17

Economics of feeding dairy cows

This chapter:

Explains the economic benefits of better feeding that can be easily quantified as the milk income less feed costs.

Presents full economic analyses of small holder dairy systems in Thailand and Vietnam.

The main points in this chapter:

- milk income is derived from milk volume and unit price, both of which can increase with improved feeding management
- feed costs make up 50% to 60% of total farm day-to-day costs on small holder dairy farms
- knowing the nutritive values and units costs of feeds allows decisions to be made on the cheapest way to provide the nutrients to achieve target milk yields
- during the dry season, the use of rice straw to supplement limited forage supplies can seriously affect milk yields by restricting appetites due to high dietary fibre levels
- the energetic efficiency of producing the same volume of milk with fewer cows is enhanced by having fewer cows to feed when dry and having to rear fewer heifer replacements
- this benefit is in addition to the higher milk income less feed costs arising from improved feeding practices
- unit returns from milk can be increased through improving milk composition (by increasing milk solids content) and milk quality (by reducing contamination following milk harvest)
- managing non-productive stock on dairy farms is a major cost, comprising over 40% of total farm cost of milk production.

17.1 The business of dairy farming

All dairy farmers milk cows to make money. Throughout South-East Asia, modern small holder dairy farming is a business and should be treated as such. Farmers should make farm management decisions based on their ultimate profitability. Understanding the principles of feeding dairy cows is only part of their occupation. Their most important occupation is converting this knowledge into money.

When small holder dairying first developed in South-East Asia, the primary motivation for government support was social welfare. Milk production is highly labour intensive, thus providing many employment opportunities, not only on the farm, but also in transporting and processing of milk. Furthermore, farmers could enter the industry with few resources. In countries like Indonesia, up to 20% of the small holders do not own land and they harvest their forage along the roadsides and the banks of rice paddies. They repay the purchase cost of concentrates out of their milk returns and can even source livestock on credit, repaying cooperatives with newly born replacement stock rather than actual cash. Nowadays, many government sponsored programs of social welfare and rural development are being replaced by those aimed at improving farm business management.

Dairy farmers need to develop many new skills to become successful business managers. Not only must they able to budget their cash inputs to match their cash returns during the different seasons of the year, but also they must be able to invest wisely in improving their cattle housing and feeding systems. The availability and quality of dry season forage supplies is generally the major limiting factor to increased farm milk production and profitability, and this should be addressed in any farm development program. Every effort should be made to ensure a reliable supply of quality forages to supplement their wet season forages during the dry season. For example, dairy farmers may consider contracting nearby cropping farmers to grow whole crop maize for silage, then store it in a pit near the milking cows, rather than continue to depend on rice straw and other low quality forages as the major dry season feed.

17.2 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% to 60% of the entire variable (or the day-to-day) costs in small holder dairying, so are an important contributor to the overall cost of production.

A useful measure of the economics of feed management is 'milk income less feed cost' (MIFC). This quantifies the margin available to cover all other costs and leave a profit. It can be defined as:

MIFC = (income from milk sales) less (total feed costs)

Where,:

milk income = milk volume (L) × unit price in local currency/L

Milk income: this can be influenced in several ways and these have been covered in previous chapters of this manual. First, milk volume increases with better feeding practices. Second, 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 contents. Reducing the bacterial contamination, or improving milk quality, can also increase unit price.

Total 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 growing heifer or a dry cow.

Total feed costs are for 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 farmer.

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 over a certain time period (day, month or year), at the minimum feed cost. This is called a 'least cost ration' and is used routinely by commercial feed mills to formulate concentrate mixtures to certain specifications based on their 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 Chapter 12. Effectively we will do the same in this chapter, but our 'computer' is the human brain.

This chapter presents a series of case studies for small holder 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 reduces 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 occur on all small holder farms in South-East Asia.

17.3 Case studies of small holder dairy farmers

17.3.1 Introduction to case studies

This section contains three case studies for small holder farmers in Thailand. The unit of energy is then Total Digestible Nutrients (TDN) and the unit of currency the Thai Bhat. Appendix 3 presents the unit of currency in other South-East Asian countries, together with their relative values in February 2005. The feed costs in the following tables should not just simply be converted from Baht 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.

For example, Tables 8.1 and 8.2 in Chapter 8 present feed and nutrient costs in Thailand and Vietnam. Compared to the energy sourced from home-grown forages, the energy costs from formulated concentrates are two to three times higher in Thailand but are three to four times higher in Vietnam.

This Thai farmer has a wide variety of feeds available (see Table 17.1) for his herd of milking cows, all at different stages of their lactation cycle. Cows then differ in their levels of milk production and milk composition and their pregnancy status. The forages range from good quality (immature grass and legume, maize silage) through to very poor quality (rice straw). The concentrates range from formulated to high energy (cassava chips) and high protein (cottonseed meal).

The farmer in this example 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 17.1, are 'typical' values for dry matter (DM), Crude Protein (CP), Crude Fibre (CF) and Neutral Detergent Fibre (NDF) and energy (Total Digestible Nutrients, TDN, and Metabolisable Energy, ME) based on the tables presented in Chapter 10. The cost of the energy and protein contained in all these feeds is presented in Table 17.2. The cheapest energy source is cassava chips (and mature grass), while the most expensive is maize silage. The cheapest protein source is cottonseed meal and the most expensive is cassava chips.

