the year. The species of pasture, the season of the year and how effectively the pasture is used affect the quality of nutrients supplied to the cow. These conditions also determine the quantity of pasture available.

Deficiencies of both the quality and quantity of nutrients can occur in pasture, and you should know how and when to use supplements to correct these deficiencies. This is the basis of ration balancing. This section examines the

Table 1.11: Recommended vitamin requirements for dairy cattle on total mixed rations

Vitamin	Unit	Ration levels: Recommended	Ration levels: Maximum	Estimated amount per day
A	IU/kg	3260 - 4000	67,500	65250
D	IU/kg	1000	10,000	20,250
E	IU/kg	16	2025	315

feedstuffs that can supply different categories of nutrients.

Energy supplements

Cereals

Cereal grains and their by-products are the main sources of energy supplements. These supplements can be fed whole, or as part of a pelleted ration or ration mix.

As a rule, the dry matter and energy contents of most cereal grains are similar. The main exception is oats, which can be lower in energy. By contrast, the protein content of grains can be very variable and can range from less than 6% crude protein to over 16% crude protein. It is a good idea to analyse cereal grains for crude protein content with each harvest shipment; never assume that the next shipment will be similar to the last.

Cereal grains can be poor sources of UDP (except for maize and sorghum). Grains are medium–high in phosphorus but low in calcium.

A large percentage of whole grain can pass through to the faeces undigested, resulting in a loss of energy to the cow and loss of money to the farmer. Usually the contact time between the rumen microbes and whole grain is too short for the grain seed coat to be broken down. Consequently the grain is poorly digested.

All grains, with the possible exception of oats, benefit from some degree of processing, because it makes the grain more accessible to digestion in the rumen. The degree of processing needed for a grain depends on its starch content. With processing, the grain starch and soluble carbohydrates (NSC) become more available to the rumen microbes and the rate of rumen fermentation increases.

Wheat, barley and triticale should be rolled or cracked. These grains contain the highest amounts of starch. Corn and sorghum require fine grinding or hammer milling to release their starch. These two grains can also be cooked or steam flaked.

By-product feeds

The production or manufacture of food industry commodities results in the production of waste that has little commercial value as a product. Dairies operating near areas where these commodities are produced can use the waste or by-products from the production process as cattle feed ingredients.

By-product feeds potentially contain chemical residues. Any fruit and vegetable waste, fibre waste or seed from crops that have been treated with pesticides and herbicides, as well as ‘new’ by-products not previously used in cattle rations, should be tested for chemical residues. **Never assume that residue testing has been performed on a feed. Always ask for residue information before you use a by-product feed.**

Some by-product feeds might have a higher energy content than that reported on the feed analysis report. In the absence of more complex and expensive analysis, the energy content of processed or pelleted feed is estimated from its digestibility and may be lower than the true energy content. Biscuit meal may contain vegetable oil, a concentrated energy source, as well as soluble sugars. Citrus pulp, although important as a source of fibre, is also a good source of soluble carbohydrates such as pectin.

Table 1.12 gives an analysis of common energy feeds.

Fats and oils

Fats are a concentrated source of energy that can supply up to 35 MJME/kg DM.

Fats are useful when the maximum amount of grain to forage ration is fed and the diet still cannot meet the cow's energy needs. Milk responses to adding fat can be up to 3 litres, with an increase of 0.33% in milk fat for each kilogram of fat eaten.

Fats that contain all the hydrogen atoms possible in their structure are **saturated fats**. Those which contain less than the maximum amount of hydrogen are **unsaturated fats**.

Unsaturated fats are less stable, have a lower melting point and are more prone to go rancid than saturated fats. Unsaturated fats are found in oilseeds like soybean and cottonseed, and in the oils from these seeds.

Saturated fats are found in tallow and fats of animal origin.

High fat concentrations in the diet (greater than 7% of the ration) can have negative effects on rumen digestion and microbial growth. Feeding saturated fats reduces the chance of these adverse effects occurring. Vegetable oils should be avoided. Oilseeds such as soybeans and cottonseed can be used, because although they contain unsaturated fat it is released slowly as the seeds are digested.

When you feed fat in a ration the fibre level of the ration should be high, with at least 21% ADF, and an NDF of 28–32%. Calcium and magnesium levels should be raised because these minerals are less available in the rumen, and since rumen bacteria do not benefit from the added

Table 1.12: Analysis of some common energy feeds

Feed	DM%	Metabolisable energy MJME/kg DM		Crude protein (%)		NDF (%)
		Average	Range	Average	Range	
Cereal grains						
Barley	90	13	12ñ13	11	7ñ15	20
Wheat	90	13	12ñ13	12	9ñ16	12
Oats	90	11	9ñ12	9	6ñ13	26
Triticale	90	13	12ñ13	12	8ñ16	8
Maize	90	14	12ñ16	10	7ñ14	9
Sorghum	90	10	7ñ13	11	6ñ15	10
By-products +						
Wheat pollard	90	11		17		36
Biscuit	84	11	10ñ13	8	4ñ12	18
Citrus pulp	18	10	8ñ11	8	6ñ11	23
Brewersí grain	25	10	9ñ11.5	23	21ñ26	42

+ These are only the commonly used by-product feeds. Many by-products from a number of agricultural industries can be used in cattle rations. The analysis for a number of the feeds is listed in several Australian publications, for example: the *Funny Feeds* booklet from NSW Agriculture; *Dairy Cattle Production*, Proceedings No.161, a 1991 publication available from the Post Graduate Foundation in Veterinary Science (phone 02 9264 2122); and the CAMDAIRY computer program.

energy as fat, the level of UDP in the ration should also be increased. Fat should be added gradually to the diet because it can reduce palatability of the diet.

Protected fats bypass the rumen and are digested in the small intestine. These fats can be fed at higher levels without affecting rumen digestion. However, they are very expensive and should be fed only to high producing cows in early lactation—these cows will be losing live weight at a rate that can affect their future fertility and health.

Most feeds contain some fat. When you add fat to the diet, make sure you account for the fat in the entire ration. If the ration is dusty, up to 1% of liquid fat or oil can be added to settle the dust providing the ration does not already a high percentage of fat.

Buffers

What are buffers?

Buffers are substances that help combat the reduced pH that can occur in the rumen from the formation of acids. Saliva is a natural buffer that contains sodium bicarbonate and sodium biphosphate. Feed additives used as buffers include sodium bicarbonate, magnesium oxide (causmag), sodium bentonite and limestone. These feed additives vary widely in their ability to buffer the rumen from very effective to useless.

Why do we need buffers?

Under normal conditions, saliva buffers the formation of acid products in the rumen. Saliva is produced in response to a fibrous diet, which stimulates chewing.

When cows are fed large amounts of cereal grains, the starch in the grain is rapidly fermented to produce lactic acid. This acid has a greater ability to reduce rumen pH than the volatile fatty acids normally released from fibre and protein digestion. The end result is a build-up of acid products in the rumen. The microbes capable of breaking down these acid products can be overwhelmed, so that they slow down production of the by-products needed by other microbes (including those that digest fibre) for growth. As fibre digestion decreases the rumen function slows, and the cow's appetite drops.

This condition is called **lactic acidosis**. It can sometimes occur if cows are fed a 'slug' of cereal grain in the bails during milking.

The risk of lactic acidosis can increase dramatically with some grains if they are processed. Milling or crushing can make the grain starch more readily available for digestion in the rumen. **Wheat** and **triticale** have a high starch content and are highly rumen-digestible (about 60% is digested in the rumen). The risk of acidosis is greater using these grains, so they should be coarsely processed.

The risk of acidosis is lower with whole, uncracked **barley** and **oats**, which have a rumen digestibility is about 40%. Oats, which have a fibrous husk, stimulate greater saliva production and more natural buffering than other grains. Cracking the grains increases digestibility.

The least risk occurs with **sorghum** and **corn**. With these, about 30% of the grain starch is digested in the rumen. When they are fed whole or with little processing, many grains appear in the manure. Both grains can be finely processed to improve digestion.

During drought or at other times when there is little pasture or conserved forage, saliva production and its buffering effect is reduced. Take care feeding cereal grains, because the risk of rumen acidosis can be high. Oats, which have a fibrous husk, may be the safest grain to feed if fed whole.

Feeding buffers can reduce the risk of acidosis in diets which are high grain/low fibre or in which the grain portion of the diet is fed separately from the fibre portion (such as in the milking bails). The feed additives which have been used as buffers, the recommended amounts to use and their effectiveness as buffers are listed in table 1.13.

Avoid sudden changes in dairy cattle rations. Such changes would include introducing cattle to grain or changing from one grain type to other (for example, oats to wheat). Rumen microbes should be allowed to adapt to the change in diet— otherwise milk production and cow health will suffer.

Table 1.14 gives a timetable for introducing pasture-fed cattle to 3 kg/head of cereal grain supplements.

After about 3 weeks the cows will have adapted to the grain diet and you will be able to stop adding the buffer.

Protein supplements

Protein can be provided by a number of supplements. Urea is regarded as a protein feed because it is a source of nitrogen for microbial protein synthesis. It can be used as a substitute for true protein in feed rations and is effective when fed with an adequate energy source. Table 1.15 tells you what's in some common protein supplements.

The protein meals are usually a good source of UDP, although the quality can vary. The UDP levels in vegetable protein meals vary, but generally increase with processing. The manufacturing processes (usually heating and pressing) can vary, and the degree of protection of the protein quality and degradability can also vary. Peanut meal has the same Pdg% as sunflower and safflower meals – that is, 10% greater than that of soyabean meal. Some manufacturers use formaldehyde to reduce the Pdg% of some vegetable meals.

The protein in grain legumes is readily degradable. The percentage of protein in legumes is similar to that in brewers' grain. The crude protein in brewers' grain is approximately 30% UDP because of the heat generated by the fermentation process.

Table 1.13: Some feed additives used as buffers

Additive	% of total diet DM	kg/tonne of grain	Comment
Sodium bicarbonate	1.5ñ2.0	15ñ20	Neutralises rumen acids. Unpalatable if fed at more than 4% of ration. Can clump if feed is moist.
Magnesium oxide (causmag)	Up to 1	10	Neutralises rumen acids. Source of magnesium for treatment of grass tetany. Do not use in springer or close-up rations.
Sodium bentonite	Up to 4	Up to 40	Uncertain effectiveness as buffer. Affects intake of grain by moderating grain digestion in rumen.
Calcium carbonate (limestone)	1.5	15	Uncertain effectiveness as a buffer. Source of calcium.

Table 1.14: Suggested timetable for introducing a cereal grain supplement

Day	Grain per cow (kg)	Buffer (for example, sodium bicarbonate) (% of ration)
1	0.5ñ1.0	0.5
3	1.0ñ1.5	0.5
5	1.5ñ2.0	1.0
7	2.0ñ2.5	1.5
9	2.5ñ3.5	2.0

Because of the ‘mad cow’ scare in Europe there is a voluntary ban on the use of animal protein in cattle rations. A similar ban has existed for the use of chicken litter since outbreaks of botulism occurred in feedlot cattle using this supplement as a protein source.

Roughage supplements

Pastures and conserved forages such as hays and silages provide fibre in the ration. These supplements are usually good sources of energy and crude protein, although the quality can vary as it depends on the maturity of the pasture or crop. Table 1.16 shows what’s in some common roughage supplements.

As roughages mature, the NDF percentage increases but the metabolisable energy and crude protein percentages decrease. Hay cut from late-flowering lucerne would be an excellent source of total fibre but would have a lower energy level (8.2) and crude protein percentage (15%) than hay made from early-flowering lucerne (9.2 MJME; 22% CP).

The quality of silage is affected by how it is conserved and stored. When silage is made, the carbohydrates in the original forage are converted into fatty acids. The decreased pH stops bacterial growth, so that the silage remains good until it is fed. You can find out how well the silage has fermented by measuring (in addition to the usual dry matter, crude protein, energy and fibre content) the acidity (pH), the amounts

Table 1.15: Analysis of some common protein supplements

Feed	DM%	Metabolisable Energy MJME/kg DM		Crude Protein (%)		NDF (%)
		Average	Range	Average	Range	
Urea	100	0		250		0
Grain legumes						
Lupins	92	13	12ñ14	31	27ñ41	27
Cowpea	88	13		24	21ñ26	43ñ61
Faba bean	91	12.5		26		n/a
Protein meal						
Soybean	88	13		51		15
Sunflower	93	10		33		40
Cottonseed	85	12		42	37ñ45	30

and types of acids formed during the ensilage process, the ammonia and the NSC. This analysis can be requested from a Feed Analysis Laboratory.

