5

The importance of colostrum to newborn calves

This chapter discusses the management of colostrum feeding in the first few hours of a calf's life.

The main points in this chapter

- Calves are born with no immunity against disease, so must depend on their dam to provide passive immunity through colostrum: the first milk produced after birth.
- The essence of good colostrum feeding management is the 3 Qs; quality, quantity and quickly.
- Quality is essential to ensure there are sufficient antibodies (against diseases) in the colostrum for absorption by the calf.
- Quantity to ensure the calf ingests sufficient of these antibodies.
- Quickly means the calf's digestive tract is still receptive to absorbing them.
- Modern day dairy cows do not produce good-quality colostrum and many calves will not drink soon after birth. Therefore it is better to stomach tube each newborn calf to ensure it can acquire passive immunity against diseases.
- The level of circulating antibodies in the calf's blood has a direct influence on its disease resistance, its performance as a mature cow and the financial contribution to the farm's profit.

Calves need to receive individual attention and care immediately following birth. There is a direct link between good calf care and improved milk production and longevity in the milking herd. Care of the newborn calf is discussed in Chapter 14 of this manual.

Calves are born with no immunity against disease. Until they can develop their own natural ability to resist disease, through exposure to the disease organisms in their surroundings, they depend entirely on the passive immunity acquired by drinking colostrum from their dam (see Figure 5.1).

Colostrum is the thick, creamy-yellow, sticky milk first produced by cows initially following calving, and contains the antibodies necessary to transfer immunity onto their

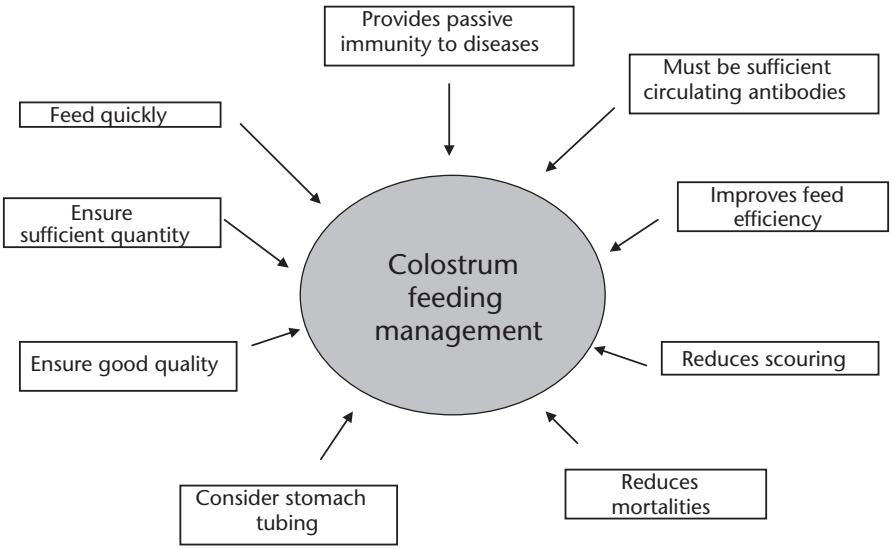

Figure 5.1. The key factors and benefits of colostrum feeding management in newborn calves

calves. It is essentially milk reinforced with blood proteins and vitamins. It has more than twice the level of total solids than in whole milk, through boosted levels of protein and electrolytes. It also contains a chemical allowing newborn calves to use their own fat reserves to immediately provide additional energy.

Newborn calves have no immunity against disease.

The calf should be assisted for its first suckle from its dam.

The concentrations of protein and vitamins A, D and E in colostrum are initially about five times those of whole milk, with a protein content of 17–18% compared with milk's 2.5–3.5%. However, within 2 days these are little different from those in whole milk. The levels of vitamins in colostrum are dependent on the vitamin status of the cow. The blood proteins transfer passive immunity from mother to offspring through maternal antibodies or immunoglobulins (Ig).

The chances of calves surviving the first few weeks of life are greatly reduced if they do not ingest and absorb these antibodies into their bloodstream. It takes far fewer disease organisms to cause disease outbreaks in such calves than if they can acquire immunity from their dam. Calves without adequate passive immunity are four times more likely to die and twice as likely to suffer disease, than those with it. Furthermore in certain situations, blood levels of antibodies in heifer calves are directly related to their milk production in later life.

