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Introduction

This chapter:

Presents an outline of the manual and its role in developing training programs for farmers and students. The skills in ration formulation are summarised. Some basic concepts in the nutrition of dairy cows and the terminology encountered throughout the manual are introduced.

The main points in this chapter:

- cows are ruminants
- the mature stomach of the cow has four chambers, the largest of which is the rumen
- cows are well adapted to a forage diet
- cows need water, energy, protein, fibre, vitamins and minerals in their diet.

1.1 The feeding manual

1.1.1 Aims of the manual

Readers of this manual will be able to calculate and provide their dairy cows and young stock with cost-effective feeds that match the targets of their particular farming system. Formulation of diets will be based on using forages first, then supplements. Practical experience will reinforce the understanding of dairy cow nutritive requirements, the benefits and drawbacks of various feed components as well as determining the optimal diet balance. Additional information is provided on growing and conserving quality forages as silage.

Readers will also develop a good understanding of problems encountered when milking cows are fed unbalanced diets, for example the metabolic diseases associated with poor nutrition. Small holders milk cows as a business and must make a profit to remain viable. This manual will teach readers how to calculate profit margins from small holder feeding systems.

The final chapter provides readers with a good understanding of some of the major obstacles to improving feeding management on small holder dairy farms in the humid tropics.

In summary, to develop the skills in supplying and formulating cost-effective rations for dairy stock, farmers need to:

- understand the nutritional requirements of cows and be able to express them in terms of dry matter, energy, protein and fibre
- compare feeds on the basis of their nutritive value
- understand the effect of nutrition on milk production, health and reproduction, and the growth of young dairy stock
- check whether a diet is balanced in terms of energy, protein and fibre
- understand how forages and feed supplements interact, including the factors that affect responses to supplements and how they determine the profitability of supplementary feeding
- calculate milk income less feed costs as a measure of profit
- understand the principles of growing quality forages
- understand the principles of making quality silage.

1.1.2 Outline of the manual

This manual is written for advisers, students and skilled farmers who produce milk from small holder dairy systems in the humid tropics. Much of the basic knowledge needed to understand how cows produce milk is explained in the following chapters.

Although small holders are the major suppliers of milk in the tropics, many larger farms with up to 1000 milking cows, both intensive feedlot and less intensive grazing systems, have been established throughout South-East Asia to satisfy the increasing demand for more fresh milk. Such farmers and their advisers will gain much from this manual. This manual also provides relevant and up-to-date background information to research scientists in many aspects of tropical dairy production, such as forage production and conservation, herd and feeding management and farm management economics. In addition, policy makers and senior managerial staff would benefit from reading selected chapters.

Most tropical countries have proactive programs to increase local supplies of milk, which require an increasingly trained workforce in the dairy industry. Consequently, educators from agricultural schools, universities and technical colleges need to keep abreast of the latest technical developments and applications in dairy farming. This manual also serves this purpose. Some suggestions on how this manual can be used in structured training programs have been presented in Table 1.1 (see Section 1.1.4)

Chapters 2 and 3 describe features of tropical small holder dairy systems and trends in dairy production in South-East Asia. Chapters 4 and 5 provide the elements of ruminant nutrition, highlighting the importance of the rumen as the key organ of digestion. Chapters 6 and 7 quantify requirements for feed nutrients in different demand phases of the cow's lactation cycle.

Feed nutrients are supplied from a wide variety of sources: fresh forages (Chapter 8), conserved forages (Chapter 9), concentrates and forage supplements (Chapter 10), all of

which interact when subjected to rumen digestion and metabolism (Chapter 11). The major goal of this manual is to formulate a diet (Chapter 12) for a desired level of animal performance. However, such a production diet may fail to achieve its target and some of the causes are discussed in Chapter 13.

Dairy stock make many demands on nutrients in addition to milk production, such as use in body reserves (Chapter 14), fertility (Chapter 15) and growth prior to calving (Chapter 16). Dairy farming is a business with a variety of economic measures of success. 'Milk income less feed costs' is relatively easy to monitor and provides a useful measure of economic efficiency (Chapter 17).

Milking cows store reserves as body tissue for later use as energy sources and a system for scoring changes in body reserves is described in Chapter 18. This scoring system then provides an objective assessment of how well cows are being fed in relation to their nutrient demands, which fluctuate markedly in the course of a single lactation.

Chapter 19 discusses some of the non-nutritional constraints to performance such as genetic merit, heat stress and effluent management, all major limiting factors for tropical dairying. Attention is also given to problems encountered when importing exotic genotypes into small holder tropical systems.