Table 17.1 Nutritive values and price of feeds available to the small holder dairy farmer in Thailand
Thai baht (Bt), dry matter (DM); Crude Protein (CP); Crude Fibre (CF); Neutral Detergent Fibre (NDF); and energy Total Digestible Nutrients (TDN); Metabolisable Energy (ME).

Feed	Price (Bt/kg)	DM (%)	CP (%)	CF (%)	NDF (%)	TDN (%)	ME (MJ/kg DM)
Forages							
Immature grass	0.8	20	10	30	55	60	9.2
Mature grass	0.6	30	8	35	70	50	7.4
Legume	1.0	25	20	32	65	55	8.3
Maize silage	1.5	28	8	24	50	65	10.1
Rice straw	2.5	90	4	42	75	45	6.4
Concentrates							
Formulated concentrate	5.0	90	18	15	25	75	12.0
Maize grain	4.0	85	10	7	8	80	12.9
Cassava chips	2.8	88	2	3	20	80	12.9
Rice bran Gr A	4.5	90	14	13	25	70	11.1
Cottonseed meal	5.2	90	45	13	35	75	12.0

The costs of specific feed nutrients (Table 17.2) can be calculated using Work sheet 3 from Chapter 12.

If the profitability of dairy feeding systems was based only 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 (see Chapter 12).

Table 17.2 Costs of energy and protein in feeds available to the small holder dairy farmer in Thailand
dry matter (DM); Crude Protein (CP); Neutral Detergent Fibre (NDF); and energy, Total Digestible Nutrients (TDN); Metabolisable Energy (ME)

Feed	Feed cost (Bt/kg)	DM cost (Bt/kg)	Energy cost (Bt/kg TDN)	Protein cost (Bt/kg CP)
Forages				
Immature grass	0.8	4.0	6.7	40
Mature grass	0.6	2.0	4.0	25
Legume	1.0	4.0	7.2	20
Maize silage	1.5	5.4	8.2	67
Rice straw	2.5	2.7	6.2	67
Concentrates				
Formulated concentrate	5.0	5.6	7.4	31
Maize grain	4.0	4.7	5.9	47
Cassava chips	2.8	3.2	4.0	160
Rice bran Gr A	4.5	5.0	7.1	36
Cottonseed meal	5.2	5.8	7.7	13

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 17.3, calculated from the Tables in Chapter 6 and Work sheet 1 in Chapter 12.

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 TDN 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 be quite high.

Table 17.3 Energy requirements of the small holder's milking cows (in kg TDN/day) at different stages of lactation and pregnancy status

Cow details	Cow 1	Cow 2	Cow 3	Cow 4	Cow 5	Cow 6	Cow 7
Description							
Live weight (kg)	550	550	550	550	500	500	500
Month of pregnancy	0	0	0	3rd	6th	7th	9th
Milk prod (L/d)	20	17	13	10	8	5	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	+0.5	+1.0
Energy requirements (kg TDN/d)							
Maintenance	4.1	4.1	4.1	4.1	3.8	3.8	3.8
Activity	0	0	0	0	0	0	0
Pregnancy	0	0	0	0	0.6	0.7	1.4
Milk production	*20 × 0.4* = 8.0	*17 × 0.4* = 6.8	*13 × 0.4* = 5.2	*10 × 0.4* = 4.0	*13 × 0.4* = 5.2	*5 × 0.4* = 2.0	0
Weight gain or loss	*–0.5 × 2.0* = –1.0	*0*	*0*	*0*	*0*	*0.5 × 3.1* = +1.5	*1.0 × 3.9* = +3.9
Total energy requirements	11.1	10.9	9.3	8.1	*7.6*	8.0	9.1

17.3.2 Case study 1: Formulating least cost rations

This farmer wants to formulate a ration for Cow 1 (in Table 17.3) requiring 11.1 kg/d of Total Digestible Nutrients using the cheapest possible ingredients. The cow is in early lactation, non-pregnant and producing 20 L/d of milk, which at 12 Bt/L generates a milk income of 240 Bt/d. The basal forage is immature grass and the main supplement is formulated concentrate. Rather than feed it at the usual rate of 1 kg to 2 L milk, the farmer only wants to feed a total of 7.5 kg/d of concentrates. This case study involves using this range of feeds to formulate the cheapest ration for Cow 1. Four feeding strategies are presented in Table 17.4 as follows:

1. Feeding 50 kg/d of immature grass plus 5 kg/d of formulated concentrate
2. Substituting some of this grass with high-protein legume
3. Substituting some of the concentrate with high-protein cottonseed meal
4. Substituting some of the concentrate with high-energy cassava chips

Table 17.4 Case study 1: Four feeding strategies for Cow 1 (in Table 17.3) producing 20 L/d of milk in early lactation

dry matter (DM); Crude Protein (CP); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN).

	Feeding strategy			
	1	2	3	4
Fresh feed intakes (kg/d)				
Immature grass	50	40	50	50
Legume	–	10	–	–
Formulated concentrate	7.5	7.5	5.5	5.5
Cottonseed meal	–	–	2	–
Cassava chips	–	–	–	2
Ration descriptors				
Total DM intake (kg/d)	16.7	17.2	16.8	16.8
Total TDN intake (kg/d)	11.0	11.2	11.4	11.5
CP (%)	13.2	13.3	16.7	12.1
NDF (%)	43	45	44	42
Intake limit (kg DM/d)	15.5	14.8	15.1	15.7
Total feed costs (Bt/d)	77	80	78	73
Milk income less feed cost (Bt/d)	163	160	162	167

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, the rations supply 11 to 11.5 kg/d of Total Digestible Nutrients, NDF% is always too high, hence the appetite limits too low. According to Table 12.1, to allow Cow 1 to fully consume 16.5 kg DM/d, the NDF% should be only 40%, which is just not possible with tropical feeds. Furthermore, cows in early lactation require 16% to 18% CP. This may be the case for intensively fed cows producing 25 or 30 L/d of milk, but for small holder cows, lower protein levels would suffice. Therefore, 13% to 14% CP should be adequate.