The term colostrum is generally used to describe all the milk produced by cows up to 5 days after calving, until it is acceptable for use by milk factories. However, a more correct term for milk produced after the second milking post-calving is transition milk (Moran 2002). This milk no longer contains enough Ig to provide maximum immunity to calves, but still contains other components, which reduce its suitability for milk processing. Milk factories can now test for and penalise farmers who include transition

milk in their milk vat. Because it has no market value, transition milk should all be fed to calves to reduce their total feed costs. However, it must be stressed that the immune properties of this pooled milk are much reduced once first milking colostrum is diluted with that from second or later milkings.

When considering colostrum feeding to dairy calves, it should be appreciated that modern milking cows are vastly different to the primitive, feral cows from which they evolved thousands of years ago. Their udders are much larger and often hang too low for easy suckling by their offspring. They produce vastly greater quantities of milk, which means that their first and second milking colostrum is much more dilute than is desirable for optimum quality. Furthermore, because mothering ability has little relevance on dairy farms and has probably been bred out of cows, they may be less likely to want to suckle their progeny immediately after birth. This is still not the case with beef cows, where unassisted suckling is a highly efficient means of passive transfer of immunity in beef calves. These natural methods are less effective in dairy herds, meaning that farmers often have to rely on so-called less natural techniques.

5.1 Current recommendations on colostrum feeding

Recommendations for colostrum feeding have changed dramatically over the last two decades. Twenty years ago, it was considered acceptable for all calves to run with their dams for 1, 2 or even 3 days and for her to pass on passive immunity through natural suckling. As producers learnt more about the causes and prevention of calf diseases, they became more 'colostrum conscious'. Current advice to farmers is to ensure all calves drink from their dam within the first 3–6 hr of life and, if not, to provide additional colostrum from its mother or another freshly calved cow. Colostrum quality can be assessed visually, or more accurately, using a colostrometer, which works on the same principle as the hydrometer used to measure the acid level in car batteries. Recently, more sensitive field test kits have become available to calf rearers in many countries.

Two feedings during the first day, 6–12 hr apart, and each of 2 L of good-quality colostrum used to be considered sufficient to provide passive immunity, mainly because of concern about the small capacity of the abomasum in newborn calves. However, US advisers now recommend that dairy farmers remove the calf as soon as possible after birth (within 15 min) and feed it 3–4 L of top-quality colostrum at one feeding. This may not be possible with small calves, so it could be spread over two feedings, 6 hr apart. This can be via teat, bucket or stomach tube. The latest findings are that this extra colostrum will be stored in the rumen, from where it slowly passes through the abomasum into the intestines where the Ig are absorbed into the blood.

For those rearers who still wish their calves drink from their dams, the UK guidelines provided by Margerison and Downey (2005) are that suckling should always be supervised, and assisted where necessary, to achieve colostrum intake levels of 2.5 L within the first 6 hr of life and 4 L within the first 12 hr of life. Where the calf is not able to suckle successfully, it should be offered milked or stored colostrum from a nursing bottle or stomach tube and, in these cases, all feeding utensils should be kept scrupulously clean. To ensure adequate quality, the colostrum consumed should be from adult cows,

Table 5.1. Recommended colostrum allowances for newborn calves

Age (days)	Period	Allowance (L)
1	<6 hr	2.5
1	<12 hr	4
2 –3	Daily	3–4
Continued	Continued	5% total milk offered

Where scours is a problem, continued feeding of good-quality colostrum is recommended up to 3 weeks of age.

because heifers tend to have lower immunoglobulin levels in their colostrum. The amount of colostrum required to be consumed according to age is presented in Table 5.1.

This chapter highlights the important principles behind colostrum feeding, to ensure that all calves get a 'good start to life' through adequate transfer of passive immunity. These principles can be categorised into 3 Qs, namely:

- **Quality** is providing good-quality colostrum.
- **Quantity** is ensuring calves ingest sufficient antibodies.
- **Quickly** is timing the first feed to ensure efficient absorption of the antibodies into the blood.

