12

Formulating profitable rations

This chapter presents examples of milking rations formulated to optimise their profitability, as quantified by milk income less feed costs.

The main points in this chapter

- One of the simplest measures of profitable feeding is milk income less feed costs (MIFC), as this takes into account the cost of the specific feed nutrients required to produce milk.
- To assist with selecting the most cost effective feed, all feeds should be compared on the unit cost of each kg of dry matter, MJ of energy and kg of protein.
- The first step in ration formulation is to calculate the daily energy requirements of cows. These will vary with cow live weight, pregnancy status, yield and composition of milk and change in body condition or live weight.
- When formulating milking rations, it is also important to consider requirements for protein and the adverse effect of excess dietary fibre levels.
- This chapter presents three case studies for feeding cows in early lactation, when producing different yields of milk (17 v 13 v 10 kg/d) and during the dry season in late lactation.

Feed costs comprise more than half the variable costs on a dairy farm, so sourcing ingredients and formulating cost effective rations can greatly benefit farm profitability. Chapters 12 and 13 concentrate on the mechanics of matching feed supplies to cow requirements with close attention to profit margins.

12.1 Defining 'Milk income less feed costs'

One of the primary skills of dairy farm business management is to be able to quantify the day-to-day profits from correct feeding practices. Feed costs make up 50–60% of the entire variable (or the day-to-day) costs in smallholder dairying, so are an important contributor to the overall cost of production (COP).

The simplest single measure of the economics of feed management is milk income less feed cost (MIFC). This can be defined as:

$$\text{MIFC} = (\text{income from milk sales}) \text{ less } (\text{feed costs})$$

where

$$\text{Milk income} = (\text{milk volume in kg}) \times (\text{unit price in local currency/kg})$$

Milk income can be influenced several ways. Firstly, milk yield increases with better feeding practices; secondly, in many regions, unit price increases with improved milk composition, that is, producing milk which contains more milk fat and/or protein. This again is the result of providing additional feed nutrients, mainly through increasing milk protein content. Reducing the bacterial contamination or improving milk quality, can also increase unit price.

Feed costs is the total money spent on feeding milking cows on a daily basis. It does not take into account the costs of feeding dry cows and young stock, although these are part of the total dairy feed costs because every milking cow must spend part of her life as a heifer or dry cow.

Total feed costs are calculated from all the feed consumed, both forages and concentrates. Much of the forage may be home-grown, but it still has a cost. There are many definitions about the cost of home-grown forages, but the simplest definition is its 'opportunity cost' or what it would cost to purchase directly from another source.

Figure 12.1 The most profitable farmers place great emphasis on home-grown forages (Malaysia)

The end point of profitable ration formulation is to formulate a ration to satisfy the nutrient requirements of the animal to achieve a target level of production at the minimum feed cost. This is called a 'least cost ration' and is used routinely by commercial feed mills to manufacture concentrate mixtures formulated to certain specifications based on the cheapest ingredients. In this case, the concentrate mixture is usually formulated using computers, because it only involves a series of simple calculations. Computer programs are also used to develop least cost rations in intensive animal production units, such as piggeries or beef cattle feedlots, where the nutrient requirements have been fully documented. Computer aids to ration formulation have been discussed in *Tropical dairy farming* (Moran 2005). A new Excel spreadsheet, FEEDPROFIT, has recently been developed to formulate rations and calculate MIFC. This program can be used to undertake the formulation of the rations presented in this chapter and is available at no cost from the author, Dr John Moran at john.moran@dpi.vic.gov.au (or jbm95@hotmail.com).

This chapter presents a series of case studies for smallholder dairy farmers. They are examples of the types of decision-making processes possible once you have some knowledge about cow requirements, the nutritional value of available feeds and their costs. There are many ways in which such information can be used in dairy farm business management, for example, deciding when to purchase feeds that vary in cost throughout the year.

Because cows are herbivores, production rations should be based on feeding as much good quality forage as possible, then supplementing with concentrates. Ideally, the unit cost of the forage is reduced as more of it is grown to feed the milking herd. That is certainly the case with grazing herds in Australia, although it may not always be the case on all Asian smallholder farms.