The cheapest ration (73 Bt/d) is No. 4, containing grass plus formulated concentrates supplemented with additional cassava chips. The cheapest ration, to produce the same level of milk (valued at 12 Bt/L), means it also has the highest milk income less feed costs.

17.3.3 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 17.5 presents rations formulated to satisfy the energy requirements of Cows 2, 3 and 4 (from Table 17.3) when fed a basal ration of 50 kg immature pasture.

Table 17.5 Case study 2: Profits from feeding Cows 2, 3 and 4 (in Table 17.3) producing 17, 13 and 10 L/d milk
dry matter (DM); Crude Protein (CP); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN).

	Cow		
	2	**3**	**4**
Fresh feed intakes (kg/d)			
Immature grass	50	50	50
Formulated concentrate	7.2	4.9	3.1
Ration descriptors			
Total DM intake (kg/d)	16.5	14.4	12.8
Total TDN intake (kg/d)	10.9	9.3	8.1
Milk yield (L/d)	17	13	10
CP (%)	13.1	12.4	11.8
NDF (%)	43	46	48
Intake limit (kg DM/d)	15.3	14.4	13.7
Total feed costs (Bt/d)	76	65	56
Milk income less feed cost (Bt/d)	128	91	64

The 'bottom line' of Table 17.5, 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 71% and 50% of the milk income over feed costs.

17.3.4 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. Rice straw has always been a regular forage source throughout South-East Asia, but for milking cows, it is a very low quality one. Maize silage, however, is an excellent forage, but from Table 17.2, is a more expensive energy source than rice straw (8.2 v 6.2 Bt/kg TDN). The relative energy costs of these two feeds 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 rice straw will produce much milk, because their appetites would be limited from the very high amounts of Neutral Detergent Fibre (NDF) consumed. Table 17.6 presents three example rations (X, Y, Z) based on these forages, two with a small amount of mature grass, for Cows 5 and 6 which from Table 17.3, have similar daily total digestible nutrients requirements.

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 on the rice straw-based Ration X compared to the high maize silage Ration Z (9.8 v 12.5 kg DM/d). The difference between the formulated dry matter intake and that calculated from NDF% is presented in Table 17.6 as the value

'A – B', which is considerably higher on Ration X. Therefore, Cows 5 and 6 would be unlikely to be able to consume all of Ration X, causing a decrease in milk yields (from 8 and 5 L/d, respectively) hence a lower 'Milk income less feed cost' compared to Ration Z.

Table 17.6 Case study 3: Three dry season feeding strategies for Cows 5 and 6 (in Table 17.3)
dry matter (DM); Crude Protein (CP); Neutral Detergent Fibre (NDF); Total Digestible Nutrients (TDN).

	Ration		
	X	Y	Z
Fresh feed intakes (kg/d)			
Mature grass	20	20	–
Rice straw	5	–	–
Maize silage	–	20	40
Formulated concentrate	2	1	–
Cottonseed meal	2	1	2
Ration descriptors			
A Total DM intake (kg/d)	14.1	13.4	13.0
Total TDN intake (kg/d)	7.7	8.0	8.6
CP (%)	12.7	11.1	13.2
NDF (%)	61.4	56.3	48.0
B Intake limit (kg DM/d)	9.8	10.7	12.5
A – B (kg DM/d)	4.3	2.7	0.5
Total feed costs (Bt/d)	45	52	70

17.4 Determining the optimum herd size

It is always energetically more efficient to feed fewer cows better. The same total farm volume of milk can be produced with fewer cows. Table 17.7 presents annual energy audits for three herds each producing 50,000 L/yr of milk, with varying numbers of milking cows. Herd A has 10 cows each producing on average 17 L/d, Herd B has 13 cows each producing 13 L/d while Herd C has 17 cows each producing 10 L/d. Daily energy requirements are the same as those for Cows 2, 3 and 4 in Table 17.5, although Table 17.7 expresses them in terms of MJ/d of metabolisable energy (ME) instead of kg TDN/d. The cows produce milk for 300 days and are dry for 65 days. Each herd has a 30% heifer replacement rate, meaning that the farmer must rear 3, 4 or 5 heifers each year. Total energy requirements to rear one heifer for one year are assumed to be 22,000 MJ of ME.

Cows in the higher yielding Herd A use less of their daily energy intakes for maintenance (40 v 46 v 52%), allowing them to be more efficient on a day-to-day basis. Compared to Herds B and C, milking cows in Herd A then require 12% and 29% respectively less of their daily energy intakes to produce the same total volume of milk.

After taking into account all the farm dietary energy costs associated with producing milk (including maintaining dry cows and rearing heifers), Table 17.7 expressed this as the total energy requirements to produce the same volume of milk (in MJ/L milk). This amounted to 11.0 for Herd A compared to12.8 for Herd B and 15.0 MJ/L for Herd C.