In the UK, silages are graded according to the composition:

Grade I. High sugar levels with some fermentation acids. Mineral acids are added during ensilage.

Grade II. Low-acid silage with high dry matter content. Wilted pasture is ensiled without being damaged by rain or other mishap. Animals usually perform well on these silages.

Grade III. Normal. Contains mainly lactic acid with some acetic acid. The ammonia level is below 10% of the total nitrogen. Animal performance will reflect the chemical composition of the silage and will not be affected by the fermentation products.

Grade IV. High lactic acid content, high energy, low pH (below 4.0). Reduces the cows' dry matter intake unless fed with a buffer such as sodium bicarbonate.

Grade V. Contains highly volatile fatty acids, extensive fermentation with mainly acetic acid, high ammonia, low energy, unstable. Silages of this grading have been damaged through poor storage. The original pasture or crop may have been too wet, or did not contain enough carbohydrate to produce enough acid, and too much of the protein was broken down to ammonia. Cows that eat it have a low dry matter intake because of its slow digestibility.

Grade VI. Highly acid silage with both lactic and volatile fatty acids and low protein breakdown. Reduces the cows' dry matter intake.

Minerals

The mineral content of a feed or supplement is of little value to formulating a ration unless the availability, or digestibility, of the mineral is known. Biological availability tells how a mineral is digested and used by the animal. As the availability of a mineral decreases, the amount of the mineral needed to meet the

Table 1.16: Analysis of some common roughage supplements

Feed	DM %	Metabolisable energy MJME/kg DM		Crude protein (%)		NDF* (%)
		Average	Range	Average	Range	
Hays						
Lucerne hay	85	8.7	8.2ñ9.2	20	15ñ22	49ñ57
Clover hay	88	9.3	8.2ñ10.2	16	13ñ18	40ñ43
Ryegrass/clover hay	84	9		12		49ñ67
Sorghum hay	89	8		8		68
Silages						
Maize silage	30	9.9		8		48
Ryegrass/clover silage	24	9		13		39ñ58
Sorghum silage	30	8		9		68

* ranges reflect early-late maturing of harvest

cow's requirement will increase. The availability is also affected by the level of other minerals in the diet and the age of the stock. Table 1.17 gives the relative availabilities of some calcium, phosphorus, magnesium and sulphur sources for the cow.

Getting value from feed analysis

How accurate are the results from your feed analysis laboratory? The answer is that they are only as accurate as the sample you sent in for testing.

When you are sending in a feed sample for analysis, follow these rules to make sure the results will be accurate:

- **Make sure the sample represents the feed you want to test.**

  If a sample is taken from a pasture that contains a mix of different species, it should reflect this mix properly. For example, if the pasture is ryegrass with 30% clover, the sample should contain this same mix.

  If you're taking a sample from hay or silage, use a corer. If you want to test a hay shipment, take samples from at least 20 bales to get an average result. If you're testing silage, take a sample from the centre of a round bale, about 10 samples from the face of the pit, or a sample from the silage before it is fed out. Don't take a sample from the outside edge of the bale or pit, as this part has been exposed to air and is

Table 1.17: Relative availabilities of calcium, phosphorus, magnesium and sulphur from common feed sources

Relative availability	**Source** Calcium	 Phosphorus	 Magnesium	 Sulphur
High	Calcium chloride	Monocalcium phosphate	Magnesium oxide	Calcium sulphate
	Monocalcium phosphate	Monosodium phosphate	Magnesium sulphate	Sodium sulphate
	Dicalcium phosphate	Ammonium phosphate	Magnesium carbonate	Potassium sulphate
		Dicalcium phosphate		Magnesium sulphate
Medium	Calcium carbonate	Sodium tri-polyphosphate	Magnesium chloride	
	Limestone	Defluorinated phosphate		
Low	Forages	Low fluorine rock phosphate	Dolomitic limestone	Elemental sulphur
		Soft rock phosphate	Forages, grains	

Note: Bone meal is not recommended because of concerns over 'mad cow disease'.

usually drier or has deteriorated in quality.

Sample cereal grains and feed mixes from the storage bin, not from the feed bails.

- **Send the sample to the laboratory in a sealed plastic bag.**

  If the sample is dry (such as a cereal grain) this will stop it being lost during transport to the laboratory.

  If the sample is moist (such as pasture) try to remove as much of the air as possible from the bag before it is sealed. This will stop the sample drying out and reduce the risk of moulds developing.

  If the sample is silage, freeze it before transport and send it to the laboratory as soon as possible. Silage contains many volatile components and can deteriorate rapidly when exposed to air.
- **Send the sample to the laboratory immediately.**
- **Select the best test for your type of feed.**

  There are several ways the sample can be analysed at the laboratory. The Near InfraRed (NIR) spectrophotometry method can measure the important components of common feeds such as single forage crops or pastures and single cereal grains. If you want tests on mixed feeds (such as grain mix and pasture mix) or unusual feedstuffs (such as a biscuit meal or silage), or if you want a wider than normal range of components measured, then the feed should be analysed by laboratory methods called 'wet chemistry'.

  Feeds may be sent to other specialist laboratories for analysis for different minerals, vitamins, toxins and moulds.

  Feeds can contain other components that have no feed value but can leave residues in the cow, the calf or the milk. These components are usually contaminants such as pesticides, herbicides, insecticides and other chemicals used in the production or preservation of the feed. Any feed source can contain these contaminants and they should be tested for.

Some examples of how you can benefit from feed analysis

The following examples are based on the information presented in this section. Use them as a guide to determining the nutrient content of the feed you are giving your cows.

Example 1: A cow eats 85 kg of ryegrass pasture a day. A sample of pasture is analysed and the following results obtained:

Dry matter	20%
Nitrogen	3.52%
Crude protein	22%
ADF	24%
Energy	11 MJ of ME

How much crude protein and energy is the cow consuming each day?

Step 1: Calculate the amount of dry matter consumed. The cow is eating 85 kg of pasture of which 20% is dry matter. The remainder is water.

Multiply 85 by 20 and divide by 100 to get the dry matter content of **17 kg**:

$$85\ \text{kg} \times 20/100 = 17\ \text{kg}$$

Step 2: Each kg of dry matter contains 22% of crude protein. Remember crude protein is calculated by multiplying the **nitrogen** value by 6.25.

Multiply 17 kg by 22 and divide by 100 to get the total amount of crude protein of **3.74 kg**:

$$17\ \text{kg} \times 22/100 = 3.74\ \text{kg}$$

Step 3: Each kg of dry matter contains 11 MJ/ ME.

Multiply 17 by 11 to get the total energy of the diet of **187 MJME**:

$$17 \times 11\ \text{MJME} = 187\ \text{MJME}$$

Example 2: We have two groups of cows. Each is being fed 22 kg of brewers' grain, but the grain is from two different shipments, A and B. The cows being fed brewers' grain from shipment A are producing 2 litres more milk than those being fed from shipment B. What is the problem?

Feed samples from both shipments were sent for feed analysis. Both shipments have a crude protein percentage of 18% and an energy content of 10 MJME. Shipment A has a dry matter content of 40% and shipment B has a dry matter content of 35%.

The cows fed brewers' grain from shipment A will get (40/100 (DM%) × 18/100 (protein %) × 22 kg) or 1.58 kg of crude protein and (40/100 (DM%) × 10 MJME (energy) × 22 kg) or 88 MJME of energy. Those cows fed from shipment B will get (35/100 (DM%) × 18/100 (protein%) × 22 kg) or 1.39 kg of crude protein and (35/100 (DM%) × 10 MJME (energy) × 22 kg) or 77 MJME of energy.

The lowered milk production in the cows being fed from shipment B is probably due to the lower total protein and energy intake.

Example 3: A cow is consuming 3 kg of a barley – cottonseed meal mix in the bails and is grazing ryegrass pastures. You have used a pasture meter to determine that the average intake of ryegrass pasture per cow is 14 kg dry matter.

The bail mix consists of two 50 kg bags of cottonseed meal to each tonne of barley.

Feed analysis for the barley and cottonseed meal follows:

	Barley	Cottonseed meal
Dry matter	90%	90%
CP	11%	44%
ADF	7%	19%
Energy	13 MJ	11 MJ

The analysis of the ryegrass is the same as in example 1.

Estimate how much crude protein and energy the cow is consuming.

In this example we need to do some calculations on how much barley and cottonseed meal the cow could be getting in the bail feed. We are **estimating** what this cow is eating in the bails. We do not know for certain what the actual content of the bail feed is, even though we know the ingredients. We are assuming that the bail feed is mixed properly, distributing the cottonseed meal throughout the barley grain, and that the feed droppers have delivered 3 kg of this mix to the cow.

Step 1: Calculate the amount of cottonseed meal in the total bail feed. Two 50 kg bags of cottonseed meal are added per tonne of barley. Therefore there are 100 kg of cottonseed meal in each 1100 kg of bail feed (1000 kg of barley and 100 kg of cottonseed meal).

The percentage of cottonseed meal in the bail feed is 100 divided by 1100 multiplied by 100, to give **9.1%**.

100/1100 × 100 = 9.1%

We are also **estimating** the amount of pasture eaten by the cow. She may be eating more than 14 kg dry matter or she may eat less. We have no way of accurately measuring how much she is eating. We know that the entire herd has consumed an average of 14 kg dry matter so we will use the **average figure** for our cow.

Step 2: Calculate the total dry matter consumed by the cow.

The bail feed contains 9.1% cottonseed meal. The cow is consuming 3 kg of the feed. The dry matter content of cottonseed meal is 90%.

Multiply 3 kg by 9.1 and divide by 100. Multiply this answer by 90 and divide by 100 to estimate the cottonseed dry matter intake of **0.25 kg**:

3 kg × 9.1/100 × 90/100 = 0.25 kg

The bail feed contains (100–9.1) or 91.9% barley. The cow is consuming 3 kg of the feed. The dry matter content of barley is 90%.

Multiply 3 kg by 91.9 and divide by 100. Multiply this answer by 90 and divide by 100 to estimate the barley dry matter of **2.48 kg**:

3 kg × 91.9/100 × 90/100 = 2.48 kg

The total dry matter consumed by the cow is **16.73 kg** (0.25 [cottonseed meal] + 2.48 [barley] + 14.0 [pasture]).

Step 3: Calculate the total crude protein consumed by the cow.

We need to calculate the amount of crude protein each component contributes to the ration.

(a) Each kg dry matter of cottonseed meal contains 44% crude protein.

Multiply 0.25 kg by 44 and divide by 100 to get the cottonseed crude protein contribution of **0.11 kg**:

0.25 kg × 44/100 = 0.11 kg

(b) Each kg dry matter of barley contains 11% crude protein.

Multiply 2.48 kg by 11 and divide by 100 to get the barley crude protein contribution of **0.27kg**:

2.48 × 11/100 = 0.27 kg

(c) Each kg dry matter of ryegrass pasture contains 22% of crude protein.

Multiply 14 kg by 22 and divide by 100 to get the ryegrass crude protein contribution of **3.08 kg**:

14 kg × 22/100 = 3.08 kg

The total crude protein content of the diet is 3.46 kg (0.11 [cottonseed meal] + 0.27 [barley] + 3.08 [pasture])

Step 4: Calculate the total energy in the diet consumed by the cow.

We need to calculate the amount of energy each component contributes to the ration.

(a) Each kg dry matter of cottonseed meal contains 11 MJ.

Multiply 0.25 kg by 11 to get the cottonseed energy contribution of **2.75 MJ**:

$$0.25 \text{ kg} \times 11 = 2.75 \text{ MJ}$$

(b) Each kg dry matter of barley contains 13 MJ.

Multiply 2.48 kg by 13 to get the barley energy contribution of **32.24 MJ**:

$$2.48 \times 13 = 32.24 \text{ MJ}$$

(c) Each kg dry matter of ryegrass pasture contains 11 MJ.

Multiply 14 kg by 11 to get the ryegrass energy of **154 MJ**:

$$14 \text{ kg} \times 11 = 154 \text{ MJ}$$

The total energy content of the diet is 189 MJ (2.75 [cottonseed meal] + 32.24 [barley] + 154 [pasture]).

Costing pasture & supplements

Aims of this section

Pasture is the most important source of feed for dairy cattle in Australia. It can supply a well balanced diet very cheaply—this is important if we are to maintain our dairy industry's competitiveness in the world export market.

But there are occasions when pasture alone is not the best feed for the cow.

In this section you will gain a greater knowledge of:

- when and why pasture may not be adequate for feeding cows
- how much pasture can cost as a feed
- when and why feed supplements are used
- how to feed supplements
- how to use cost to compare supplements.