5.1.1 Colostrum quality

Colostrum is produced by the pregnant cow up to 5 weeks before she calves down. If cows are not well managed, colostrum quality could be reduced. Good management includes providing a good-quality diet for dry cows, ensuring they are in good general health and minimising stresses such as climatic or overcrowding during late pregnancy. Older cows, and cows raised in the herd (compared with those purchased as in-calf heifers), will generally produce better quality colostrum, containing more antibodies for those diseases existing on that farm. First-calf heifers are likely to have the lowest levels of antibodies in their colostrum because they have had less exposure to these diseases.

The immune properties of colostrum can be enhanced by vaccinating cows at drying off. There are vaccines to improve calf immunity against *E. coli*, *Clostridia*, *Leptospira* and *Salmonella*, but they may not always be readily available in Asian countries. Selection of the most appropriate vaccines should be based on the prevalence of particular calf diseases in that area – information readily available from local advisers and veterinarians. American farmers are fortunate in having vaccines against two other major causes of calf scours, rotavirus and *Cryptosporidia*, and also against several respiratory infections. As demand for better quality colostrum increases, such dry cow vaccines should become available in Asia.

Newborn calves need to ingest at least 100 g of Ig within their first 3–6 hr of life, and the same amount no less than 12 hr later. The quality of colostrum is expressed in terms of its Ig concentration, with excellent quality colostrum containing at least 90 g/ L, good quality 65–90 g/L, moderate quality 40–65 g/L and poor quality less than 40 g/L. The volume of colostrum that should be drunk to supply 100 g of Ig can then be calculated from its quality.

The higher the colostrum quality, the faster and more efficiently the Ig are absorbed by newborn calves. With poor-quality colostrum, not only must calves be fed very large volumes to provide sufficient Ig intakes, but it is likely that, even then, inadequate amounts of Ig will be absorbed into the blood. For example, 2 L of colostrum containing 80 g/L of Ig will provide more passive immunity than 4 L of colostrum containing only 40 g/L of Ig. Bloody colostrum may also be lower in antibody levels.

After their first milking, dairy cows begin to reabsorb the Ig back into their udder tissue. For this reason, colostrum from the second milking contains only half the Ig content as that from the first milking. Cows are generally deficient in Ig levels if they have been previously milked or are seen to be leaking milk prior to calving. Colostrum quality is also low in induced cows or those with less than 4 weeks between drying off and calving.

On the whole, Jerseys produce colostrum containing more Ig than do Friesians. In fact, very few Friesian cows produce excellent quality colostrum. Cows yielding large volumes of first milking colostrum (8 L or more) are more likely to have low Ig concentrations. There is little seasonal effect on colostrum quality. Some studies have found seasonal differences in acquired immunity in calves, but this is more related to changes in colostrum feeding management rather than colostrum quality.

Recent studies in Australia have confirmed US findings that many dairy cows do not produce good-quality first milking colostrum. This is also likely to be the case with dairy cows in tropical Asia. Using a colostrometer to assess quality, colostrum was categorised (with the percentages of cows) as poor (41%), moderate (34%), good (21%) and excellent (4%). These findings highlight the importance of identifying cows producing poor-quality colostrum soon after parturition then feeding their calves on stored good- or excellent-quality colostrum (Humphris 1998).

Johne's disease (or paratuberculosis) is an ongoing problem in many dairy regions in Western countries, and probably in Asia as well. It is possible for Johne's disease to be transmitted from cow to calf prior to calving, and also via the colostrum. Although the incidence of transfer by these methods may be quite small, it should be taken into account in any Johne's disease prevention program. For this reason, current recommendations are for disposal of both the infected cow and her daughter, if the last calf before breakdown was a heifer. The most important aspect of any Johne's disease control program is to minimise contact between milking cows and replacement heifers until at least 6–12 months of age. Rearing systems based on milk replacers, rather than whole milk, are often recommended, but this is mainly to reduce the possibility of cross-infection from cows being milked in the dairy to calves being fed fresh whole milk in the rearing shed.

The protection from the passive immunity passed onto the calf peaks 1–2 days after effective colostrum transfer and then it declines. By 2 weeks of age, it has declined enough to increase the calf's susceptibility to bacteria, viruses and other pathogens, before the calf's own immunity increases to an effective level. Therefore the calf can be quite vulnerable to pathogen invasions coming from dirty feeding equipment or other sources between 14 and 21 days of age.