Table 17.7 also presents the 'Productive feed energy' or the percentage of total farm energy used by milking cows when lactating. Again Herd A is the most efficient with 81%

of its annual feed energy used to produce milk in the lactating cows, compared to 78% (Herd B) and 76% (Herd C).

Table 17.7 Annual energy audit for three herds producing 50,000 L/yr of milk

	Herd		
	A	B	C
Milking cows	10	13	17
Total milk yield (L/cow/yr)	5000	3846	2941
Average milk yield (L/cow/d)	16.7	12.8	9.8
Daily energy requirements (MJ/d)	148	128	113
Energy for maintenance (%)	40	46	52
A Total farm energy for milk prod (000 MJ/300 d)	444	499	576
Daily energy cost to produce milk (MJ/L)	8.9	10.0	11.5
B Total farm energy for dry period (000 MJ/65 d)	39	51	66
C Rearing heifer replacements (000 MJ/yr)	66	88	110
Total farm requirements or *A* + *B* + *C* (000 MJ/yr)	549	638	752
Productive feed energy (%) = *A* / (*A* + *B* + *C*)	81	78	76
Total energy cost to produce milk (MJ/L)	11.0	12.8	15.0

Table 17.7 clearly shows the energetic efficiency of feeding fewer higher yielding cows. However, as well as considering the costs of sourcing that energy, other factors must be taken into account when determining herd profitability, and these will be discussed in the following section.

17.5 Other factors influencing herd profitability

'Milk income less feed costs' is based on the daily feed intake of milking cows and, because Herd A (in Table 17.7) is energetically the most efficient, this would also be expected to be higher than for the other two herds, as they are for Cow 2 is Table 17.5. However, this conclusion is based on the assumption that the milk responses to supplements do not differ between herds (see Chapter 11). Consequently the profitability of feeding supplements in Herd A, compared to those in Herds B and C, may be reduced as Herd A cows would have been fed better to produce more milk.

Another factor influencing herd profitability is the marginal cost, or the cost of each additional unit of energy that is fed. For example, higher quality forages and concentrates often cost more and better fed cows may require

It is very important to monitor the weight of fresh forage offered to each animal (East Java, Indonesia).

these higher quality feeds. To maintain their higher levels of milk production, Herd A cows would require rations providing extra protein and less fibre. Higher yielding cows have greater demands for protein even if their marginal energy requirements are the same per litre of milk produced. Furthermore, such animals must maintain higher feed intakes, which would be more adversely affected by high fibre diets. The cost of providing such rations for high yielding cows may be higher than for lower yielding cows. As this would increase feed costs, profitability levels are likely to decline.

Milk composition depends on nutrient intake (see Chapter 14) and Herd A cows would be fed a better balanced ration supplying more energy and protein and less fibre each day than Herd B and C. It is then likely that milk composition may vary between herds. Herd A cows would produce milk with more milk protein, because of their better energy status, and more milk fat, unless their ration becomes deficient in dietary fibre, which is unlikely because all tropical forages have such high fibre levels. In many countries in South-East Asia, higher milk solids contents return a higher unit milk price, thus providing financial benefits to better fed herds.

Unit milk price can also be affected by milk quality, or the level of bacterial contamination. This is greatly influenced by on-farm hygiene. In South-East Asia, milk quality payments are given on both objective and subjective assessments. For example in Thailand, the objective assessments are actual measures of bacterial contamination, while the subjective assessments are based on inspection of farm equipment and facilities. For cows in Herd A to produce 5000 L milk/lactation, their overall farm management must be excellent. Not only does this include feeding, but also the health, milking, reproduction and rearing of young stock. It is then likely that any subjective assessment for milk quality would be provide maximum premiums, hence increase unit milk price, hence 'milk income less feed costs'.

The data in Table 17.7 were calculated on the assumption that cows produced one calf each year and 30% of the heifers were used as herd replacements. From Chapter 15, cows provided with adequate energy have higher fertility because they are more likely to cycle earlier post-calving. It is likely that Herd A cows will cycle earlier than Herd B or C cows because of their higher feed, hence energy intakes. Consequently, heifer replacement rates may differ as a result of different culling pressures in the three herds.

If 'milk income less feed costs' were calculated on a whole-farm basis over 12 months, Herd A would be the most profitable. Its higher energetic efficiency and greater unit milk price would offset any greater substitution rate and higher unit feed costs discussed above. The above factors highlight the complex interactions between feeding management, milk responses and herd profitability. Ideally all biological responses should be expressed in terms of financial returns less cost inputs. At least in nutrition, there are now the tools to do this with more confidence than in other areas of farm management.

17.6 Improving unit returns for milk

Sanderson (2004) argues rightly that there is no point in focusing on nutrition, breeding and other improved herd management if the infrastructure of the industry is not in place to ensure that the raw milk is supplied to the milk processor in a clean and safe manner. Too often, particularly in warm climates, breakdowns in milking hygiene have led to serious outbreaks of food poisoning. Even for dried milk products such as powder, the processing costs can be dramatically increased and the longevity of the end product can be markedly reduced, in raw product with high levels of bacterial contamination. Even though milking hygiene is not an integral part of feeding management, its influence on unit milk returns justifies its brief mention in this manual.

17.6.1 Milk composition

As already mentioned, improving milk composition, or the content of milk fat, protein or Solids-Not-Fat (SNF), can increase unit milk returns. Chapter 14 discusses the effects of feeding management on milk composition. Each country in South-East Asia has developed its own unique milk pricing structure, which incorporates premiums and penalties based on milk composition. Countries with more developed milk analytical laboratories can test for milk fat and solids-not-fat ,while others only use Total Solids (TS) in their pricing structure (see Tables 17.8 and 17.9 for examples of such payment schedules).