Knowledge level required

To understand this section you will need some knowledge about pasture types and how they are established and used. This information is given in the DairyLink manuals *Establishing Pastures* and *Managing Pastures*.

Why not feed pasture alone?

Pasture is recognised as the cheapest source of feed for dairy cattle. It does not need to be harvested or stored and it doesn't need special facilities for feeding out. The cow harvests what she requires. But you must still make sure that the quality and quantity of the pasture available is adequate for your cows' needs.

How good is pasture as a feed?

The quality of pasture can vary from excellent to very poor, depending upon the species of pasture and its maturity. Tables 2.1 and 2.2 compare different pasture species at different stages of growth.

Table 2.1 shows that the younger the pasture, the greater the energy and protein content and the overall digestibility. So should we feed cows only young pasture?

The answer is both yes and no. It depends upon the physiological state of the cow, her genetic potential for milk production and the nutrient balance in the pasture.

Table 2.1: Changes in protein and energy with maturity and after grazing in a ryegrass pasture (from Feed Evaluation Service Database)

Stage of maturity	Dry matter (%)	Metabolisable energy MJME/kg DM	Crude protein (%)
Young ñ early vegetative	10	11.2	24.6
Flowering	22	9.1	13.8
Regrowth (32ñ38 days)	14	10.9	21.8

Table 2.2: Changes in energy, protein and yield in an oat crop as it matures (from Cole VG, 1981,* Guide to Fodder Crops for Livestock, *Macarthur Press

Stage of maturity	Metabolisable energy MJME/kg DM	Crude protein (%)	Yield kg DM/ha
Immature	12.8	28	2000
Early bloom	12.0	15	6000
Full bloom	8.3	10	8750

Energy

Young lush pasture has a very low dry matter content. Remember that all nutrients in a feed are compared with the dry matter content. In young ryegrass, the energy content is 11 MJ of ME per kg dry matter and the dry matter percentage is only 10%. The digestibility of the pasture is high (80%) and the fibre content (ADF) is low.

If we are feeding the cow from the example on page 1.18 (a 550 kg cow in late lactation producing 15 litres per day), you will remember that she required 149 MJ of ME a day. Her total dry matter intake (using the 'rule of thumb' equation on page 1.12) is 15 kg. At full appetite, the cow could eat 132 MJME from the lush ryegrass pasture (15 kg × 11 MJ × 0.80 [digestibility]), which is 17 MJ less than the energy she requires.

This intake is equivalent to 150 kg of fresh feed, of which 135 kg is water (10% dry matter means 90% water content). The cow would need a large number of hours grazing to take in this much fresh feed. If her grazing time was restricted, the energy deficit in the diet would be greater.

If the same cow was in early lactation, with the potential to produce a peak milk yield of 40 litres, her potential dry matter intake would be 20 kg. Her total energy requirement would be 270 MJ of ME a day.

At full appetite, this cow would be able to consume only 176 MJME from the pasture.

Pasture that has enough energy for a late lactation cow can be unsuitable for an early lactationcow producing 40 litres. However, this pasture may be able to provide enough energy for an early lactation cow with lower production or a late lactation cow.

Energy is only one nutrient we need to consider in pasture. Even if enough energy is provided, deficiencies or excesses of other nutrients can occur. The protein, fibre, macro mineral, micro mineral and trace element contents now need to be considered.

Protein

Lush spring pastures (especially ryegrass and white clover) are usually high in protein (mainly RDP). Pasture is not a good source of UDP. Only 10% UDP is provided by most pastures. High-producing early lactation cows require at least 30% UDP in their diet.

If the RDP content of the pasture is too high, an excessive amount of ammonia will be absorbed from the rumen; this will need to be converted to urea before it is excreted in the urine. High blood levels of both ammonia and urea can reduce fertility. There is some debate about what pasture protein percentage or blood urea level is damaging to the cow and her fertility. New Zealand cattle reportedly can eat diets with RDP levels much higher than those said to cause fertility problems in American dairy cattle and have no ill effects.

Kellaway suggests that RDP intakes greater than 11 g/MJME can lead to fertility problems.

Example: A ryegrass pasture has a crude protein content of 31%, energy level of 12 MJME and dry matter content of 15%. Could this pasture cause a fertility problem?

In most pastures 90% of the protein is RDP. The amount of crude protein for each kg of dry matter is 31 × 15 = 465 g protein/kg DM, of which 90% or 465 × 90/100 = 418.5 g is RDP.

If we divide the amount of RDP by the energy content of the pasture (418.5/12), we get 35 g/MJME, which more than three times over the threshold suggested by Kelloway. This pasture may be the cause of fertility problems in the herd.

Fibre

The proportion of ADF in the NDF fraction of a plant increases as a plant matures—the proportion of indigestible components in the plant increases.

Some pastures have higher levels of NDF at all stages of growth. Kikuyu and paspalum have considerably higher NDF levels than ryegrass and clover.

In young pasture, the low NDF % is accompanied by high crude protein percentages. Since the digestibility of the pasture is high, there will be a rapid passage of feed through the rumen. Excess protein will enter the rumen and be degraded. The nitrogen is converted to ammonia for excretion into the bloodstream and processing into urea. The effect of high ammonia levels was discussed in Section 1.

Mature pastures contain higher percentages of NDF with a higher proportion of indigestible components. The energy content of these pastures is lower because the indigestible fibre can prevent the rumen microbes from reaching and digesting the starches and sugars of the pasture. There is a slower passage of the feed through the rumen. Cows may reach ‘gut fill’ before they can take in enough energy.

Minerals and trace elements

As indicated in the DairyLink *Managing Pastures* manual, the mineral content of pastures can vary considerably.

Most minerals and trace elements are supplied to the plant from the soil. Some soils can be naturally deficient or can become depleted after long-term cropping or grazing. Fertilisers can replace some lost minerals, such as phosphorus, potassium and sulphur. The change in soil pH after fertiliser use can make trace elements such as selenium and cobalt unavailable to the plant. Irrigation and heavy rainfall can leach minerals from the soil or can change the oxygen content of the soil, and this can change minerals into forms that are unavailable to the plant.

Legumes are usually low in trace elements such as selenium, and grasses can be low in copper. Pasture species such as kikuyu can be deficient in calcium and sodium but can contain very high levels of potassium.

Summary

Pasture, although a very good feed source, may not be an adequate feed for high levels of milk production, weight gain, fertility and overall health throughout the year. Supplements can replace the shortfall in pasture quality and quantity or optimise rumen microbial activity during times of excess nutrients.

Substitution

Cows will reduce their intake of pasture if they are offered a dietary supplement. The **rate of substitution** is the reduction in pasture intake divided by the weight of the

Figure 2.1: Predicted substitution rates for a supplement of 80% digestibility on pastures averaging 70% (heavy line) and 50% (light line) (from Kellaway & Porta 1993)

supplement given. For example, if hay is given to a grazing cow, the cow's intake of pasture will decrease by the same amount of hay consumed. The substitution rate of hay is 1.0.

When concentrates are fed, the rate of substitution can vary depending on the amount and quality of the pasture fed, the quantity of the supplement eaten and the degree of processing of the supplement.

Figure 2.1 shows the effect of the availability and digestibility of the pasture on the substitution rate of a concentrate with a digestibility of 0.8.

The substitution rate is less when cows are grazing a pasture of low digestibility or when the availability of pasture is low. The rate of substitution increases with the proportion of concentrate in the diet from 0.6 (if feeding less than 25% of the diet as concentrate) to about 1.2 (if more than 50% concentrates are fed). Substitution is higher if the concentrates are rapidly fermented (for example, wheat starch) than if they are slowly fermented (whole oats).

How much does pasture cost?

Example: Here is an example of the cost of both dryland and irrigated pasture production for 100 milkers on a 74 ha farm (adapted from Kellaway)

Item	**$/ha/year**
Seed, fertilisers and chemicals	194
(Single superphosphate	
Perennial ryegrass	
White clover	
Greentop (20:5:0)	
Nitram	
Muriate of potash	
Annual ryegrass	
Sprayseed®)	
Tractor depreciation	28
Tractor maintenance and fuel	25
Machinery depreciation and repairs	82
Fencing depreciation and repair	12
Labour	242
Rates	40
Dryland total	**623**
Extra costs for irrigation:	
Irrigation electricity	94
Irrigation depreciation and repairs	74
Irrigation pump deprecation	4
Irrigation fittings	6
Irrigation total	**800**

(Cost of buying water for irrigation not included.)

Assume that the pasture production for both dryland and irrigated farms is 15 tonnes DM per hectare. Then the dryland cost of pasture is $41 per tonne DM and the irrigated cost of pasture is $53 per tonne DM.

This example estimates the cost of growing pasture, both for dryland and irrigated pastures. This cost is the **minimum** for each kg of pasture dry matter produced. Unfortunately, a cow does not eat all of this dry matter. It will not eat the pasture to the ground.

As outlined in the *Managing Pastures* DairyLink manual, the persistence of a pasture is affected by the dry matter left after grazing (the residual). For example, if cows are grazing a ryegrass pasture in a good season (when there is adequate rainfall or there is access to irrigation), then the pasture can be grazed down to 5 cm or 1000–1500 kg dry matter without any adverse effect on future production. In a dry season, a greater amount of pasture should be left—about 7–9 cm or 2000 kg dry matter.

When you are calculating the cost of pasture, make sure you assess the amount of pasture left behind after the cows have grazed. This value can help you calculate the approximate use of the pasture, which is:

$$\text{Percentage of pasture used} = \frac{\text{Total dry matter yield} - \text{residual dry matter}}{\text{Total dry matter yield}}.$$

Once you have calculated the total percentage used you can then work out the total cost of the pasture as a feed.

If the total use of the pasture is 50% and the cost of growing the pasture is $67 per tonne DM, then the cost of the pasture as feed is $124 per tonne DM. The poorer the use of the pasture, the more expensive the pasture costs as a feed. In a study of three dairy farms in the Sydney basin and South Coast of NSW, Kellaway found that pasture use ranged from 11% to 40% at different times of the year. The cost of pasture at low utilisation rates approaches the cost of some bought supplements on a dry matter basis!

Why use supplements?

You can get many benefits from using supplements. They can be categorised into two classes: short-term and long-term.

Short-term benefits

Increased milk production and quality

The responses in milk production to feeding supplements normally occur with 1 to 3 weeks, depending on a number of interrelated factors (such as the stage of lactation, degree and level of underfeeding, genetic potential and weight).

Problems with low milk fat percentages or sudden falls in milk protein can be corrected by adding the correct supplement, depending on the severity of the underfeeding. Responses are quite variable.

Milk response to supplementation is greater during early lactation. On most farms, the increased milk production benefit received from feeding supplements to early lactation cows compensates for the cost of feeding the supplements. Long-term responses to concentrates average 1.2 L of milk per kg of concentrate. Short-term responses range from 0 to 0.5 L of milk per kg of concentrate.

At times of low pasture growth, supplements like cereal grains can help maintain milk production until pasture growth improves or until a cheaper source of supplement (such as high quality forage crops) becomes available.

Supplying the nutrients missing in pasture

Pasture can be inadequate in energy, protein, minerals and trace elements at different periods of the year. Milk production can suffer if the right mix of nutrients is not present in the ration.

Providing sufficient nutrients to early lactation cows

After calving, the cow's rumen capacity is too small in relation to the dry matter intake needed to reach her potential milk production. The cow needs a **nutrient dense** ration where the quantities of all the nutrients such as dry matter, energy, protein and fibre are increased in the ration to compensate for her lower appetite. Rations with high amounts of water (low DM %) fill up the rumen before the cow can get enough nutrients for her energy requirements.

Supplementing pasture with energy feeds such as cereal grains can provide a ration that is more energy dense. Other supplements may be needed to meet the protein, mineral and trace element requirements.

After the cow has reached full appetite and her milk production starts to decline (that is, after peak lactation), the nutrient concentration of the feed can be reduced. Most cows will be able to get their nutrient requirements from pasture, although high-producing cows will still need some supplementation.

Long-term benefits

Better pasture use

The DairyLink *Managing Pastures* manual outlines the best ways to manage pastures.

High pasture utilisation, although ensuring pasture quality, can cause insufficient pasture intake for high producing cows. Supplements can make up the shortfall in dry matter intake.

Supplements can be used to reduce overgrazing and meet shortfalls when pasture growth is slow.

Improved body condition of the cows

Lactation length, persistence of the peak milk yield and fertility are all influenced by the cow's overall nutrition.