12.2 Case studies of smallholder dairy farmers

12.2.1 Introduction to case studies

This section contains three case studies for smallholder farmers in Malaysia. The unit of energy is Metabolisable energy (ME) and the unit of currency is the Malaysian ringgit (MR) or sen (100 sen per MR). Appendix 3 presents the unit of currency in other Asian countries, together with their relative values in March 2009. The feed costs in the following tables should not just simply be converted from ringgits into the currency of the country of interest because their relative purchase (or grown) values will depend on the market forces in that particular country.

This particular Malaysian farmer has a wide variety of feeds available (see Table 12.1) for his herd of 10 milking cows, many at different stages of their lactation cycle. Cows differ in their levels of milk production and milk composition, and in their pregnancy status. The forages range from good quality (immature grass, leucaena leaves, maize silage) through to very poor quality (oil palm fronds). The concentrates range from formulated to high energy (palm kernel cake) and high protein (soybean meal). Feed prices and milk returns are for Malaysian farmers in 2009.

Figure 12.2 Truckloads of maize stover for feeding to feed dairy and beef cattle in Sumatra, Indonesia

Note that this farmer has purchased maize silage, not maize stover silage. Maize grain is the major contributor of energy, so the farmer has decided to invest in the maize including the cob, not just the stover. Maize stover silage would obviously be cheaper, but its nutritive value would also be much lower.

The nutritive values of the feeds, presented in Table 12.1, are 'typical' values for dry matter, crude protein (CP), fibre (NDF) and energy (ME) (Moran 2005). The cost of the

Table 12.1 Nutritive values and price of feeds available to smallholder dairy farmers in Malaysia

Feed	Price (sen/kg)	DM (%)	ME (MJ/kg DM)	CP (%)	NDF (%)
Forages					
Immature grass	8	20	9.2	10	55
Mature grass	6	30	7.4	8	70
Leucaena leaves	10	25	9.0	20	55
Maize silage	10	28	10.1	8	50
Oil palm fronds	2	30	6.0	4	75
Concentrates					
Formulated concentrate	100	90	12.0	16	25
Palm kernel cake	70	90	12.0	15	65
Brewer's grain	10	26	10.0	29	57
Rice bran Grade A	40	90	11.1	14	30
Soybean meal	150	90	13.0	45	25

The costs of specific feed nutrients (Table 12.2) can be calculated using Worksheet 3 from Appendix 5.

Table 12.2 Costs of energy and protein in feeds available to smallholder dairy farmers in Malaysia

Feed	Feed cost (sen/kg)	DM cost (sen/kg)	Energy cost (sen/MJ of ME)	Protein cost (sen/kg CP)
Forages				
Immature grass	8	40	4.3	4.0
Mature grass	6	20	2.7	2.5
Leucaena leaves	10	40	4.4	2.0
Maize silage	10	36	3.5	4.5
Oil palm fronds	2	7	1.2	1.7
Concentrates				
Formulated concentrate	100	111	9.2	6.9
Palm kernel cake	70	78	6.5	5.2
Brewer's grain	10	38	3.8	1.3
Rice bran Grade A	40	44	4.0	3.1
Soybean meal	150	166	12.8	3.7

energy and protein contained in all these feeds is presented in Table 12.2. Oil palm fronds is a cheap but very poor quality forage so its use is very limited for milking cows. The cheapest energy sources are brewer's grain and rice bran (and mature grass), while the most expensive is maize silage. The cheapest protein source is brewer's grain and the most expensive is formulated concentrate.

If the profitability of dairy feeding systems was only based on the cost of feed nutrients, ration formulation would be a relatively simple exercise. However, this is not the case, because ration formulation requires cows to be fed the correct balance of nutrients to produce milk, before nutrient costs can be considered. Not only must diets provide sufficient energy and protein, but fibre levels must not be too high. Appendix Table A4.9 provides a guide to the influence of NDF content of the entire ration on the potential appetite of lactating cows of various live weights.

In his herd of 10 milking cows, this farmer has seven mature cows, weighing on average 550 kg, at different stages of lactation, and with daily milk yields ranging from 0 to 20 L/cow. Their energy requirements are presented in Table 12.3, calculated from Appendix 5 Worksheet 1.