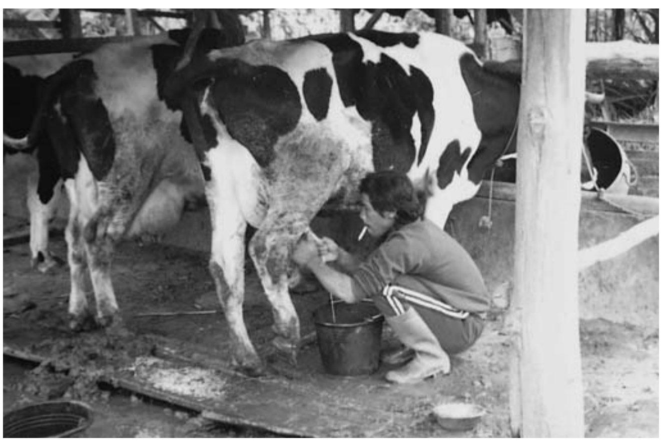
17.6.2 Milk quality

Milk quality refers to the level of various contaminants in milk, be they bacterial, chemical or any other adulterations that can be detected. In many South-East Asian countries, however, the term 'milk quality' covers milk composition, hygiene and adulteration.

Adulteration of milk can be intentional or unintentional. Intentional adulteration occurs when farmers add compounds to the raw milk (eg water and sugar) in an attempt to increase its volume and at the same time, maintain its density, so the hygrometer will not detect changes in specific gravity. If successful, such farmers will receive a higher payment for volume with a similar payment for estimated total solids content. Organoleptic (or taste) and alcohol tests can normally detect such adulterations with the resultant penalty, or even outright rejection. Antibiotics can also be classified as intentional adulteration, occurring when farmers do not follow the recommended drug withholding periods following animal treatments. Tests for antibiotics and inhibitory substances are now routine in most South-East Asian countries.

Unintentional contaminations can occur either from within the milking cow, such as mastitis, or more usually following milk harvesting. The somatic cell count detects mastitis while an initial screening can be done using the Californian (or Rapid) Mastitis Test.

Inferior milking hygiene is the major cause of poor milk quality and can arise:



Poor milking hygiene will reduce the unit return for milk (Central Java, Indonesia).

- on-farm, through poor cleaning and sterilising practices of milk harvesting equipment
- post-farm gate, due to unclean milk handling and storage equipment and delays to cooling.

Constructing fireplaces in the cowshed ensures good hot water supplies for on farm milking hygiene.

Installing gas fired hot water units in Milk Collection Centres ensures good milking hygiene post farm gate.

The key to any successful domestic milk production system is the establishment of a satisfactory milk harvesting, storage and transport infrastructure. Milk must be harvested in a clean and hygienic manner and cooled as quickly as possible, if it is to have any value for processing. There are several measures of milk contamination following harvest, transport and storage such as Total Plate Count (TPC), Methylene Blue Reductase Test and Resazurin Test. Total plate count is measured in millions of colony forming units per millilitre of milk (M/mL). These tests and the key principles of good milking hygiene practices are fully described in the final report on our Indonesian and Malaysian milking hygiene workshops (Moran *et al*. 2004).

To give examples of the magnitude of measures of milk composition and quality on unit returns of milk from small holder dairy farmers, the current payment schedules for raw milk in Malaysia and Indonesia are presented in Tables 17.8 and 17.9. Small holder dairy industries are very different in these countries in that the infrastructure to handle raw milk post-farm gate is very poor in Indonesia, leading to considerable bacterial contamination once milk leaves the farm.

The Malaysian government penalises farmers for low TS% and SNF%, the latter being determined using fat tests, and high total plate count, with levels over 1 M/mL being severely penalised. The particular milk processor in Indonesia only uses TS% as a measure of milk quality whereas, because of the problems with maintaining milk temperature during transport, it includes an incentive payment for extra cool milk.

Milk produced in Indonesia suffers from low TS% and very high TPC levels. The base payment is given to milk with 11.3% TS, 20 to 30 M/mL TPC and 6 ºC to 8 ºC, compared to 11.75% TS and less than 0.25 M/mL TPC in Malaysia. Note the marked difference in acceptable TPC levels in raw milk from these two countries.

One session in our milking hygiene workshops is called 'Milk quality makes money' (Moran *et al*. 2004), because of the large financial benefits arising from improved milking hygiene practices. For Malaysian farmers, improving milk grade from D to A (see Table 17.8) through reducing TPC levels from 0.5 to 0.25 M/mL will increase unit milk price by 12%. For farmers with poorer milk harvesting practices, improving milk grade from G to D, through reducing TPC levels from less than 1 M to less than 0.5 M/mL will increase unit milk price by 29%.Clearly this is an enormous price signal to improve milking hygiene with smallholder farms quickly responding.