The cow's body reserves at about the time of calving can influence the amount of milk produced at the time of peak yield. The better the condition of the cow (providing she is not too fat), the greater the chance of her reaching her expected peak milk production.

Cows in good body condition after calving start their heat cycling and conceive in a shorter time than cows in poorer body condition. Fertility is therefore influenced by how the cow was fed during late lactation, during the dry period and the period after calving when most cows are in negative energy balance.

Pasture shortages at certain times of the year may prevent weight gains in lactating cows and dry stock.

Reduced rate of involuntary culling

Voluntary culling is a management decision to cull cows because they are unsuitable in milk production, milk composition or body conformation. Voluntary culling is done to improve genetics and overall milk production.

Involuntary culling means the culling of a cow because of disease or poor production. The cow 'selects' herself to be culled. Cows of high genetic merit may be wasted through involuntary culling because they have a condition that may not have occurred if feeding was adequate.

Increased farm profitability

The use of cost-effective supplements can increase milk production and increase your profits. Other long-term economic benefits are:

- better fertility (fewer services for each successful conception, reduced overall semen cost, reduced cost of treatment of non-cycling cows)
- reduced involuntary culling costs (the cost of raising an increased number of replacement heifers minus the income from the sale of the culled cows)
- reduced costs of disease treatment, especially of cows at calving and early lactation. The metabolic diseases that occur in early lactation are usually the result of inadequate or imbalanced nutrition.

How do I use supplement sensibly?

Basic requirements for feeding supplements

Feeding a supplement involves more decisions than choosing a feed. This section deals with the practical aspects of feeding supplements.

Storage

All supplements must be stored before they are used. It is not feasible or economic to transport supplements to the farm only when they are needed.

Store the supplements so that they don't deteriorate. If a supplement is exposed to moisture or excessive heat and humidity (or air if it is stored as silage), moulds and fungi can grow. These can cause the nutrient content to drop and create health problems in the cattle being fed the supplement.

Silos, feed sheds, feed bunks, silage pits and plastic-wrapped feed bales can provide suitable storage for different classes of feed.

Feeding-out

Dairy bails. Many dairies feed supplements in the dairy bails. If you are feeding in the dairy shed, the minimum requirements are a feeding trough and a means of transferring the feed to the trough. The equipment required to do this can range from a bucket to different types of manual and automatic feed dispensers, feed augers for transferring the feed from the storage to the dispensers, or fully computerised feeding systems.

Advantage of feeding in the dairy bail:

- the farmer can regulate the quantity of each cow's supplement depending upon her milk production or stage of lactation.

Disadvantages of this form of feeding:

- each cow receives a ration of the same composition, despite differences in lactation stage or production
- only feeds that can readily moved by augers can be used, and this can restrict the use of by-product feeds
- dusty feeds can cause respiratory problems in dairy workers and could cause quality problems in milk.

Feed troughs. Feeding a supplement on the ground is a wasteful exercise and can dramatically increase the overall cost of using the supplement. At least 50% of the supplement might not be eaten because it has been trampled by the cows.

Troughs can be used to feed out all types of supplements, including forage supplements. However, unless special feeding equipment (such as a feed wagon) is used, feeding-out can be labour intensive, especially if the trough is above ground level. Clean the troughs and remove all uneaten food before you add new feed; doing this is labour intensive too.

There should be enough space at the feed trough for all cows. If there is not enough space, heifers and the less dominant cows in the herd will be disadvantaged.

Feed pads. A feed pad can be set up using a fence line or an electric fence to stop the cows walking on the feed, or it can be a concrete-based feeding area with head bails in a feed shed.

As with trough feeding, the use of feed pads can be labour intensive if you do not use equipment to feed out and to clean the uneaten feed from the pad.

Pelleting

Pelleted feed is available commercially.

The main advantage of using pellets is the convenience—there is no need for capital equipment such as a feed mixer or for a labour unit for processing the feed, there is little dust if the pellets are fed in the dairy bails, and there is no risk of cows selectively eating part of the ration and neglecting another.

The main disadvantage with using pellets is the lack of control the farmer has over the composition of the feed in the pellet and the quality of the feed ingredients. One component inthe feed—such as the cereal grain source—can be changed between shipments, and this can lead to digestive problems in the cow. The ingredients cannot be changed to 'fine-tune' the ration if there is a change in the quality of the forage component.

When you buy pellets, ask for the nutrient analysis of the pelleted ration. The analysis should show the energy content, the protein quality (including RDP and amino acid content), the proportion of crude protein percentage which is urea, and the quantity of added minerals, vitamins and other additives. Get this information for every new shipment of pellets.

Pre-mixed supplements

Local feed merchants and feed companies can supply supplements ready for use on the farm. You can decide on the mix, or a private nutrition consultant or a nutritionist employed by a feed company can do it.

The advantages of using these mixes over pellets is that you have more control over the ingredients, which can be adjusted to suit changes in other parts of the ration. The mix can be fed directly into the dairy bail or a feed trough, or mixed with a forage before feeding out. A feed mixer and labour is required.

Home mix

Mixing the cow's ration on-farm allows you to buy the ingredients you want and then mix them to your cows' requirements to a recipe devised by you or a nutritional consultant. You can buy ingredients like grains and by-products more cheaply in bulk, but you need plenty of storage. If you don't have enough storage and have to buy bagged feed, the price of the supplement will increase dramatically.

The capital equipment required for home mixes can be expensive. The minimum requirement is a good feed mixer. If cereal grains have to be processed, you will need a rollermill or hammermill. If you are using more than one supplement, you might need a number of augers. If the feed mix has multiple ingredients and/or forage must be added, then you will need a feed wagon capable of weighing ingredients as they are added. Without the correct equipment, home mixes can be very labour intensive as well as inaccurate. Making a poorly mixed supplement can be an expensive exercise.

The cost of supplying a good home mix may exceed any savings you make by buying cheaper ingredients, especially in small dairy herds. The economies of scale occurring in larger dairy herds (greater spread of fixed costs over greater total milk production) make home mixes more profitable than other methods of supplementation.

How do I choose a cost-effective supplement?

Many supplements have similar nutrient values. Which supplement should I use?

One method of selecting supplements is by their **unit cost.** This is the cost per unit of nutrient (which can be energy, crude protein or UDP).

The basic formula is:

$$\frac{\text{Cost per tonne delivered of feed)}}{1000 \times \text{(nutrient content in diet)} \times \text{DM \%}}$$

in $/ MJ.

So if barley is $190 a tonne delivered, the DM content is 90% and the energy content is 12 MJME/kg DM, then the cost per unit of energy is:

$$\frac{190}{1000 \times 12 \times 90/100} \quad \text{or 1.7c/MJ.}$$

Supplements may provide more than one nutrient, so you should work out the cost of the other nutrients using the equation above. For example, brewers grain provides both energy and protein and can be a source of UDP.

Remember, though, that cost is only one factor involved in selecting supplements. You should consider all the ingredients in the ration when you select a supplement.

Working out a ration

Aims of this section

The nutrients in the dairy cow's diet must be in the right proportion to keep her healthy and support milk production, pregnancy and growth. Any imbalance in the ration can result in poor milk production or other signs of ill health. Remember that we are also feeding the cow's rumen as well as the cow.

To get the correct balance in the ration we must calculate the cow's requirements for maintenance, growth, milk production, pregnancy and overall activity, and then match these to the nutrients provided in the feedstuffs we intend to use to make up the ration.

In many cases, you can devise a basic ration using a pen, paper and calculator. There are also several computer packages that can help you formulate a cow's ration in more detail than by hand.

The computer packages are tools for helping with complex calculations; don't expect the computer to substitute for the knowledge you do not have.

A computer is only accurate when the information you give it is accurate—it can't make concessions for mistakes in feed analysis or estimations of cow feed intake.

In this section, you will:

- learn what information you need to collect before you start doing your calculations or using a computer package
- work out whether a sample ration is adequate.

Knowledge level required

- completion of Sections 1 and 2 of this manual
- basic computing skills.

Guidelines for feeding dairy cattle at different stages of lactation

Before you work out your ration you must get clear in your mind what your cows need at this moment . The dry matter intakes and energy requirements of dairy cattle vary according to their live weight, milk production, activity, body condition and stage of pregnancy. Methods for estimating these values have been given in section 1 under 'What nutrients does the cow need?'.

The guidelines in table 3.1 are based on cattle receiving a total mixed ration. Some figures (such as the crude protein figures) are higher than those normally quoted for pasture-fed cattle. The higher milk production of these cattle and the inclusion of nutrients such as fat in these diets make these higher requirements necessary. These rations are formulated to maximise the amount of microbial protein produced in the rumen by balancing the dietary carbohydrate and protein.

If you need to know the amount of a nutrient in grams per kg DM, multiply the percentage value by 10.

What else do I need to know before I can balance a cow's diet?

Important abbreviations

We discussed the following abbreviations in Section 1; refer back to this section if you don't remember what these measurement units mean.

DM Dry matter

Table 3.1: Nutrient needs of dairy cattle at various stages of lactation

	Milking			Dry cow	
	Early	Mid	Late	Dry	Springer
Protein					
CP (%)	17.5ñ19.5	15ñ17	14ñ15	12	14.5ñ15
UDP (as % of CP)	35ñ40	33ñ37	30ñ36	30ñ35	33ñ38
Carbohydrate					
ADF (min. %)	17ñ21	19ñ22	21ñ25	30ñ35	25ñ29
NDF (min. %)	28ñ31	28ñ33	34ñ40	42ñ50	37ñ43
Min. forage NDF (%)	18ñ23	19ñ23	21ñ25	35ñ38	31ñ34
NSC (%)	35ñ42	34ñ43	32ñ45	30ñ40	34ñ40
Min. forage in diet (%)	40ñ45	45ñ50	50ñ55	60	55
Energy					
Average energy of ration (MJME)	11.4	11.2	10.6	8.9	9.9
Total fat (%)	5ñ7	5ñ6	3ñ5	3ñ4	3ñ5
Macro-minerals (% of ration)					
Calcium	0.80ñ0.85	0.70ñ0.80	0.65ñ0.75	0.60ñ0.80	0.60ñ0.80
Calcium if diet has added fat	0.90ñ1.10	0.90ñ1.00	0.85ñ0.95	ñ	ñ
Phosphorus	0.48ñ0.55	0.43ñ0.47	0.38ñ0.42	0.30ñ0.36	0.34ñ0.40
Magnesium	0.32ñ0.40	0.28ñ0.35	0.25ñ0.30	0.18ñ0.20	0.20ñ0.25
Potassium	1.20ñ1.40	1.00ñ1.20	0.90ñ1.00	0.70ñ0.80	0.70ñ0.80
Sodium	0.20ñ0.30	0.18ñ0.25	0.18ñ0.25	0.10	0ñ0.10
Chlorine	0.25ñ0.30	0.25ñ0.30	0.25ñ0.30	0.20	0.20
Salt	0.25ñ0.50	0.25ñ0.50	0.25ñ0.50	0.22ñ0.25	0ñ0.25
Sulphur	0.20ñ0.25	0.20ñ0.25	0.20ñ0.22	0.16ñ0.20	0.16ñ0.20
Nitrogen: sulphur ratio (N:S)	11ñ13:1	11ñ13:1	10ñ12:1	10ñ13:1	5ñ12:1

CP — Crude protein
RDP — Rumen degradable protein
UDP — Undegraded protein
NPN — Non-protein nitrogen (such as urea)
ME — Metabolisable energy, expressed as megajoules of metabolisable energy per kilogram dry matter (or MJ of ME/ kg DM)
kg — kilogram

Table 3.1: Nutrient needs of dairy cattle at various stages of lactation *continued*

	Milking			Dry cow	
	Early	Mid	Late	Dry	Springer
Micro-minerals (mg/kg DM)					
Cobalt	0.5	0.4	0.3	0.3	0.4
Copper	20	15	12	12	20
Iodine	0.8	0.8	0.8	0.5	0.5
Iron	100	100	100	100	100
Manganese	70	60	50	60	70
Selenium	0.1	0.1	0.1	0.1	0.1
Zinc	80	70	60	70	80
Vitamins					
Vit A ◊ 1000 IU/day	150ñ250	100ñ150	75ñ100	75ñ100	100ñ150
Vit D ◊ 1000 IU/day	40ñ60	30ñ50	25ñ35	25ñ30	25ñ35
Vit E IU/day	600ñ800	400ñ600	300ñ500	400ñ600	600ñ1000

Information you must know before you formulate a ration

If we want to formulate a ration for cows, whether by using a pen, paper and calculator or a computer package, we need to know the following information:

Average cow live weight (kg)

This can be assessed for the herd or it can be assessed for different lactation groups such as early lactation (up to 100 days), mid-lactation (100–200 days) and late lactation (over 200 days). If a ration is being formulated for heifers or dry cows, estimate their weights too.