In well-managed herds with few disease challenges, calf isolation is particularly important because the colostrum is likely to have lower Ig levels because pregnant cows

would have been exposed to fewer pathogens. Providing calves with both isolation and high-quality colostrum is important in these herds, and also those with high culling rates because they would contain a higher proportion of first-calf heifers. Farmers with seasonal-calving herds and practicing oestrus synchronisation of heifers to calve before the older cows face a quandary of not having fresh supplies of high-quality colostrum on hand. These farmers may consider storing colostrum from the previous year, which means they must be able to identify the best quality colostrum for long-term storage. If they are concerned about the quality provided by any freshly calved cows, then additional colostrum should be fed to their calves from a store of good-quality colostrum.

5.1.2 Timeliness of colostrum feeding

Every half hour after birth that colostrum feeding is delayed, antibody transfer decreases by about 5%. A calf that does not drink until 6 hr old has then already lost the opportunity for 30% of the possible antibodies entering its bloodstream.

Margerison and Downey (2005) reported on the mortality of calves suckling colostrum, for the first time, at different hours of life, as shown in Table 5.2.

Colostrum feeding can then be seen as a race between the arrival of the protective colostrum Ig in the calf's intestines and the disease-causing pathogens. The longer calves are without Ig, the more opportunity for these pathogens to invade the gut. If certain pathogens, such as *E coli*, 'win the race' in the first few hours, they can even be absorbed into the blood, causing severe scours and reduce the effectiveness of any absorbed Ig.

The timing of colostrum feeding is crucial. The cells in the intestinal wall mature in these first 12 hr, eventually shutting down their absorption mechanism. Furthermore, after 24 hr, when the abomasum starts to secrete acids to make the milk-digestive enzymes more effective, these degrade the Ig proteins, which reduce their effectiveness. Another confounding factor is that protection against pathogenic bacteria is minimal until the abomasum can secrete sufficient acid to reduce their potential to cause scours. Provided the calf has drunk colostrum, the maternal antibodies can control the spread of these harmful bacteria. The Ig in colostrum is still beneficial to the calf even if it can no longer be absorbed into the blood, as it lines the intestinal walls to provide local protection against the build up of pathogens.

Stressed calves, such as those born in cold, rainy weather and left unprotected, and those requiring assistance during birth, cannot absorb Ig for as long a time as calves with easier births. Calf rearers who feed colostrum by artificial means give these calves a greater chance of survival.

Table 5.2. The mortality of calves suckling colostrum for the first time at different hours of life

Hours post-natal	Mortality (%)
2–6	5
7–12	8
13–24	11
25–48	20

The current US recommendations for first feeding are to offer 3 L to Jerseys and small Friesians and 4 L to average-sized Friesians, as soon as possible after birth. A second feeding of 2 L, or more if the calf is willing, can be provided 6 hr later, although it is not really necessary to feed these calves until the following day. Colostrum and transition milk should then be fed for the first few days of life to provide extra nutrition and local protection against disease.

If calves are not weak from a lengthy and difficult birth and are breathing well, they do not require further stimulation from their dams, such as licking off. There is little benefit for cows to have them lick their calves to strengthen maternal bonds. In searching for the teat, calves are likely to take in more pathogens than they would get from a sterilised stomach tube.

The longer calves spend with their dams, the greater their chances of contracting disease. The practice of 'snatch calving', or removing the calves from their dams at birth, may be difficult to encourage in seasonal calving herds unless there are obvious benefits through reduced health problems, such as Johne's disease, and reduced mortalities. It would greatly increase labour requirements during any busy calving period.

5.1.3 Identifying and storing good-quality colostrum

Over the years, there have been various attempts to assess the quality of colostrum. Unfortunately, visual appraisal is a poor way of assessing quality because thick, creamy colostrum may simply be indicative of its high fat content. There is a negative relationship between Ig level and fat content in colostrum because the Ig resides in the non-fat component of the milk solids. The colostrometer was developed specifically to determine Ig levels, but recent research has shown up some limitations. When using colostrometers to quantify Ig status, it is important to measure it at room temperature, or better still, use a thermometer to make certain the colostrum is measured at the recommended temperature. Colostrometers are good at detecting poor samples, but unfortunately they are limited in their ability to make other assessments. Their major role should be to screen samples to ensure only colostrum with more than 80 g/L of Ig is fed fresh or stored for later use.