Table 17.8 Milk quality payments used by the Malaysian government in 2005
solids-not-fat (SNF); total solids (TS); Total Plate Count (TPC); Malaysian Ringgit (MR). Base price is 1.23 MR/L for milk containing 3.25% fat, 8.5% SNF and 11.75% TS. (Source: Moran *et al.* 2004)

Grade	Milk composition			Milk quality		Final price
	SNF(%)	TS(%)	Incentive (MR/L)	TPC (M/mL)	Penalty (MR/L)	(MR/L)
A	>9.25	>12.5	0.12	<0.25	0	1.35
B	9.0–9.25	12.25–12.5	0.06			1.29
C	8.5–9.0	11.75–12.25	0			1.23
D	>9.25	>12.5	0.12	0.25–0.5	–0.15	1.20
E	9.0–9.25	12.25–12.5	0.06			1.14
F	8.5–9.0	11.75–12.25	0			1.08
G	>8.5	>11.75	0	0.5–1.0	–0.30	0.93
X				>1.0		0.50

Table 17.9 Milk quality payments used by an Indonesian milk processor in West Java in 2005
total solids (TS); Total Plate Count (TPC); temperature (temp); Rupiah (Rp); Base price is 1720 Rp/L (Source: Moran *et al.* 2004)

Milk composition		Milk quality			
TS(%)	Bonus (Rp/L)	TPC (M/mL)	Bonus (Rp/L)	Temp. (ºC)	Bonus (Rp/L)
<10.7	–25	<1	100	>8	–10
10.7–10.9	–20	1–3	75	**6–8**	**0**
11.0	–15	3–5	50	<6	10
11.1	–10	5–10	40		
11.2	–5	10–15	20		
11.3	**0**	15–20	10		
11.4–11.6	20	**20–30**	**0**		
11.7–11.9	30	30–40	–10		
>12.0	40	>40	–20		

Financial benefits are less clear in Indonesia because milk quality is not monitored for individual farmers, just for the dairy cooperative they supply. If such a cooperative handling 30 t/d of raw milk can reduce TPC levels from 30 M/mL to 5 M/mL, it would generate an additional 3% from milk sales, or 45 M Rp/mth. Reducing TPC levels from 30 M/mL down to 1 M/mL would generate an additional 6%, or 90 M Rp/mth. As well as returning some of these premiums to individual farmers, there are many opportunities to invest in better milk handling equipment and practices, such as those suggested by workshop participants and reported by Moran and Miller (2004). Surprisingly such clear price signals have not had much impact on milking hygiene practices in Indonesia.

17.7 Economic analyses of small holder dairy systems

17.7.1 Results from a survey in Thailand

Skunmun and Chantalakhana (2000) undertook whole farm economic analyses of 10 small holder farms in Thailand, with dairy stock numbers per farm varying from 6 to 30 milking cows, 3 to 26 growing heifers and 1 to 6 female calves. Cow milk yields ranged from 6 to 12 L/d. They found that the average cost of milk production for the entire herd, which included cash and non-cash (eg land rent, labour, depreciation) costs, was 10.5 Bt/L, with milk returning only 8.5 Bt/L, considerably lower than the 12 Bt/L received by farmers in 2005. They then concluded that, after taking into account all the costs involved, small holder dairy farming was not a profitable enterprise with that level of milk returns.

The feed costs were broken down into those for roughages and concentrates. As a proportion of whole farm costs, roughage costs were 23% (ranging from 16 to 32%), concentrate costs were 34% (ranging from 20 to 46%) and total feed costs were 58% (ranging from 51 to 67%).

Skunmun and Chantalakhana (2000) were able to break down the total farm costs of producing milk into those associated with growing out young stock and maintaining dry cows. Of the 10.5 Bt/L total cost, 34% was attributed to growing out replacement heifers, 12% to maintaining cows when dry and 54% to maintaining cows while milking. This clearly shows that managing non-productive stock is a major expense for small holder farmers.

17.7.2 Comparing farming systems in Vietnam

In many countries, small holder dairying began in peri-urban areas, but because of increasing population pressures leading to higher feed costs, it has progressively became rural-based. Cai *et al.* (2000) compared the profitability of small holder dairying in rural (Binh Duong province) and peri-urban (Ho Chi Minh City) areas of South Vietnam. They used the following assumptions:

- cows were milked for 300 days, produced 3900 L, followed by a 120-d dry period
- cows were culled after four lactation cycles
- one of the four calves was reared as a replacement, giving a replacement rate of 25%.

The assumed costs and returns are presented in Table 17.10 where the major difference between the two systems was the supply of forages, either home grown or purchased, and the costs of some of the purchased feeds. Each cow on rural farms consumed 25 kg/d of on-farm and 5 kg/d of purchased forages whereas each cow on peri-urban farms consumed 5 kg/d of on-farm and 25 kg/d of purchased forages. Other feeds consumed (in kg fresh feed/cow per day) were formulated concentrates (3.5 while milking and 1.0 kg fresh feed/cow per day while dry), rice straw (2.0 kg fresh feed/cow per day), brewers grain (2.0 kg fresh feed/cow per day), cassava residue (2.0 kg fresh feed/cow per day) and soybean curd (2.0 kg fresh feed/cow per day). Heifer rearing costs were also lower on rural farms because of the greater supply of on-farm forages.

Two tables present farm profitability data for new farmers purchasing their cows (Table 17.11) or for established farmers using their own heifer replacement (Table 17.12). Unlike the Thai study above (Skunmun and Chantalakhana 2000), dairying was profitable on both rural and peri-urban farms. For new farmers, feed costs comprised 50 to 60% of total production costs. Profit margins were more than four times higher on rural farms because of their lower total feed costs, which were only 66% of those on urban farms.