Live weight change (kg/day)

Cow live weights change throughout the lactation cycle. We can monitor these changes by **condition scoring**. We can estimate how much weight a cow needs to gain or how much she could lose by scoring changes in her condition.

Condition scoring is explained fully in section 4. Important information to remember is that one condition score change in:

- Holstein–Friesians equals 42 kg live weight
- Holstein–Jersey crosses equals 34 kg live weight
- Jerseys equals 26 kg live weight.

For Brown–Swiss and Australian Red breeds (Ayrshire, Illawarras) use the average Holstein–Friesian values. For Guernseys, depending on their size, use the Jersey values or the crossbred values.

Example: a Holstein–Friesian cow needs to put on one condition score between the third and the sixth month of lactation (from condition score 3.5 to condition score 4.5).She should remain at this condition for the next three months of lactation. How much weight should she gain each day?

The cow needs to put on one condition score over the next three months. If the weight is to be gained slowly, the daily weight gain would be 42 kg divided by 90 days—or 0.5 kg/day.

Milk yield (litres)

You need to estimate the potential milk yield for each lactation group as a whole. Some cows may produce more, and some less, depending upon their breeding, health (mastitis history, milk fever episodes, lameness) and physiology (first calf heifer, pregnant cow). However, the average milk production for a group should be good enough for the purposes of your calculations.

Milk composition (% butterfat, % protein)

The energy needed to produce a litre of milk differs depending on the composition of milk (see table 1.6). The cow uses more energy to produce a litre of milk with high butterfat and protein than a litre of milk with lesser composition.

Remember that there is a genetic influence over how much butterfat and protein a cow can produce. Even the best diet will not achieve good milk composition in a cow if she does not have the right genetics.

Estimated feed intake of the cow (kg/ day)

Calculate the estimated daily intake of a cow using the following equation:

(2.2 x live weight + 20 x daily milk production) / 100.

DM values

Every feed analysis will give a dry matter percentage. Appendix 1 describes how you can determine the dry matter on your own pasture using a microwave or ordinary oven.

We need to know the dry matter content of the feed because this value determines how much feed the cow can eat. We should be able to convert the dry matter value to an **as fed** value so that we know the total volume of feed that has to be fed out or added to a mix.

ME and CP value of feeds

The ME and CP values of feeds are two important measures for formulating a ration if you are doing the calculations yourself. You should also be aware of the fibre content (NDF and ADF), the types of proteins present in the feeds (RDP, UDP, NPN), the digestibility of the feed and the mineral and vitamin content. When you include these latter factors into the formulation, the calculations can become complex. Fortunately, there are a number of computer packages for ration formulation that not only do the calculations but also have databases containing information on the analysis of most of the common feeds we use in dairy cow rations.

Example: A cow in mid-lactation with an estimated feed intake of 15 kg is being offered a cereal grain – hay mix in a ration of 1 part grain to 2 parts hay. The dry matter content of the grain is 90% and the dry matter content of the hay is 75%. If we have 20 cows with these requirements, how much feed do we need each day?

The ration for a single cow will be 5 kg dry matter grain and 10 kg dry matter hay. We need to convert the dry matter values to **as fed** values. This means that we need to include the moisture content of the feed. The **as fed** amount is calculated by multiplying the dry matter amount in kg by the inverse of the dry matter percentage. Grain has a dry matter content of 90% or (90/100) so the inverse is (100/90).

So the total **as fed** amount is 5.6 kg grain (5 ∞ 100/90) and 13.3 kg hay (10 ∞ 100/75) for each cow.

For 20 cows we will need to supply 112 kg of grain and 266 kg hay.

Handy hints

- One small bale of hay weighs 25–33 kg.
- One large bale of hay weighs 440–600 kg.

Working out whether a ration is adequate: step by step example

Now that you have collected as much information about your cows and the feeds you intend to use, you should be ready to calculate whether the ration you are using is supplying all the needs of your herd.

The following example calculates the requirements and ration for a **550 kg cow in late lactation**.This is the same cow we calculated the energy requirements for in section 1 of this manual (see page 1.18 of section 1).

After the example you may be asking the question, 'Why aren't my cows producing more milk?' There are many reasons why cows do not reach a certain production level. The genetics of the herd is one main constraint that cannot be solved in the short term, but there are other causes that can be resolved—and the adequacy of the ration is one.

Now to fill in the charts. First work out the nutrient needs of your cow. You will need to refer to the tables mentioned in the charts to get some of the figures.

Step 1: Work out your cow's daily needs

Energy needed

Use this chart to calculate how much energy one cow needs:

Protein needed

Cowís live weight		550 kg
Months pregnant		6
Distance walked		4 km (flat terrain)
Weight gain needed		0.5 kg/day
Daily milk production		15
Milk composition	Fat %	3.8
	Protein %	3.2
Predicted dry matter intake		15 kg
Energy needed for maintenance (table 1.4)		59 MJ
Energy needed for pregnancy (table 1.5)		8 MJ
Energy needed for activity		4 MJ
Energy needed for weight gain		17 MJ
Energy needed for milk production (table 1.6)		78 MJ
Total energy needed (MJ of ME each day)		166 MJ

Use this chart to calculate how much protein the cow needs:

Cowís live weight		550 kg
Days in milk or stage of lactation (early, mid, late)		late
Daily milk production		15 litres
Milk composition	Fat %	3.8
	Protein %	3.2
Crude protein needed (g) (tables 1.7 and 1.8)		460 + 1230 = 1690 g (12ñ14% of total diet)
minimum RDP needed (g) (table 1.9)		1168
minimum UDP needed (g) (table 1.9)		209

Fibre needed

The minimum fibre content in the diet should be 19–21% ADF. If NDF values were available for feed, then the NDF% should be from 25–30%.

Calcium and phosphorus needed

The minimum amount of calcium and phosphorus required is 0.65% and 0.38% of ration dry matter respectively. (see Table 3.1). The ratio of calcium to phosphorus in the diet should be between 1.2:1 and 1.5:1.

Step 2: Work out what the ration supplies

The ration to be fed in this example is a pasture/barley/lupins/hay mix. The estimated intake for each cow is **25 kg of pasture, 4 kg of barley, 2 kg of lupins and 5 kg of hay.**

You can get information on the feed composition of the diet from a number of sources:

- Feed composition tables in books, farming magazines or hand-outs
- Results from the analysis of the feed by a feed testing laboratory
- Analysis information from the label of a feed product or information from the company which supplies the feed.

The dry matter percentage of pastures can be calculated using the microwave method explained in Appendix 1.

Table 3.2 contains information on feed composition that is used in this exercise.

Table 3.2: Feed composition data

	Composition of feeds on a dry matter basis							
	DM %	MJ of ME	CP (g)	RDP (g)	UDP (g)	Fibre (g)	Calcium (g)	Phosphorus (g)
Pasture	20	11	271	190	81	130	7.3	3.2
Barley	90	13.7	120	96	24	53	0.8	3.7
Lupins	90	13.2	300	180	120	140	2.2	3.9
Hay	90	8.4	86	60	26	330	6.2	3.4

Dry matter intake

kg dry matter eaten = kg eaten x dry matter percentage/100

Use this chart to calculate how much dry matter the cow is getting:

	Dry matter percentage	kg eaten per cow	kg of dry matter eaten per cow
Pasture	20	25	5
Cereal grain or pellet (barley)	90	4	3.6
Hay	90	5	4.5
Silage			
Supplement 1(lupins)	90	2	1.8
Supplement 2			
Total dry matter intake per cow per day			14.9 kg

Energy intake

MJ of ME supplied to each cow = kg dry matter eaten x MJ of ME supplied per kg of dry matter**.**

Use this chart to calculate how much energy the cow is getting:

	MJ of ME supplied per kg of dry matter	kg of dry matter eaten per cow (calculated in the previous chart)	MJ of ME supplied to each cow
Pasture	11	5	55
Cereal grain or pellet (barley)	13.7	3.6	49.3
Hay	8.4	4.5	37.8
Silage			
Supplement 1 (lupins)	13.2	1.8	23.8
Supplement 2			
Total energy intake per cow			165.9 MJ of ME

Protein intake

Use this chart to calculate how much crude protein the cow is getting:

	% crude protein	g of crude protein per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of crude protein supplied to each cow
Pasture	27.1%	271	5	1355
Cereal grain or pellet (barley)	12.0%	120	3.6	432
Hay	8.6%	86	4.5	387
Silage				
Supplement 1 (lupins)	30.0%	300	1.8	540
Supplement 2				
Total crude protein intake per cow				2714 g

Protein intake as RDP

Use this chart to work out the cow's RDP intake:

	% RDP in feed	g of RDP per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of RDP supplied to each cow
Pasture	70	190	5	950
Cereal grain or pellet (barley)	80	96	3.6	346
Hay	70	60	4.5	270
Silage				
Supplement 1 (lupins)	60	180	1.8	324
Supplement 2				
Total RDP intake per cow				1890 g

Protein intake as UDP

Use this chart to work out the cow's UDP intake:

	% UDP	g of UDP per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of UDP supplied to each cow
Pasture	30	81	5	405
Cereal grain or pellet (barley)	20	24	3.6	86
Hay	30	26	4.5	117
Silage				
Supplement 1 (lupins)	40	120	1.8	216
Supplement 2				
Total UDP intake per cow				824 g

Fibre intake

Use this chart to calculate how much ADF the cow is getting:

	Fibre (% ADF)	g of fibre per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of fibre supplied to each cow
Pasture	13.0	130	5	650
Cereal grain or pellet	5.3	53	3.6	191
Hay	33.0	330	4.5	1485
Silage				
Supplement 1	14.0	140	1.8	252
Supplement 2				
Total ADF intake per cow				2578 g

Calcium intake

Use this chart to calculate how much calcium the cow is getting:

	Calcium (%)	g of calcium per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of calcium supplied to each cow
Pasture	0.073	7.3	5	36.5
Cereal grain or pellet	0.008	0.8	3.6	2.9
Hay	0.062	6.2	4.5	27.9
Silage				
Supplement 1	0.022	2.2	1.8	4
Supplement 2				
Total calcium intake per cow				71.3 g

Phosphorus intake

Use this chart to calculate how much phosphorus the cow is getting:

	Phosphorus %	g of phosphorus per kg of dry matter	kg of dry matter eaten per cow (already calculated)	g of phosphorus supplied to each cow
Pasture	0.032	3.2	5	16
Cereal grain or pellet	0.037	3.7	3.6	13.3
Hay	0.034	3.4	4.5	15.3
Silage				
Supplement 1	0.039	3.9	1.8	7
Supplement 2				
Total phosphorus intake per cow				51.6 g

Step 3: Put it all together

Summary of cow's daily requirements

Use this chart to summarise the cow's daily needs:

Predicted dry matter intake per cow	15 kg
Total energy needed for the cow (MJ of ME/day)	166 kg
Crude protein needed	1690 g
minimum RDP needed	1169 g
minimum UDP needed	209 g
minimum calcium needed	97.5 g
minimum phosphorus needed	57 g

Summary of cow's daily ration

Use this chart to summarise the cow's daily intake:

Total dry matter intake per cow	14.9 kg
Total energy intake	165.9 MJ of ME
Crude protein intake	2714 g
Crude protein percentage	18.2%
RDP intake	1890 g
UDP intake	824 g
Total fibre intake	2578 g
Total fibre percentage	17.3%
Total calcium intake	71.3 g
Total phosphorus intake	51.6 g
Calcium to phosphorus ratio	1.38: 1

Now you have all the figures written down in the charts, study them carefully. Does the ration have sufficient energy, protein and fibre to supply the cow's requirement for maintenance, pregnancy, activity, milk production and weight gain?

- For this cow, she is eating to capacity and there is adequate energy supplied in the ration for her needs.
- These is too much crude protein.
- Fibre intake is borderline.
- Even though the calcium to phosphorus ratio is in the correct range, the ration is deficient in both calcium and phosphorus.

Adding calcium and phosphorus to the diet would be the major change. Adding dicalcium phosphate (310 g calcium per kg DM; 130 g phosphorus per kg DM) at the rate of 0.08 kg per cow per day would increase the calcium content of the ration by 24.8 g and the phosphorus content by 10.4 g.

Removing the lupins from the diet and increasing the barley and hay content may be a solution if the excessive protein and marginal fibre are considered detrimental to the cow's production. Hay has less RDP and more fibre; although it has less energy it is sufficient.