Much of the research into dairy feeding management over the last 20 years has more relevance for less hostile climates, namely in temperate countries where dairy farming has evolved into more sophisticated production systems. Chapter 20 highlights some of the developments and environmental considerations required for tropical dairy to become and remain more efficient and profitable.

Full publication details of all sources are presented in References and further reading. A glossary of technical terms and abbreviations used in the manual is also provided. Appendixes are included to facilitate sourcing specific information and gaining experience in ration formulation. Appendix 1 presents the Temperature Humidity Index, the universal method of quantifying heat stress in dairy stock. Appendix 2 provides conversion factors to the standard metric system from a wide variety of systems used for describing weights and measures. Appendix 3 presents a currency converter for South-East Asian countries as at February 2005. Tables of nutrient requirements are presented for vitamins and minerals (Appendix 4) and energy, protein and fibre (Appendix 5). Appendix 6 provides four scenarios and the opportunity to calculate nutrient requirements and then formulate the most cost-effective rations.

1.1.3 Sources of information

This manual draws on published information from many sources:

- Chapters 4, 5 and 6 (principles of the feeding management) were developed in Victoria during the late 1990s (Target 10 1999)
- Chapter 8 (growing forages) and Chapter 9 (silage making) were prepared for small holder farmer training programs in Indonesia (Moran 2001a, Mickan 2003)
- Chapter 15 (nutrition and fertility) was adapted from an Australian nationwide extension program 'InCalf' (Morton et al. 2003)
- Chapter 16 (nutrition and young stock) was adapted from my books on the calf and heifer management (Moran and McLean 2001, Moran 2002)

- Chapter 18 (body condition scoring) was developed by a team of Victorian dairy scientists (Robins et al. 2003).

The examples in the manual of practical feeding management were collected from both first-hand experience and published data from many South-East Asian countries.



The author, John Moran, discussing feeding management with a small holder farmer and a dairy adviser in northern Thailand.

1.1.4 Role of the manual in training programs

This manual is multipurpose. It forms the basis of structured training programs in small holder dairying for advisers and educators (for farmer training organisations, agricultural high schools and universities), while also providing background information to researchers and policy makers in tropical dairy industries.

Table 1.1 presents two structured training programs and highlights those chapters written more specifically for dairy researchers and policy makers. Two Dairy Nutrition programs are outlined, first a basic one for farmers and high school students, 'Feeding dairy cows', and second, an advanced one for more highly skilled farmers, advisers and university undergraduates, 'Dairy nutrition and dairy farm production'. It is assumed that participants in the advanced program would be familiar with topics covered in the basic program; if not, they should be introduced initially as an abridged basic course.

The basic 'Feeding dairy cows' course introduces participants to:

- chemical constituents of forages and concentrates (Chapter 4)
- principles of ruminant digestion (Chapter 5)
- nutrient requirements of dairy cows and how they vary during the lactation cycle (Chapters 6 and 7)
- nutritive value of tropical dairy feedstuffs (Chapter 10)
- milk responses to supplements (Chapter 11)

- formulating rations for milking cows (Chapter 12)
- body condition scoring (Chapter 18).

The advanced ‘Dairy nutrition and dairy farm production’ course does not duplicate topics from the basic course and introduces participants to:

- growing and conserving quality forages (Chapters 8 and 9)
- using computers to formulate rations for dairy stock (Chapter 12)
- problems with unbalanced diets (Chapter 13)
- influences of ruminant nutrition on milk synthesis in the udder and on body condition (Chapter 14)
- nutrition and fertility (Chapter 15)
- nutrition and young stock (Chapter 16)
- economics of milk production (Chapter 17)
- overcoming environmental constraints to cow performance (Chapter 19).