Table 17.10 Cost and returns on rural and peri-urban farms in South Vietnam

Amounts are shown in in Vietnam Dong (VND). Those feed costs that differ between rural and peri-urban farms are shown in italics. (Source: Cai *et al.* 2000)

	Rural farms
Feed costs (VND/kg fresh)	
On-farm forage	100
Purchased forage	200 (*300 peri-urban*)
Formulated concentrates – milking	2100 (*2300 peri-urban*)
Formulated concentrates – dry cow	1900 (*2300 peri-urban*)
Rice straw	200 (*550 peri-urban*)
Brewer's grain	500 (*400 peri-urban*)
Cassava residue	200
Soybean curd	400
Other costs (VND)	
Daily milk transport	2500
Total AI costs/conception (2.5/conception)	375,000
Veterinary cost/lactation cycle	300,000
Shed maintenance/cycle	125,000
Shed construction over 10 years	2,500,000
Other equipment or investments/cycle	1,200,000
Cow purchase	11,500,000
Rearing heifer from birth to first calving (per milking cow)	467,000 (*756,000 peri-urban*)
Interest on loans (% per year)	12
Returns (VND)	
Milk sales/litre	3200
Cull cow sale	3,500,000
Bull calf value	200,000
Heifer calf value	1,000,000
Monthly manure sales	25,000

The reduced costs through rearing their own replacements increased profitability, particularly for peri-urban farmers (Table 17.12). Using milk income less feed costs, rural farmers were 46% more profitable than the peri-urban farmers, whereas profit margins (taking into account all farm costs) were 96% higher for the rural farmers.

Another useful measure is the total cost of production, expressed as VND/L milk. From Tables 17.11 and 17.12, this ranged from a low of 1,945 VND/L for the established rural farmer to a high of 3,240 VND/L for the new urban farmers. For fresh local milk to remain competitive with reconstituted milk from imported ingredients, Sanderson

(2004) considered that farmers should expect to receive no more than US 20 to 30 c/L, or 3,170 to 4,740 VND/L at current exchange rates (see Appendix 3).

Table 17.11 Profitability of small holder dairying on rural and peri-urban farms in South Vietnam, for new farmers purchasing their cows
* Operational costs calculated as 5% of feed costs. (Source: Cai *et al.* 2000)

Farm type	Rural		Peri-urban	
Cost or return category/420-day lactation cycle	**VND (000)**	**% Total costs**	**VND (000)**	**% Total costs**
Feed costs				
Formulated milking cow concentrates	2,205	22	2,415	19
Other milking cow purchased feeds	780	8	990	8
Formulated dry cow concentrates	252	3	276	2
Other dry cow purchased feeds	48	–	156	1
Roughages	1,470	15	3,360	27
Total feed costs	*4,755*	*48*	*7,197*	*57*
Other operating costs				
AI	375	4	375	3
Veterinary	300	3	300	2
Milk transport	750	7	750	6
Housing	437	4	437	3
Other equipment or investments	300	3	300	2
Operational (electricity, water) *	238	2	360	3
Total other operating costs	*2,400*	*23*	*2,522*	*19*
Cow purchase				
Purchase cost	2,000	20	2,000	16
Loan interest	920	9	920	7
Total costs	*10,075*	*100*	*12,639*	*100*
Total cost/L milk (VND)	*(2,583)*	–	*(3,240)*	–
Returns				
Milk sales	12,480	124	12,480	99
Calf sales/value	600		600	
Manure sales	350		350	
Total returns	*13,430*	*133*	*13,430*	*107*
Total returns/L milk (VND)	*(3,443)*	–	*(3,443)*	–
Profit per cow	3,355		791	
Annual profit	2,915		687	
Profit per litre milk (VND/L)	860		202	
Milk income less feed costs (VND/L)	1,980		1,354	

Even at this lowest milk return (US 20 c/L or 3,170 VND/L), small holder dairy farming can still remain profitable. In addition to milk sales, each litre of milk returns an additional 243 VND from non-milk returns (calf and manure sales), thus grossing 3,413 VND/L, and providing just 173 VND/L profit for the new urban farmer.

In most western studies of profitability of dairy farming, economic analyses of farm profits usually incorporate a component for labour costs (and/or management skills) since farmers can generate other income if they are not dairying. Such analyses are undertaken to assess whether farmers could spend their time more profitably undertaking other forms of income generation. However, in most developing countries, such analyses can provide a guide as to the level of support required for dairying to be economically viable, hence not require government or institutional financial support.

Table 17.12 Profitability of small holder dairying on rural and peri-urban farms in South Vietnam, for established farmers rearing their own replacement heifers
(Source: Cai *et al.* 2000)

Farm type	Rural		Peri-urban	
Cost or return category/420 day lactation cycle	**VND (000)**	**% total costs**	**VND (000)**	**% total costs**
Total feed costs	4,755	62	7,197	69
Total other operating costs	2,400	32	2,522	24
Heifer replacement costs	467	6	756	7
Total costs	*7,622*	*100*	*10,475*	*100*
Total cost/L milk (VND)	*(1,954)*	–	*(2,686)*	–
Total returns	*13,430*	*176*	*13,430*	*128*
Profit per cow	5,808		2,955	
Annual profit	5,047		2,568	
Profit per litre milk (VND/L)	1,489		758	
Milk income less feed costs (VND/L)	1,980		1,354	

17.8 Flow charts of feeding decisions that drive profit

Flow charts of the major feeding management decisions driving profit are presented in Figures 17.1 and 17.2. For each component in Figure 17.1, the feed inputs, the cost of home-grown inputs depend on their quality and availability, both of which are under farmer control. However, the cost of purchased feed inputs are driven by market forces, although farmers can influence these by purchasing these when they are in plentiful