Note that adding hay and grain would slightly change the calcium and phosphorus intake.

The ration should be formulated to suit the majority of cows in the herd. The cows' requirements will change during lactation and the dry period (see Table 3.1). In some cases a single ration will not be suitable. If the dairy herd is large, it could be separated into 'strings' (groups of cows at the same stage of lactation) that can be fed rations of different energy, protein and UDP levels. Some farmers may opt to feed different amount of concentrate in the milking bails to achieve the same result. The downside with the latter method of feeding is that some cows may be receiving too large a 'slug' of high energy – low fibre feed, such as cereal grain, which would upset the activity of the microbes in the rumen. A balanced bail feed such as formulated pellets may decrease the chance of these upsets occurring.

Can I use a computer for ration balancing?

Teaching the use of a computer package for developing a ration for a herd is beyond the scope of this manual. There are a number of computer packages available and training courses for use of these packages are available. You may already have a nutritional adviser who uses a computer package.

With any computer program, the value of the output from the program depends on the quality of the information entered and how the information which is produced is interpreted. Never assume that the computer is always right. There is an old computer term, 'GIGO', which means 'garbage in—garbage out'.

Consider the computer and any software package as a 'dumb slave'. The computer will do all the complex calculations needed to determine the value of a ration for your herd. It will calculate the amount of milk that could be produced. It will show the adequacy of the ration for all nutrients (including minerals) and for maintaining or increasing body condition. One further calculation that can be done is the total cost of feeding your cows for each litre of milk produced.

One feed ration computer program for dairy farmers is CAMDAIRY. Before you use this program, you will need the following information about your farm, your herd and the feeds you intend using.

Milk production details

- peak milk production (the amount of milk the average cow should produce 6–10 weeks after calving)
- average milk fat percentage
- average milk protein percentage
- total weekly milk production for market milk (quota) and price received per litre
- total weekly milk production for manufacturing and price received per litre.

Herd details

- breed of cow
- number of cows in milk
- average adult live weight
- average condition score of the cows (degree of fatness)
- percentage of heifers in the herd
- average heifer live weight
- average heifer condition score
- average number of weeks since calving (average 'days in milk') for the herd

- average number of weeks pregnant
- activity level of the herd. The amount of walking the cows have to do each day depends on the terrain of the farm and the feeding system used. The cows may be kept in a feedlot, on abundant pasture, sparse pasture or very hilly terrain. The amount of energy above maintenance needed in the diet to compensate for this activity is calculated by the farmer.

The dairy herd may be separated into different groups for milking or for feeding. The information above can be redone for each group of cows in the herd—for example, early lactation cows are fed a separate ration from mid- and late lactation cows.

Feed information

List all feeds in the ration, including the type and stage of maturity of pasture. Estimate the amount of each feed fed to an individual cow on an ‘as fed’ or ‘dry matter’ basis. Estimate the cost of each feed per tonne (including the cost of producing pasture).

The computer program has a database where the information on most feeds are stored. If you are using a feed or pasture that is not in the database, you can enter information on its nutrient content into the program if you have the feed analysis results for that feed. If you are missing different information on a feed (such as its NDF or mineral content), then the overall analysis of the ration generated by the computer will be deficient in these nutrients.

Fine-tuning your feeding

How do you measure the success of the ration you are feeding? The most obvious measure is milk production—but what if the cow is a growing heifer or dry? Then you must use condition scoring. Body condition scoring is an important tool for determining whether a ration is adequate for body maintenance at different stages of growth and lactation.

If the ration is imbalanced, the cow can show signs of ill-health. These conditions will often require veterinary treatment, but they can be prevented by using the proper ration.

This section will help you to understand these and other issues you need to know about if you are to fine-tune your rationing.

Aims of this section

In this section, you will:

- learn about and use body condition scoring
- learn to recognise the different metabolic diseases
- learn how changes in diet can affect milk composition
- gain a better knowledge of the role of macro minerals and micro minerals in a cow's ration
- learn about the use of transition rations for springer cows.

Knowledge level required

- sections 1, 2 and 3 of this manual
- general knowledge of dairy cows.

Body condition scoring

Why measure body condition?

It is normal for cows to use their body reserves and lose weight in early lactation. If a cow loses too much body weight at this time she will be much more prone to metabolic diseases such as ketosis or acetonaemia.

It is important to manage live weight loss by feeding correctly, so that there is no adverse effect on milk production or the ability to get in calf.

Cows that are thin at calving will preferentially gain weight after calving, when they should be putting all their energy into milk production.

Cows that lose more weight during early lactation for milk production are more prone to metabolic diseases such as ketosis and poorer fertility.

One body condition score equals:

- 42 kg live weight in a Holstein–Friesian
- 34 kg live weight in a Friesian–Jersey cross
- 26 kg live weight in a Jersey

At calving, one body condition score means an extra:

- 130 litres milk
- 10 kg butterfat
- 15% butterfat

during the first 20 weeks of lactation.

How does body condition scoring work?

Body condition scoring (BCS) tells us the amount of stored energy reserves in a cow's body. These reserves affects health, production and reproduction.

There is no one ideal BCS for a cow; instead, there is a range of desirable scores that can vary during lactation and the dry period. It is the change in BCS for individual cows over time that is important. Body condition score charts available from some animal health companies will give you a good guide to what to look for.

By regularly evaluating the body condition of your cows and heifers you can fine-tune their feeding management. BCS is an essential tool for the progressive farmer. It can be masteredwith a little training and by using good observation skills.

In Australia we use BCS from 1–8. In the USA, BCS ranges from 1–5. To convert from the American system to the Australian system, simply multiply the BCS by 1.6 or multiply by 8 and divide by 5.

BCS 1—8 system hints

The BCS technique is subjective, so the same person needs to score the cows on a regular basis for the scores to be repeatable. However, on occasions you should get someone who does not see the cows every day to condition score the cows, just to keep you on track. Working with cows every day can make you less aware of changes in their condition.

Regular monitoring of first and last batches of cows through the dairy is all you need to do. However, you might want to condition score cows at different stages of lactation.

When is the best time to score the cows?

- at calving
- after calving
- at the time of mating (either natural mating or artificial insemination)
- when you are checking cows for pregnancy or at mid-lactation
- at drying-off
- during milking time, when the cows are in the yard.

What should the BCS be at different times?

Early lactation

In early lactation the cow’s appetite is only 75% of her potential intake of dry matter. Her energy requirements for milk production exceed her appetite. Her body reserves are used to make up the deficit, so she will lose weight during the first 100 days.

Cows should calve at BCS between 5 and 6. These cows have a greater chance of reaching peak milk yields, and their peak yields and lactations persist longer **providing the ration is both adequate and balanced**.

They should lose a maximum of 1.5 condition scores during the first month after calving when they are in negative energy balance. If cows lose more condition it could be difficult to get them into calf.

Cows calving at lower BCS will have poor body energy reserves for peak lactation and reproduction. These cows will direct many of the nutrients in their diets into improving body condition. Milk production will suffer as a result. They may not start their heat cycles for more than 40 days after calving.

Cows calving at higher BCS may have difficulty at calving because fat in the birth canal can prevent normal birth. Fat cows are prone to a number of metabolic diseases, such as ketosis, where the by-product of fat metabolism builds up in the blood stream, affecting normal liver function. The liver is important in converting chemicals absorbed from the rumen into energy (glucose) and body fat (triglycerides). It is also important in removing toxins from the blood. In serious cases, the by-products can give an ‘acetone’ smell to the breath.

Mid-lactation

In mid-lactation the cow is able to eat more dry matter, and this enables her to meet the demand for milk production and early pregnancy without using her body reserves. This means no major weight loss or gain during this second 100 days. Cows may reach BCS 4 at this time.

Late lactation

In late lactation a cow's appetite exceeds her requirement for energy, so she puts the nutrients in her feed towards gaining body condition over the 100 days in order to prepare herself for the next lactation. The cow needs to be at BCS 5 by drying-off time.

Dry period

A cow puts on weight more efficiently during late lactation than when she is dry. If the cow dries off at BCS 5 she needs to be maintained only at that score during the dry period. This helps stop her getting over-fat and having calving problems, or developing metabolic disorders in the next lactation.

About 1500 MJ of ME are required for each BCS unit gained by a lactating cow. About 2000 MJ of ME are required for each BCS unit gained by a dry cow. This means that more feed will be needed for each BCS unit if the cow is to put on condition when she is dry.

Understanding the metabolic and nutritional diseases of dairy cows

There are four main metabolic diseases that you need to know about if your cows are to stay healthy and make good weight gains:

- hypocalcaemia (milk fever)
- hypomagnesaemia (grass tetany)
- ketosis (acetonaemia)
- acidosis (grain poisoning).

Milk fever

Cause

This is a common disease in high producing dairy cows. It occurs when there is a rapid fall in blood calcium level, usually at about the time of calving. The fall in calcium is caused by a reduced absorption of calcium from the gut and an inability of the cow to mobilise calcium from her skeleton, the main reserve of calcium in the body. This fall occurs at a time when there is a huge demand for calcium with the onset of milk production. Most cases of milk fever occur within 3 days of calving.

A daily milk yield of 30 litres contains about 36 g of calcium. This is about four times the level of calcium in the blood. The cow must mobilise the calcium from her skeleton very rapidly to maintain the blood calcium level.

Predisposing factors

Milk fever is more common in third and fourth lactation cows. Older cows have a greater demand for calcium because of their higher milk production. The cows at risk are usually high producers in good body condition. Milk fever is more likely to occur in cows milked out completely within the first 48 hours after calving than in those cows left with their calves. (However, other problems, such as mastitis, can arise if high producing cows are not milked out during this time.)

Milk fever can increase when the environmental conditions are cold and wet. Under these conditions cows may graze less, so that their calcium intake decreases.

Jersey breed cows are more susceptible to milk fever than other dairy breeds.

Signs

Milk fever is commonly seen within 3–4 days after calving when milk production is increasing. Cows with milk fever at calving can often have another episode 3–4 days later.

A cow with milk fever can be excited, off her feed, show trembling in the muscles and grind her teeth. Most cows will lie down and appear drowsy, with their heads to the side. The muzzle is dry. The cow often does not pass any faeces.

The cow will be unable to stand, and she is if untreated she will become comatose and have loose limbs. Once she is lying flat on the ground she will quickly bloat and often die from inhaling regurgitated rumen contents.

Diagnosis

Milk fever must be differentiated from calving paralysis (from a difficult delivery) as well as acute infections of the gut, udder (black mastitis) and uterus—any of these diseases may occur at the same time.

A blood test for calcium may help the vet to reach a diagnosis. The blood sample should betaken before any treatment is given.

Treatment

It is essential to increase the cow's blood calcium level by giving prompt treatment with a solution containing calcium If the cow is still standing, the calcium solution can be given subcutaneously (under the skin). Cows that are lying down can be given the calcium solution subcutaneously, although in some it will need to be given into a vein (intravenously). This treatment should be given by a veterinarian because the calcium solution can be fatal if it is given too fast into the vein.

The response to the injection is usually fast, and cows may be standing and appearing 'normal' within 10 minutes of treatment. If the cow does not respond quickly, she should be checked by a veterinarian. She may need another treatment, or she may not have milk fever, or she may have milk fever complicated by another disease.

Prevention

Currently there is a debate about the best way to prevent milk fever. Traditionally rations that are low in calcium are fed before calving. Theoretically this treatment will stimulate the cow to mobilise calcium from her body reserves. Diets high in calcium (like lush pastures or hays rich in clover and lucerne) are avoided.

Feeding rations low in 'positive' ions such as potassium and sodium helps to create a slightly 'negative' environment in the cow's body; this stimulates the cow to mobilise calcium. Normal feed additives such as salt (sodium chloride), sodium bicarbonate and lime (calcium carbonate) supply 'positive' ions to the diet and should not be fed to springers. Neither should causmag or magnesium oxide. Special springer rations can be formulated; they contain 'anionic salts' to help create the 'negative' environment. One anionic salt that is commonly used is magnesium sulphate. The anionic balance of the entire ration (including the contribution of the positive and negative ions in any pasture or forage that is fed) has to be calculated. The calcium content of these diets can be variable—either low or high. Because of the specialist knowledge needed for the use of anionic salts, all rations containing these salts should be formulated by a nutritional consultant.

An injection of 250 mg Vitamin D 2–8 days before calving can help. The date of calving should be accurate.

Calcium gels can be given orally 24 hours before and after calving to cows that may be at risk of milk fever. You can use a urine test to detect these cows. The test measures the urine pH.