Cow 7, although not lactating, was in poor body condition prior to drying off. Consequently, she must be fed to gain 1 kg/d of live weight during the last month of pregnancy. The energy requirements for late pregnancy and such high growth rates are greater than for Cows 4, 5 and 6, all still producing milk. Therefore, even though cows may not be lactating, their daily energy requirements can still remain high.

12.2.2 Case study 1: Formulating least cost rations

This farmer wants to formulate a ration for Cow 1 (in Table 12.3) supplying 147 MJ/d of ME. The cow is in early lactation, non-pregnant, losing 0.5 kg/day and producing 20 L/d

Table 12.3 Energy requirements of smallholder's milking cows (in MJ of ME/day) at different stages of lactation and pregnancy status

Cow details							
Description	**Cow 1**	**Cow 2**	**Cow 3**	**Cow 4**	**Cow 5**	**Cow 6**	**Cow 7**
Live weight (kg)	550	550	550	550	500	500	500
Month of pregnancy	Empty	Empty	Empty	3rd	6th	7th	9th
Milk prod (kg/d)	20	17	13	10	8	6	0
Fat test (%)	3.6	3.6	3.6	3.6	4.0	4.0	0
Protein test (%)	3.2	3.2	3.2	3.2	3.8	3.8	0
LW gain/loss (kg/d)	–0.5	0	0	0	0	+0.25	+1.0
Energy requirements (MJ of ME/d)							
Maintenance	59	59	59	59	54	54	54
Activity	0	0	0	0	0	0	0
Pregnancy	0	0	0	0	8	10	20
Milk production	20 × 5.1 = 102	17 × 5.1 = 87	13 × 5.1 = 66	10 × 5.1 = 51	8 × 5.5 = 44	6 × 5.5 = 33	0
Weight gain or loss	–0.5 × 28 = –14	0	0	0	0	0.25 × 44 = +11	1.0 × 55 = +55
Total energy requirements	**147**	**146**	**125**	**110**	**106**	**108**	**129**

of milk, which at 2.00 MR/kg generates a milk income of 40 MR/d. The basal forage is immature grass and the main supplement is formulated concentrate. A ration of 40 kg fresh grass and 6.7 kg concentrate will supply the required energy to achieve 20 kg/d of milk. Five feeding strategies are presented in Table 12.4 as follows:

1. Feeding 40 kg/d of immature grass plus 6.7 kg/d of formulated concentrate.
2. Increasing ration protein content by substituting some of the grass with leucaena leaves.
3. Increasing ration protein content by substituting some of the concentrate with soybean meal.
4. Reducing cost by substituting some of the concentrate with rice bran.
5. Reducing cost by substituting some of the concentrate with brewer's grain.

Without a computer and a specific ration formulation program it is very difficult to calculate a ration to provide the exact nutrient requirements, so compromises must be made.

In this case, all rations supplied 142–149 MJ/d of ME, and from Appendix Table 4.9, their NDF contents would not limit appetite to below the calculated intakes. Cows in early lactation require 16–18% CP, which was only supplied by the most expensive Ration 3. This high protein requirement may be the case for intensively fed cows producing 25 or 30 kg/d of milk, but for smallholder cows producing only 20 kg /d of

Table 12.4 Case study 1: Five feeding strategies for Cow 1 (in Table 12.3) to produce 20 kg/d of milk in early lactation

	Feeding strategy				
	1	2	3	4	5
Fresh feed intakes (kg/d)					
Immature grass	40	30	40	40	40
Leucaena leaves	–	10	–	–	–
Formulated concentrate	6.7	6.7	4.7	4.7	4.7
Soybean meal	–	–	2.0	–	–
Rice bran	–	–	–	2.0	–
Brewer's grain	–	–	–	–	6.9
Ration descriptors					
Total DM intake (kg/d)	14.0	14.5	14.0	14.0	14.0
Total ME intake (MJ/d)	146	149	147	144	142
CP (%)	12.6	14.2	16.3	12.2	14.2
NDF (%)	42	43	42	43	46
Intake limit (kg DM/d)	15.8	15.4	15.8	15.4	14.4
Total feed costs (MR/d)	9.9	10.1	10.9	8.7	8.6
Milk income less feed cost (MR/d)	31.1	29.9	29.1	31.3	31.4

milk, lower protein levels should suffice. Therefore, 13–14% total dietary protein would be adequate. Feed costs are reduced by substituting 2 kg of formulated concentrates with rice bran in Ration 4, but its lower protein content may limit nutrient supplies, hence depress milk yields below the desired 20 kg/d. Substituting some of the concentrate with brewer's grain (Ration 5) produced an even cheaper ration but with sufficient protein.