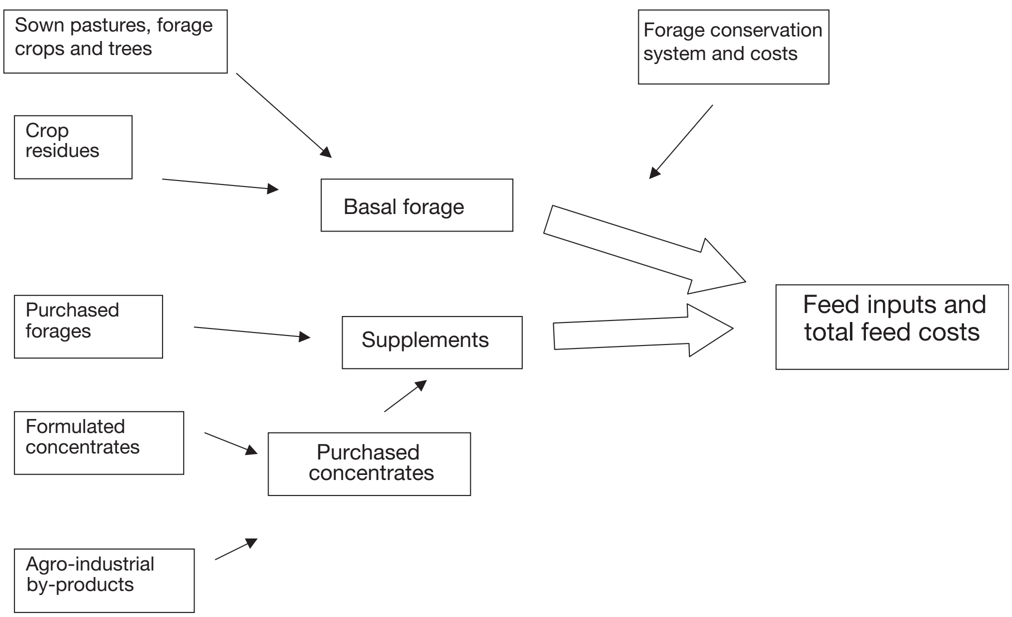


Figure 17.1 Components of feed inputs in small holder dairy farms.

supply, when they are likely to be cheaper.

For fresh forages, such as maize greenchop or grasses, or for wet by-products, such as brewer's grain or soybean curd, total costs must include conservation (as silage) until required. Dry feeds could also be purchased when cheapest but would then require some storage costs. In addition, such purchases may necessitate relatively large cash investments, hence some opportunity cost (such as ongoing interest rates) should be incorporated.

Home-grown forages should also be fully costed, preferably on the basis of cost per unit nutrient, keeping in mind that agronomic decisions to optimise quality, such as using inorganic fertilisers or using a short harvest interval, may increase cost per unit dry matter, but not necessarily per unit of feed nutrient. Furthermore, the cost of supplementing with additional nutrients from other feed sources is included in the final calculation of daily total feed costs per animal. This often leads to the conclusion that an investment in optimising forage quality (which can also improve milk yield) is worthwhile as it reduces supplement costs and/or increases milk return, and thus increases milk income less feed costs.

Figure 17.2 incorporates other factors influencing overall farm profits, such as feeding non-productive dairy stock, disease, fertility and cow genetic merit. Costing such factors is beyond the scope of this manual.

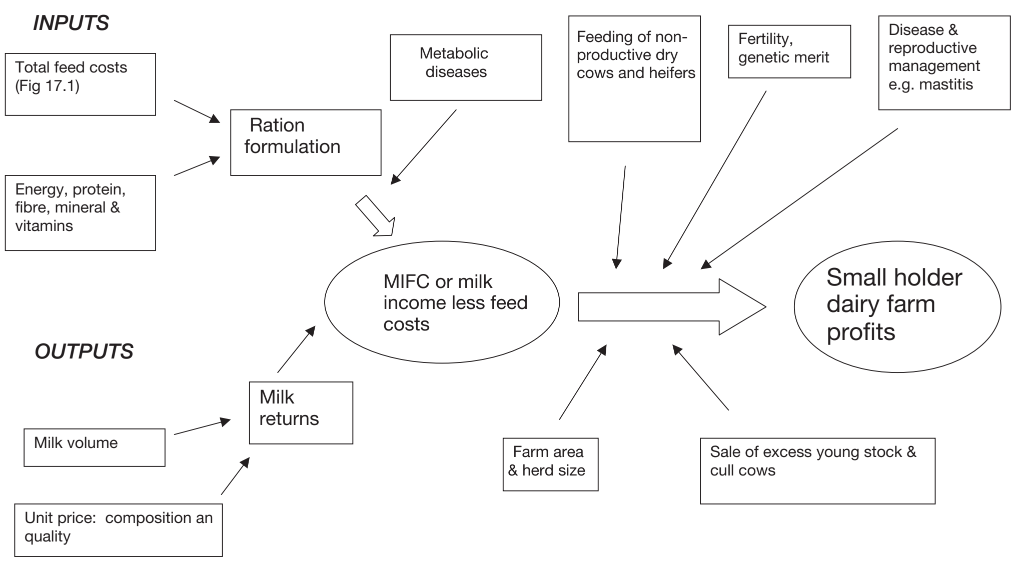


Figure 17.2 Feeding management decisions driving farm profits.