Adding 70% cereal hay to the springer ration can reduce the occurrence of milk fever by reducing calcium intake and encouraging rumination.

Summary

- reduce sodium and potassium levels in rations
- remove bicarb, lime and salt from rations
- avoid high legume pastures and hays
- provide shelter from bad weather
- avoid long periods of limited feed access
- use vitamin D injections for high risk cows

Grass tetany

Cause

Grass tetany occurs when there is a rapid fall in blood magnesium. It is commonly seen in high-producing dairy cows, particularly in the spring.

Cows cannot store much magnesium in their bodies and require a daily intake of magnesium in the diet. a cow producing 30 litres will be losing about 30 g of magnesium in her milk each day.

Pastures can have very variable amounts of available magnesium.

Predisposing factors

Grass tetany is more likely to be seen in spring when lush pastures are low in magnesium. These pasture usually have a high ammonia content, which depresses the amount of magnesium available. High levels of calcium in the soil can reduce the uptake of magnesium by the pasture. The use of potash (potassium) fertilisers can reduce the levels of available magnesium in the pasture.

Stress is a major factor in the development of grass tetany in cows. It is more likely to be seen when there is wet and cold weather. Newly calved, over-fat cows are more at risk of developing tetany.

Signs

The main clinical signs of grass tetany are caused by excitation of the nervous system. The cow can show twitching of the muscles (especially in the face), the gait can be staggery and the demeanour excitable. A normally quiet cow may try to charge. The cow may collapse, convulse then die.

Diagnosis

A blood test will show if the body magnesium is low. Low blood calcium may also be present and may precipitate tetany.

Not all cows with low blood magnesium will show tetany. Any stress such as yarding, movement or feed deprivation can bring on tetany in these cows.

Treatment

Cows with obvious signs of grass tetany should be treated with an intravenous injection of magnesium salts. These infusions are usually combined with calcium, and they are given very slowly to avoid cardiac arrest.

Prevention

Magnesium oxide (causmag) can be supplemented in the feed at about 60 g per cow per day. Alternatively, magnesium bullets can be placed in the rumen, or the pasture can be dusted with magnesium oxide at the rate of 125 kg a hectare.

Since an excess of ammonia in the pasture can be a problem, energy supplements can be fed to balance the excess. There should be limited use of potash-based fertilisers.

At the times of the year when grass tetany could occur, try to avoid stresses like yarding.

Ketosis

Cause

In early lactation, cows can be in a negative energy balance where they cannot eat enough to supply their needs for maintenance and milk production. As a result they will be mobilising their body fat.

Ketosis can occur if the mobilisation of body fat is excessive, especially if the cows are being underfed. Stress resulting from cold, wet conditions can precipitate ketosis in early lactation cows because of their increased energy requirements for maintaining body heat.

Cows that calve in too good a condition (BCS 6 or higher) can develop ketosis.

Predisposing factors

Cows that carry too much fat at calving and cows that are underfed after calving can develop ketosis. The liver cells accumulate fat, which impairs the ability of the liver to make the glucose that the cow needs for energy.

Over-conditioned cows that lose weight during the dry period can also accumulate fat in their livers and be prone to ketosis at the next calving.

Other factors include feeding high levels of concentrates twice daily and feeding poorly fermented or rancid silage that contains high levels of butyric acid.

When cows have reduced appetites because of other illnesses or because they have restricted access to feed, a disorder similar to ketosis can develop. The main cause of this disorder is weight loss following reduction in intake.

Signs

Affected cows lose weight and look dull and gaunt. Their breath may have a sweet smell similar to that of acetone. There is a drop in milk production, but the milk fat percentage of the milk increases. The cow may be constipated and show changes in behaviour. She may selectively eat roughages.

Diagnosis

Blood samples can indicate low blood glucose and raised betahydroxybutyrate (blood ketone) levels. Ketones or betahydroxybutyrate can be detected in the urine. Acetone is found in the blood when any condition causes a loss of appetite.

Treatment

Glucose can be given intravenously (500–800 mL of a 40% solution), followed by 600 mL of glycerine twice daily for the next 2–3 days. An injection of cortisone may be used if the cows are affected by stress.

Other treatments include drenching with Ketol® or propylene glycol for 7–10 days before calving, and feeding good quality hay.

Prevention

The appetite of the cow should be maintained by supplying adequate feed to meet her dry matter intake and by providing high quality roughage. The cow should not be allowed to calve in poor body condition or in too-fat body condition. Assess her body condition score during late lactation to make sure she dries off in BCS of about 5. The dry cow should be fed to maintain this body condition score until calving. Before calving, the cow should receive a springer ration, which helps to increase her dry matter intake. Rumensin® added to the feed at a rate of 200–250 mg per cow per day can help prevent ketosis.

Acidosis

Cause

There are three important causes of acidosis:

- lack of adequate long fibre in the diet
- feeding too much rapidly fermentable carbohydrate (such as starchy grains or pellets)
- feeding too many kilograms of concentrates in one feed, or rapidly introducing grain into a cow's ration.

Predisposing factors

Predisposing factors are:

- feeding high levels of grains in the dairy bail ('slug' feeding)
- sudden changes in diet and not using feed buffers (such as sodium bicarbonate)
- grain feeding, in combination with feeding young lush fibre with a low NDF % and not feeding hay or silage when increased dietary fibre is needed.

Feeding low pH silages can cause digestive upsets similar to acidosis.

Signs

The first sign of acidosis in a herd is a lowered milk fat percentage. The affected cow can show a slight drop in milk production and will go off her feed. She scours, with sweet, sludgy faeces. She can stop ruminating and might show abdominal pain by having a tucked appearance. Cows with severe cases of acidosis can develop lameness in all four feet, and some may die following severe damage to the wall of the rumen.

Treatment

Drench affected cows with sodium bicarbonate. Feed sodium bicarbonate at the rate of 200 g per cow per day.

Reduce the level of concentrates in the diet and increase the percentage of good hay in the ration.

In some cases, a veterinarian has to open up the rumen and remove the grain. The contents are replaced with hay, water and rumen liquor from another cow to help 'kick-start' healthy rumination.

Prevention

Ensure the diet contains adequate fibre (see 'What nutrients does the cow need?' in section 1).

Feed buffers (such as sodium bicarbonate) in the ration (see 'What feeds supply these nutrients?' in section 1). If you are feeding high-starch cereal grains (such as wheat or triticale) you must use buffers.

If you must feed a high percentage of concentrate, it is better to give the concentrate in many small feeds rather than two 'slugs'. The rumen bacteria can handle the smaller amounts of grain better.

Changing milk composition by changing the ration

Introduction

It is important to know the nutritional factors affecting milk composition. These include the type of feed and the level of intake. These interact, however, with a number of non-nutritional factors, such as breed, disease, stage of lactation and climate.

The effects of feeding on composition are complex; while theories provide useful predictions they cannot produce absolute recipes for improving milk composition.

If most of the herd is calved at a certain time of year, then 2–3 months afterwards, milk fat and protein levels will be at their lowest. If a spring flush occurs at the same time, then milk fat will drop further because of the low fibre levels in the pasture.

After a further 2–3 months milk fat and protein slowly increase until drying-off.

Factors affecting milk fat content

Milk fat is most sensitive to dietary changes. Milk fat composition may fall abruptly when dairy cows are fed high levels of digestible carbohydrates and low levels of fibre, when unsaturated fats are included in the diet, or simply when cows are underfed.

Areas to consider include:

Roughage to concentrate ratio

The primary factor affecting miik fat percentage is the level of fibre in the diet. Milk fat composition drops once concentrates reach 50 per cent of the diet or crude fibre levels drop below 17 per cent.

Carbohydrate type

In high grain – low forage diets the type of grains and the degree of processing have an effect on milk composition. Finely ground wheat can cause the greatest falls in milk fat percentage.

Level of feeding

At adequate levels of feeding, changes in milk composition depend on diet composition. With underfeeding, the fat percentage rises and milk production is reduced. Continued underfeeding, however, reduces fat content. The degree of reduction depends on the duration of underfeeding and is related to the body condition of the cow.

Added fat

Production responses to the addition of fat have been variable and influenced by the type of fat. Unsaturated fats (for example, vegetable oils) may depress fat levels, while saturated fats can improve the fat test. Protected fats have increased milk production, but with variable results on milk fat content.

Whole oilseeds can elevate fat tests due to the slow release of fat in the rumen. Recent dry fat products have improved the fat test and milk yield.

Dietary protein

In general, protein has a small effect on the fat content of milk, although in low roughage/high grain diets, fat levels are often increased with additional protein in the diet.

Factors affecting milk protein levels

Ways to increase protein levels in milk due to nutrition are less apparent than changes in fat levels, since the genetic scope to increase protein is less.

Level of feeding

Underfeeding reduces protein levels, and diets with insufficient energy can depress milk protein levels by 0.3 per cent. Conversely, increasing the feeding levels of underfed cows raises milk protein levels (see Figure 4.1).

Energy intake

Increased energy intake can increase milk protein levels, but responses vary because of a number of factors:

- the level and duration of underfeeding has a variable effect as mentioned above

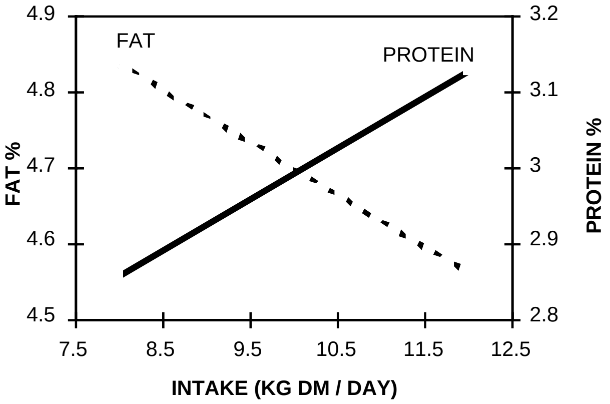


Figure 1: Effect of intake of pasture on milk composition (Ellinbank trials)

- energy is first used to meet maintenance requirements, then production functions (for example, liveweight, milk yield and milk composition). Responses to supplements by underfed cows can subsequently be slow (3-4 weeks)
- cows in early lactation respond differently to cows in mid to late lactation due to the differing physiological drive to produce milk
- immediate responses to grain can be low with well fed cows; however, in the long term high levels of milk of high composition are produced
- cows that are continuously well fed may be close to their genetic limit for milk composition (particularly protein)
- high levels of feeding of well conditioned cows support high levels of milk production and composition
- the benefits of full feeding are carried from one lactation to the next
- only minor differences have been reported in response to the type of grain and degree of processing in pasture-based diets. That is, 30 per cent concentrates)
- there is often a substitution effect when large proportions of grain are fed, and this compounds the problems of predicting responses.

arious feeding studies have shown that:

- increased availability of high quality tropical or temperate pastures increases protein levels
- clover is a superior feed for production and composition
- milk protein responses to the inclusion of grain depend on the type and levels of pasture intake
- at high levels of grain feeding (for example, 7 kg/day), particularly with low quality roughages, including protein (i.e. 18–20% CP in the concentrate) increases the milk protein content
- attempts to manipulate protein in milk by feeding low levels of grain and protected protein have been highly variable. The most consistent results have been achieved with formaldehyde casein. Formaldehyde-treated and heat-treated vegetable meals have generally resulted in increased milk yield but increases in protein content have been very inconsistent.

Note: The other main component of solids not fat (s.n.f.) is lactose. Studies show that grain fed to underfed cows increases lactose levels and subsequently raises s.n.f. At adequate levels of feeding, lactose is normally unaffected by changes in feeding.

Summary

In summary, the nutritional factors affecting milk composition are:

- Cows have a genetic milk composition potential and proper feeding allows them to reach their potential milk yield.
- With variations in composition the milk protein test generally follows milk fat levels unless feeding is abnormal.
- Genetic selection is the long-term

method of improving the composition of milk, but feeding is the main factor in the short term.

- Feed the right amounts of fermentable carbohydrates to increase milk protein composition.
- High ration digestibility increases milk composition.
- Poor quality forage limits protein test and yield.
- Underfeeding reduces protein test and yield.
- Oils and fats depress protein test and yield.
- Various additives (e.g. buffers) give variable results and should be carefully evaluated if considered at all.
- Responses to supplements depend on the level of feeding, plane of nutrition, stage of lactation and the period of underfeeding.
- It is very difficuit to provide short-term recipes to absolute levels of milk composition due to the complex interaction involved.
- Proper feeding from one lactation to the next is the simplest and most economic way to achieve high yield and composition levels in milk—after all, this is the road to high levels of profitable production.