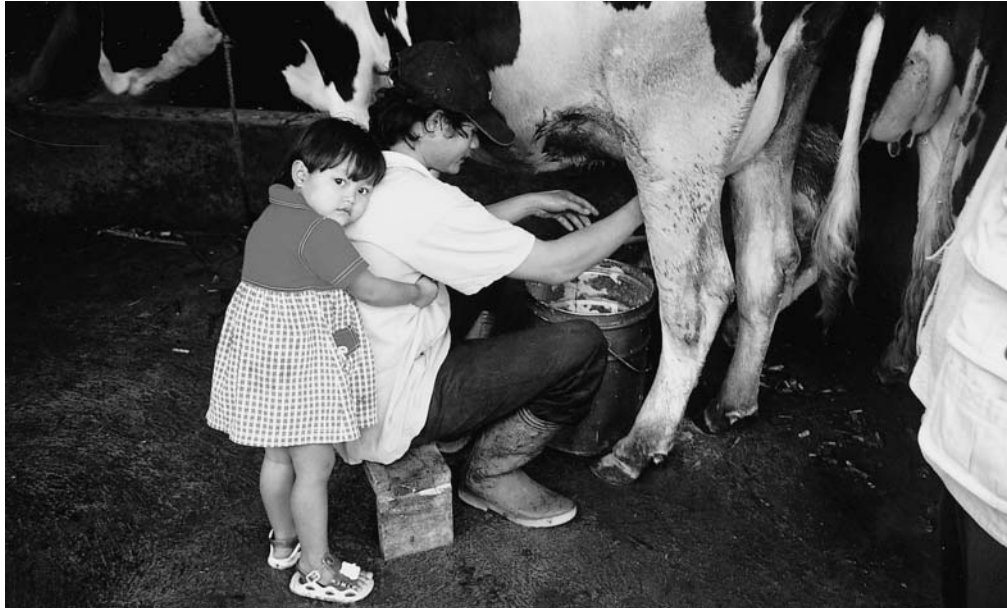
Many of the chapters in the advanced program would also be relevant to tropical dairy researchers and policy makers. Chapters written more specifically for these specialists are:

- tropical dairy systems (Chapter 2)
- small holder dairying (Chapter 3)
- future developments in feeding management in the humid tropics (Chapter 20).

Table 1.1 Suggestions (+) for the selection of chapters from this manual to use in a basic course on ‘Feeding dairy cows’ (A) and an advanced course on ‘Dairy nutrition and dairy farm production’ (B) and chapters of special relevance to tropical dairy researchers and policy makers (C)

Chapter	Topic	A	B	C
1	Introduction	+	+	+
2	Tropical dairy systems			+
3	Small holder dairying			+
4	What is in feeds?	+		
5	How the rumen works	+		
6	Nutrient requirements of dairy cows	+		
7	How feed requirements change during lactation	+		
8	Growing quality forages		+	+
9	Making quality silage		+	
10	Supplements for milking cows	+		+
11	Milk responses to supplements	+		+
12	Formulating a diet	+	+	+
13	Problems with unbalanced diets		+	+
14	Diet and milk production		+	+
15	Nutrition and fertility		+	+
16	Nutrition and young stock		+	+
17	Economics of feeding dairy cows		+	+
18	Body condition scoring	+		+
19	Overcoming environmental constraints to cow performance		+	+
20	Future developments in feeding management in the humid tropics			+
Appendices	Units and currency converters, Work sheets	+	+	+

Because of the diversity of dairy farming production systems throughout South-East Asia and the use of different nutritional terms and concepts in different countries, the chapters may contain technical information that is not always most useful, or at the appropriate level for the target audience at the particular training program. It is then up to the course planner to select the information most relevant to the course participants.



Small holder dairy farms are usually family operations (Central Java, Indonesia).



Family small holder farms can easily grow to larger operations when farmers develop their skills in herd and feeding management (West Java, Indonesia).

The chapters are written to be understood by advisers and tertiary students, hence the trainers must ensure that other target audiences can comprehend their course material. For example, Chapter 17 has been excluded from the basic 'Feeding dairy cows' course, even though parts of it are just as relevant to farmers as to advisers and tertiary students. Hence, the course planner should select the most relevant sections to incorporate into the basic course. As the chapters are written as 'stand alone' documents to be accessed via the Internet, there is some repetition, although this has been kept to a minimum.

Two different systems for describing feed energy are used in this manual. Not all South-East Asian countries use the same unit because of their political history and colonial influences,. From my personal experiences, the unit of Metabolisable Energy (ME) is more commonly used by dairy nutritionists in Malaysia and Vietnam, while the unit of Total Digestible Nutrients (TDN) is commonly used in Indonesia, Thailand and the Philippines. Their interconversion is presented in Chapter 4. The Metabolisable Energy system is the preferred one with more widespread usage throughout the world.

1.2 Nutrients for dairy cows

Cows are herbivores and have digestive systems well adapted to forage-based diets. Cows belong to a group of mammals known as ruminants. Ruminants have a complex digestive system, which is characterised by a four-chambered stomach. The largest of these chambers is the rumen.

The digestive system of ruminants enables them to digest plant material in a way that non-ruminant mammals with single stomachs, such as pigs, dogs or humans, can not. The role of the rumen to milking cow is explained in detail in Chapter 5.