Recent research has shown that refractometers calibrated in the brix scale (used to assess sugar content of sugar cane and molasses) can be used to assess the quality of colostrum with good accuracy (Dairy Australia 2011). Its accuracy is not affected by the temperature of colostrum, as is the case with colostrometers.

Colostrum allowed to sour or become overheated loses its antibody effectiveness. Freezing is the best method for storage, because this will retain its antibody activity for at least 1–2 yr. Frost-free freezers are not ideal because their freeze–thaw cycles can allow the colostrum to thaw, and this can shorten its effective storage life. Rapidly chilled colostrum can only be stored in the refrigerator for up to 5 days, before it loses its antibody effectiveness. Containers of stored colostrum should be identified with its origin and, if known, its quality. Colostrum can be pasteurised and stored for up to 10 days, but this is only practical on very large farms. Fresh colostrum should not be mixed with that being stored, so each individual cow's colostrum should be stored in a separate labelled container.

Frozen colostrum should be thawed out carefully, because overheating it to above 50°C denatures the Ig. Colostrum frozen in 1–2 L milk cartons, or better still, in thick plastic bags can be thawed out in 50°C water. The time between the first appearance of the calf's feet prior to birth until it is first ready to drink, should be sufficient for frozen colostrum to thaw in warm water at 50°C. If using a microwave oven, it should have a turning tray to avoid hot spots and the defrost setting should be used. Pour off the liquid as it thaws to reduce overheating.

5.2 Feeding colostrum to newborn calves

Clean the teats of cows from which colostrum is to be harvested and ensure it is collected into clean and sterilised containers. Even moderate levels of bacterial contamination can lead to significant scour problems. Cover the colostrum bucket tightly, both before and after collecting the colostrum, to ensure it remains clean.

US veterinarians now recommend feeding 3–4 L rather than 2 L of good-quality colostrum at first feeding, just to ensure that adequate Ig are ingested. Increasing volumes at first feeding markedly reduces the number of calves with low blood Ig levels, indicative of failure of passive transfer of immunity. It takes the first 2 L to fill the rumen while the second 2 L spills over into the abomasum. Newborn calves should readily drink 2 L through a teat from a nipple bottle, but greater volumes are generally refused. There is little difference in absorption of colostral antibodies whether calves drink it all from a nipple bottle or it has been administered using a stomach tube.

Stomach tubing a newborn calf with its first colostrum.

Stomach tubing is generally necessary to ensure the entire 3–4 L is consumed. Fluids will pass directly into the rumen, not the abomasum, because the oesophageal groove will not close. However, it will quickly flow from the rumen into the abomasum. Farmers should always have a stomach tube on hand and learn how to use it. Calves weak from difficult calvings or with swollen tongues preventing them from sucking should be tube fed the entire 3–4 L of colostrum immediately. Calves will not regurgitate it or get it into their lungs if the fluid is correctly administered with a stomach tube. Veterinarians are not overly concerned about providing the calf with too much colostrum and causing scours, because this first milk contains less lactose than later milk, and it is the overflow of lactose into the hind gut that leads to scours. The first drink is the most important because the ability of calves to absorb further Ig through the gut wall drops off markedly thereafter.

5.2.1 How to stomach tube a calf

Weak calves may not be able to drink liquids from a teat. Stomach tubing is the best way of ensuring that they consume enough liquids. Some dairy farmers routinely stomach tube all newborn calves to provide colostrum and be certain that they will absorb sufficient antibodies to enhance their immunity against diseases. Scouring calves with severe dehydration, which are too weak to drink themselves, can also be stomach tubed.

The stomach tube is a flexible piece of plastic tubing with a tear-shaped end designed to be easily inserted into the oesophagus, but not into the lungs. It is usually attached to a plastic container holding the liquid to be fed.

The first step in using the stomach tube is to determine the length of tube to be inserted. This is measured as the distance from the tip of the calf's nose to the point of its elbow behind the front leg, which is usually 45 cm or more. This point can be marked on the tube with a piece of tape.