Transition feeding

What is transition feeding?

Transition feeding is when we feed the dairy cow from three weeks before she starts lactation to up to three weeks after she has commenced milking. During this period, the cow has progressed from a heavily pregnant dry cow on pasture or other forages to a fully productive milking cow consuming a ration which can include cereal grains and other additives in addition to the forage.

What changes does the cow undergo during this period?

- The cow will have a change in ration from a pasture or forage based diet with no supplement to a ration which could contain cereal grains and other additives.
- The cow will calve; this causes physical trauma and many hormonal changes, which can affect the cow's ability to fight infection and mobilise her body reserves of minerals.
- The beginning of lactation will create a demand for greater energy, protein and calcium requirements by the cow's metabolism. This demand can be twice or more than that needed before the start of lactation.
- The dry matter intake of the cow will begin to decrease about two weeks before calving because of the increasing size of the calf in the abdominal cavity compressing the rumen. The decreased dry matter intake will continue for at least two to three weeks after calving.

How important is the transition period?

Dry cows are usually considered the uneconomic members of the dairy herd. In the past, they have been grazed on the poorest pasture and are 'forgotten' by the farmer until they calve and start paying their way again.

The period around calving is when many farmers see most of the common disease problems in their herd. These diseases include:

- downer cows
- calving difficulties or dystocia

- milk fever
- ketosis
- laminitis (lame cows)
- retained afterbirths
- clinical mastitis
- udder oedema (‘slaking’ of the udder)

In many cases, it is the best producers in the herd which are the worst affected. This group of cows may also be the most difficult group to breed and the last cows to become pregnant.

Many of the above problems can be prevented by proper management and feeding of the dry cow, especially during the transition period. It has already been discussed in the Body Condition Scoring section that cow should be dried off at a condition score of 5 and be fed to retain this condition score till calving. This means a change in philosophy for many farmers. The ration of the dry cow has to be formulated with the same care as that of the milking herd.

What is involved in transition feeding?

- The decreased dry matter intake 2 weeks before calving means that the cow will need her energy, protein and mineral requirements in a more nutrient dense ration (greater dry matter percentage). This aim may not be a major problem to achieve in the dry cow before calving because of her lower requirements but it will pose a challenge after the cow has calved and has began producing milk. The early lactation cow may not reach full appetite until 6 to10 weeks into lactation.
- UDP should be added to the early lactation ration and has been shown that added protein containing 36 to 40% of UDP to the ration of the heavily pregnant cow could result in an increase in milk production of up to 10% in the next lactation. The extra UDP replaces the need for the cow’s protein reserves to be used for her growth and her fetus’s growth needs.
- The dry cow should be introduced gradually to the milking cow ration starting about three weeks before calving. This ration should not contain any additive such as buffers (sodium bicarbonate, magnesium oxide). It will take approximately three weeks for the rumen microbes to adapt to the change in the ration. There will be less digestive upsets, resulting in a further decline in dry matter intake, and better feed digestion when the cow starts eating the milking cow ration after calving.
- The precalving ration should be low in calcium. The cow will be able to mobilise calcium from her skeleton after calving when her demand for calcium increases with the onset of milk production. If the cow was fed a diet high in calcium, she is less able to readily mobilise her calcium reserves and could develop low blood calcium and ‘droopy’ or ‘sad’ cow syndrome or else be a downer cow with clinical milk fever.
- Feeding a ration which promotes a slight metabolic acidosis in the blood can also enable the cow to mobilise calcium from her skeleton when she needs it. The metabolic acidosis is created by increasing the number of negative ions in the ration. The minerals in the ration have both positive and negative changes. The balance between the positive and negative charges in the ration is called the **dietary cation-anion balance** or **DCAB**. Sodium and potassium provide most of the positive charges whilst

chlorine and sulphur provide most of the negative charges.

The DCAB of a ration is calculated as:

(% sodium/0.023) + (%potassium/0.039) –
(%chlorine/0.035) + (%sulphur/0.016)

The percentage of these minerals in all components of the ration, including pasture, other forages and all supplements, have to be calculated to determine this balance. It is not sufficient to just look at the supplements.

Pastures that have been fertilised with potash will contain high percentages of positive charges such as potassium. When using these rations, the slight negative balance is created by the addition of anionic salts to the ration. The anionic salts include magnesium sulphate (epsom salts), ammonium sulphate, ammonium chloride, calciumchloride and calcium sulphate. One major disadvantage in feeding anionic salts is that cows usually find them unpalatable.

Several feed companies have developed specific transition cow rations which are in the correct DCAB to prevent many of the disease problems which occur around calving. The advantage of these rations is that they are ready to feed without the need for extensive testing of rations for mineral content, which can be difficult if pasture forms part of the ration. The disadvantages of using these rations include the cost of the ration which would be in excess of traditional dry cow rations and the change in management necessary to feed the ration. The dry cows may need to be separated into different groups so that the ‘close-up’ cows are able to be fed the ration. This may involve the separation of existing paddock and the provision of feed troughs and hay feeders. However, the reduction in disease problem in the early lactation period, especially milk fever and retained afterbirth, would result in reduced treatment costs and reduced labour costs, which are normally required to manage the affected cows.

Appendix 1: Measuring dry matter

You can use a microwave oven to measure the dry matter percentage of your feed. The method is easy, although it is time consuming. You need accurate kitchen scales that can measure to one tenth of a gram, a knife or scissors to chop the forage into small pieces, a brown paper bag and a glass of water.

When you collect your pasture, hay or silage sample, make certain it represents a true sample of what the cows are eating. If the pasture is ryegrass with 30% clover, make certain the sample is of the same composition.

1. Weigh the paper bag on the kitchen scales.
2. Chop up about 75 g of forage into centimetre lengths and put this into the paper bag.
3. Weigh the paper bag with the sample. This is the wet sample.
4. Put the paper bag and the glass (which should be three quarters full of water) into the microwave.
5. Microwave the bag and sample for 4 minutes. Let the sample stand for 4 minutes.
6. Weigh the bag and sample.
7. Microwave for another minute. Make certain the glass of water is still three quarters full. Refill if necessary. Let the sample stand for one minute.
8. Weigh bag and sample.
9. Repeat steps 7 and 8 until there are no further changes in weight.

Calculate the results as follows:

Wet sample weight
= weight of wet sample plus bag (step 3) minus bag weight (step 1).

Dry sample weight
= final weight of bag and sample minus bag weight.

Dry matter percentage

$$= \frac{\text{dry sample weight} \times 100}{\text{wet sample weight}}.$$

Appendix 2: Minerals & vitamins for the lactating cow

Macrominerals are needed in large amounts. The important ones are:

Calcium (Ca)
Phosphorus (P)
Magnesium (Mg)
Potassium (P)
Sodium (Na)
Chlorine (Cl)
Sulphur (S)

Microminerals are needed in small amounts. Those important to dairy cows are:

Cobalt (Co)
Copper (Cu)
Iodine (I)
Iron (Fe)
Manganese (Mn)
Molybdenum (Mo)
Selenium (Se)
Zinc (Zn)

Vitamin deficiencies are rare in Australia. Those that could potentially cause problems are:

Fat soluble vitamins

Vitamin A
Vitamin D
Vitamin E

Water soluble vitamins

Vitamin B1 (thiamine)
Vitamin B3 (niacin)
Vitamin B12 (cyanocobalamin)
Biotin
Folic acid

Macrominerals

Calcium

Calcium is required for bone formation, muscle action, milk production and general body function. There are low levels in grains, and as all plants age the levels decrease.

Deficiency can cause milk fever, displaced abomasum (where the abomasum moves to the left hand side of the abdomen and becomes compressed by the rumen) and retained afterbirth.

Phosphorus

Phosphorus is required for bone formation, milk production, energy metabolism and general body function. Grains have higher levels that grass, but as all plants mature the levels decrease.

Deficiency can cause low fertility and milk yield as well as poor appetite.

Magnesium

Magnesium helps in many enzyme processes in the cow and is needed by rumen microbes to grow.

Low levels in lush pastures can cause grass tetany. Low levels in the blood can interfere with calcium absorption and cause milk fever.

Potassium

Potassium is involved in water balance and acid–base balance, as well as muscle function. It is involved in the manufacture of protein. Mature forages have low levels.

Excess potassium fertiliser can cause udder oedema and milk fever.

Deficiency of this mineral is unlikely

in grazing dairy cows.

Sodium

Sodium is essential for the nerves and for the water and acid–base balance.

Deficiency is uncommon.

Signs of low sodium are salt cravings, loss of appetite and body condition, and increased nervousness.

Most supplement contain salt in the diet (approximately 1% of the ration).

Chlorine

Chlorine is also needed to ensure a proper salt or acid–base balance in the animal. It is also needed for stomach secretions.

Supplement with salt in the ration or salt licks. Deficiency is uncommon.

Sulphur

Sulphur is needed by both the cow and rumen microbes to make essential amino acids. It is involved in many body functions.

Some B vitamins contain sulphur. There are significant interactions between sulphur, copper and molybdenum when high pasture sulphur and molybdenum levels prevent copper uptake.

Sorghum based diets (including sudan, sudax and other sorghum hybrids) are usually deficient in sulphur.

Sulphur can be supplemented in the feed or provided to the cows by a mineral block.

Microminerals

Note: It is best to seek professional advice from a veterinarian or other farm adviser on the dose rates for these micro minerals. Excess amounts of these substances can cause toxic signs in cattle and may result in death.

Cobalt

Cobalt is needed by the rumen microbes to synthesise vitamin B12. It is essential for the production of propionic acid which is the precursor of glucose.

Cattle do not store large amounts of cobalt, so vitamin B12 production relies on a steady supply of cobalt in the ration.

Deficiency signs include reduced growth rate, especially in young animals., rough coat and ill thrift that does not respond to worming or improved ration.

Supplementation is usually by cobalt bullets in the rumen.

Copper

Copper is needed for the enzymes that control energy metabolism, pigmentation and blood formation.

Deficiency signs include weight loss, diarrhoea and a pale rough coat, and infertility. High molybdenum levels will cause a copper deficiency.

Supplement with copper oxide (as an addition to the ration or as a rumen bolus) or copper sulphate which can be added to the water or given as a drench.

Iodine

Iodine is found in the thyroid hormones that control energy, metabolism, growth and development, and skin and hair formation.

Deficiency can occur in calves as a goitre (lump in the neck) or in cows as reproductive failure.

Supplement with potassium iodide in the feed.

Iron

Iron is an essential component of haemoglobin in the blood, and of the immune system.

Deficiency rare in grazing cattle; all feed sources are generally adequate, but anaemia occurs in milk-fed calves occasionally.

Use ferrous sulphate or ferrous chloride to supplement.

Manganese

Manganese is involved in fat and protein synthesis, brain metabolism and various enzyme systems. Deficiency can reduce fertility and cause cystic ovaries and impaired growth or skeletal and birth abnormalities.

Supplement with manganese oxide or manganese sulphate.

Molybdenum

Molybdenum is mainly required for the function of the enzyme xanthine oxidase, which is involved in excretion.

Very high and very low levels of molybdenum affect the metabolism of copper. Cattle grazing high molybdenum pastures may show signs of copper deficiency.

There may be high levels of Molybdenum in plants grown on high pH (alkaline) soils.

Selenium

Selenium prevents white muscle disease; it has an enzyme function in protecting cell membranes from damage by oxidation. It also important in maintain an effective immune system.

Selenium deficiency often occurs with vitamin E deficiency. Signs are poor reproduction, retained placenta, mastitis and general ill thrift.

Supplement with selenium bullets, drenches or sodium selenate in the feed.

Zinc

Zinc is involved in many body functions in the cow. It activates 30 different enzymes and enhances the action of the reproductive hormones.

Deficiency symptoms include reduced feed intake, feed efficiency, stiff joints and cystic ovaries. In feed lot cattle, zinc supplementation may be helpful in preventing foot problems.

Supplement with zinc oxide, zinc sulphate or zinc methionine.

Vitamins

Vitamins A, D and E

Vitamin a has numerous functions, including maintenance of the skin and other tissues and prevention of night blindness.

Vitamin D mainly acts to help calcium metabolism.

Vitamin E has a similar role to selenium and helps the immune system and muscle formation.

B vitamins

Vitamin B1 (thiamine) can be synthesised in the rumen, but feedlot cattle can become deficient and need thiamine injections.

Niacin can help with energy metabolism for preventing ketosis, but it can be costly. Some rations containing high percentages of fat may include niacin to maintain rumen function.

For vitamin B12 see cobalt.

Further information

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