The rumen contains large numbers and many types of microorganisms (often referred to as microbes). These microbes feed on plant material eaten by the cow and produce end products that are used by the cow, and also by the microbes for their own multiplication and cell growth.

The microbes themselves are digested further down the digestive tract.

The ultimate purpose of dairy cows is to produce milk, so their diets must allow them to fulfil the functions of lactation, and of reproducing annually.

The nutrients required by dairy cows are water, energy, protein, fibre, vitamins and minerals. These requirements largely determine how we think about the composition of

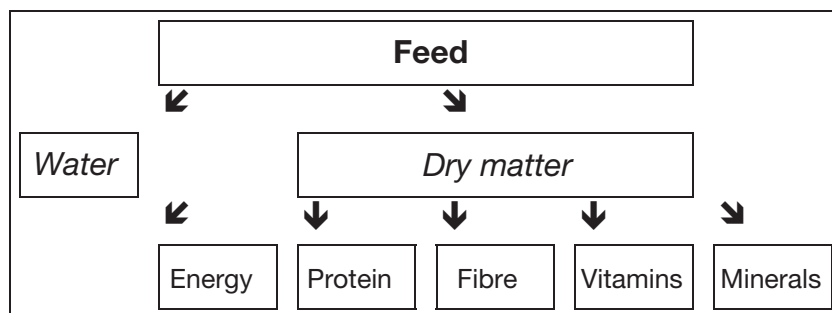


Figure 1.1 The major components of feed. (Source: Target 10 1999)

their feed. Feed contains both water and dry matter. The dry matter component of that diet is the part which contains the necessary energy, protein, fibre, minerals and vitamins. The components of the feed are outlined in Figure 1.1 and are discussed in detail in Chapter 4.

1.2.1 Water

The body of a dairy cow is composed of 70% to 75% water. Milk is about 87% water. Water is not a feed as such because it does not provide specific feed nutrients. However, water is essential to regulate body temperature. As well, water is involved in digestion, nutrient transfer, metabolism and waste removal. Water has structural and functional roles in all cells and all body fluids. An abundant, continuous and clean source of drinking water is vital for dairy cows.

1.2.2 Energy

Dairy cows use energy to function (walk, graze, breathe, grow, lactate, maintain a pregnancy). Energy is the key requirement of dairy cows for milk production. It determines milk yield and milk composition.

1.2.3 Protein

Protein is the material that builds and repairs the body's enzymes, hormones, and is a constituent of all tissues (muscle, skin, organs, foetus). Protein is needed for the body's basic metabolic processes, growth and pregnancy. Protein is also vital for milk production.

Proteins are made up of nitrogen which are bound into various amino acid molecules. Amino acids are the building blocks for the production of protein for milk, tissue growth and the development of the foetus during pregnancy.

Cows require 25 different amino acids for normal metabolic functioning. Fifteen of these can be produced by the cow's own metabolism. The remaining 10 are termed essential amino acids because they must either be supplied in the diet (as dietary protein) or as a product of the digestion of the microbes in the rumen (microbial protein).

Protein is usually measured as crude protein. Nutritionists commonly use terms like rumen degradable and undegradable dietary protein and bypass protein. These terms are explained more fully in Chapter 4.

1.2.4 Fibre

For efficient digestion, the rumen contents must be coarse with an open structure and this is best met by the fibre in the diet. Fibre contains most of the indigestible part of the diet. Cows require a certain amount of fibre for rumen function. It ensures that the cow chews its cud (ruminates) enough and therefore salivates. Saliva buffers the rumen against sudden changes in acidity.

Both the length and the structure of the fibre are important. These determine how much chewing a feed requires. Feeds which need extra chewing increase the flow of saliva.

Fibre in the cow's diet also slows down the flow of material through the rumen and thus gives the microbes more chance to digest the feed. Products of fibre digestion are important for the production of milk fat.



Roadside grass being delivered to small holder farms in Central Java, Indonesia.



Woman holding maize stover in West Java, Indonesia.

1.2.5 Vitamins and minerals

Vitamins are organic compounds that all animals require in very small amounts. At least 15 vitamins are essential for animals. Vitamins are needed for many metabolic processes in the body; for example production of enzymes, bone formation, milk production, reproduction and disease resistance.

Minerals are inorganic elements. They are needed for:

- teeth and bone formation
- enzyme, nerve, cartilage and muscle function or formation
- milk production
- blood coagulation
- energy transfer
- carbohydrate metabolism
- protein production.