The cheapest ration, to produce the same level of milk (valued at 2.00 MR/kg), means it also generates the highest milk income less feed costs, 31.4 MR/d.

12.2.3 Case study 2: Feeding cows in early lactation

It costs more money to feed higher yielding cows, but in the long run, it is more profitable. Table 12.5 presents rations formulated to satisfy the energy requirements of Cows 2, 3 and 4 (from Table 12.3) when fed a basal ration of 40 kg immature pasture.

The 'bottom line' of Table 12.5, the milk income less feed costs, clearly indicates that better fed cows produce more milk, and despite their higher feed costs, generate more income. Compared to the highest yielding Cow 2, Cows 3 and 4 only generate 74% and 54% of the milk income over feed costs.

12.2.4 Case study 3: Feeding cows during the dry season

The supply of forages during the dry season is generally the major limiting factor to farm expansion. Oil palm fronds (leaves of the oil palm tree) are becoming a regular forage

Table 12.5 Case study 2: Profits from feeding Cows 2, 3 and 4 (in Table 12.3) to produce 17, 13 and 10 kg/d milk

	Cow		
	2	3	4
Fresh feed intakes (kg/d)			
Immature grass	40	40	40
Formulated concentrate	6.7	4.7	3.3
Ration descriptors			
Total DM intake (kg/d)	14.0	12.2	11.0
Total ME intake (MJ/d)	146	125	110
Milk yield (kg/d)	17	13	10
CP (%)	12.6	12.0	11.6
NDF (%)	42	45	47
Intake limit (kg DM/d)	15.8	14.7	14.1
Total feed costs (MR/d)	9.2	7.4	6.2
Milk income less feed cost (MR/d)	24.8	18.6	13.8

source throughout Asia as more countries establish plantations to meet increasing global demands for palm oil. However, like rice straw, it is a very low quality roughage source for milking cows. Maize silage, on the other hand, is an excellent forage, but from Table 12.2, it is a more expensive energy source than oil palm fronds (3.5 v 1.2 sen/MJ of ME). The relative energy costs of these two forage sources is one way of deciding which one to feed, but it should not be used in isolation with other important principles of feeding milking cows to efficiently produce milk. It is unlikely that cows fed oil palm fronds will produce much milk, because their appetites would be limited from the very high amounts of NDF consumed. Table 12.6 presents three example rations (X, Y and Z) based on these forages, two of which have over 65% of the forage comprising mature grass. For Cow 5, this would limit appetite because of excessive levels of NDF.

These are just examples of various ways to feed cows when fresh quality forages are in short supply. In this case study, there are large differences in NDF% of these three rations, such that the intake limits are severe when oil palm fronds were fed (Ration X) compared to maize silage (Rations Y and Z). The difference between the formulated DM intake and that calculated from NDF% is presented in Table 12.6 as the value 'A-B', which is highest on Ration X. Therefore, the cows would be unlikely to be able to consume all of Rations X and Y, leading to drops in milk yields, hence a lower milk income less feed costs compared to Ration Z. Despite its higher energy cost, the more maize silage fed, the higher the profit.

Table 12.6 Case study 3: Three dry season feeding strategies for Cow 5 (in Table 12.3) to produce 8 kg/d of milk

	Ration		
	X	**Y**	**Z**
Fresh feed intakes (kg/d)			
Mature grass	20	20	–
Oil palm fronds	10	–	–
Maize silage	–	10	30
Formulated concentrate	2.5	1.5	–
Soybean meal	1.5	1.5	1.5
Ration descriptors			
A. Total DM intake (kg/d)	12.5	11.5	9.7
Total ME intake (MJ/d)	105	106	103
CP (%)	12.4	13.2	13.0
NDF (%)	59	55	47
B. Intake limit (kg DM/d)	9.8	10.9	12.8
A–B (kg DM/d)	2.7	0.6	–
Total feed costs (MR/d)	6.1	5.9	5.2
Milk income less feed costs (MR/d)	9.9	10.1	10.8