Ideally, the calf should be standing so the fluids are less likely to back up and enter its lungs. However, calves that are too weak to stand can be tubed in a sitting position and even while lying down. The stomach tube is easier to use when calves are restrained. Young calves can be backed into a corner for better head control. A calf allowed to throw its head from side to side may injure itself or the operator.

If the weather is cold, the tube can be placed in warm water to make it more pliable. The tube should be dipped into a lubricant, such as mineral or vegetable oil. The tip of the tube is then placed into colostrum or whole milk, whichever is to be fed. Calves may suck the end of the tube, making it easier for it pass into the oesophagus. A calf's mouth can be opened by gently squeezing the corner of the mouth or by holding its head over the bridge of the nose and gently squeezing the upper palate or gums.

Once the mouth is opened, the empty tube should be passed slowly along the tongue to the back of the mouth. When the tube is over the back of the tongue, the calf starts chewing and swallowing it, after which the tube is passed down into the oesophagus. The end of the tube can be felt quite easily in the neck as it passes down the oesophagus. Never force the tube: if it is being correctly put down the oesophagus, it should slide in quite easily.

After the tube is in place, and before any fluids are given, it should be checked for proper positioning in the oesophagus. If it is properly positioned, the rings of the trachea

(leading into the lungs) and the rigid enlarged oesophagus can be felt easily. If you cannot feel both of these, remove the tube and start again. The exposed end of the tube should be checked for spurts of air, which indicate that the tube has gone into the lungs. The calf will often, but not always, cough if this occurs.

It is important to ensure that fluid does not leak from the tear-shaped end of the tube while it is being inserted or withdrawn, because this fluid may be inhaled by the calf and cause pneumonia.

The tube can be unclipped or straightened out or the container can be tipped up to allow liquid to flow down into the stomach. Liquids should be at body temperature (38°C) to prevent shock to an already weak calf. It may take 3 min or more to allow sufficient fluid to be administered. The calf will regurgitate less with a slow flow rate.

When feeding is over, the tube should be slowly removed. The tube should be cleaned and sanitised, then allowed to drain and dry.

Veterinarians often concede that this method for colostrum feeding is not natural, but it does provide an easy and well-tolerated method of achieving an adequate and early intake of Ig at the first feeding. It is widely used throughout the world, where calf rearers are finding significant improvements in passive transfer of immunity and reduced calf health problems.

5.2.2 Making best use of transition milk

As mentioned earlier in this chapter, transition milk is that milk produced by the cow after the second milk post-calving. Depending on the policy of the milk processors, this milk should not be commercially sold because it can reduce the efficiency of processing the raw milk destined for dairy products than can pasteurised milk. This milk can still contain some colostral antibodies. As with true colostrum, if fed following the closure of the gut wall to antibodies entering the bloodstream, this milk will still provide protection against pathogens in the calves' stomachs and intestines. It does this by deactivating the pathogens in the gut contents. The greater the problems with scours in the calf shed, the greater the benefit of routinely feeding transition milk, and any excess colostrum, to calves within their first week of life.

Because such transition milk may have no market value, it should be fed to calves to provide nutrients for calf growth. Compared with market milk containing 12–13% milk solids, colostrum comprises 25% and transition milk 15–18% milk solids. There are a lot more nutrients available per L of colostrum and transition milk than in market milk.

Transition milk should be stored in clean containers until fed to calves and can form the initial source of milk before calves are fed CMR, if that is the main form of milk feeding. It can even be blended with CMR powder to reduce the amount of powder required to provide the daily nutrient requirements for milk-fed calves.

5.2.3 Using stomach tubes to relieve abdominal pressure

Provided it is long enough, a stomach tube can also be used to relieve pressure build up in the stomach during milk bloat. This can occur with twice daily feeding of some milk replacers. This is the result of the previous curd of clotted milk not being given sufficient time to digest before the calf is offered further milk replacer.

Milk bloat can also occur when milk enters the rumen, rather than the abomasum, and ferments with other ruminal contents. This can restrict the escape of ruminal gases. This may occur when calves have functional rumens and, in these cases, they can be weaned off milk. Where this problem occurs in immature calves, they should be examined further by a veterinarian.

To relieve pressure build up, introduce the tube, without the bottle attached, into the calf's oesophagus as described above. The gas should then be heard escaping, generally with a foul smell, and the distended abdomen will quickly return to normal.

5.3 Results from overseas research on colostrum feeding

In his survey of calf mortalities on small holder farms in Ethiopia, Jemberu (2004) reported a close relationship between calf mortality and age when calves drink their first colostrum. If later than 6 hr after birth, calves had higher morbidity (signs of sickness) and mortalities than if they consumed it earlier in life. For each hour delay in colostrum feeding in the first 12 hr of life, the chance of a calf becoming ill increases by 10%.

A large-scale survey of 600 dairy farms throughout the US (NAHMS 1994) found more than 40% of newborn calves had immunity levels below those recommended, while 25% of these calves had critically low immunity status. The death rate among all these calves was twice that of calves with adequate passive transfer of immunity. The study concluded that over 20% of the calf deaths could be avoided by ensuring adequate and timely colostrum intakes. Other estimates suggest that 50% of the mortality that occurs in pre-weaned calves is directly related to this inadequate acquisition of passive immunity (Quigley *et al.* 2005).

This study allowed a comparison of the effects of varying blood Ig levels on calf performance for 2020 calves, as presented in Table 5.3. As blood Ig levels increased, calves grew faster, had more efficient feed utilisation, had lower incidences of scours, but, of most importance, had much lower mortality rates. The extremes of mortality were 29% in the 6% of calves with very low blood Ig levels (0–5 mg/mL) compared with only 8% in the 66% of calves with good blood Ig levels (>15 mg/mL).

If calves are left to nurse from their dam for 24 hr, more than 60% do not take in sufficient Ig. In this study, a second group of calves was provided with 2 L of good-quality pooled colostrum as soon as possible after birth, and those calves recorded a 19% failure of passive transfer of immunity. A third group, fed 3 L of colostrum, had a 10% failure of passive transfer.

Herds with high-yielding cows differ in their newborn calf care from those with lower yielding cows. Top producers were more likely to separate calves from dams at birth before nursing, feed colostrum either by bucket or stomach tube, and feed 4 L/calf or more. Bucket feeding the colostrum was more popular than using stomach tubes, although more used stomach tubes in larger herds. Among farmers that allowed cows to nurse their calves, top producers were more likely to supplement colostrum delivery with hand feeding.

As a result of findings such as these, two-thirds of US dairy farmers now artificially feed the first colostrum to their calves. Of those still allowing newborn calves to nurse

Table 5.3. Four-week performance of calves with varying levels of blood Ig levels

Blood Ig level (mg/ml)	0–5	5–10	10–15	15–25	>25
Percentage of calves	6	11	16	29	37
4-week live weight gain (kg)	9.6	10.7	11.0	11.1	11.6
Feed conversion (kg feed/kg gain)	2.7	2.1	2.2	2.0	1.8
Average faecal score[a]	1.4	1.3	1.2	1.2	1.2
Scour days[b]	7.3	5.7	4.8	5.1	4.9
Mortality (%)	29	16	11	8	8

[a]Faecal scores: 1 normal; 2 loose; 3 watery; 4 blood or mucous.
[b]Scour day, any day when faecal score is 2 or more.

from their dam, 40% assist each calf, thereby increasing the calves' chances of receiving adequate and timely quantities of first colostrum. Although providing calves with immediate assistance to stand and suckle increases the ingestion of Ig, many calves still show failure of passive transfer of immunity.

Delayed suckling is the major cause of poor transfer of immunity: surveys have shown that 25–30% of calves fail to suckle by 6 hr and nearly 20% by 18 hr. The first suckling is later in calves born to heifers and in those born to cows with low, pendulous udders. Diseases are more prevalent in calves that have delayed their first suckling.

Furthermore, there is considerable variation in the actual quantities of colostrum drunk by naturally suckled calves, but the average intake is only 2.5 L within their first 24 hr of life. Unless this is very high-quality colostrum, inadequate Ig intakes will occur.

These findings demonstrate several important aspects of colostrum management. The very high failure rate with calves nursing their dams is due to the inability of calves to drink sufficient colostrum within a few hours after birth. The udder of the cow at birth is large, and at times painful, making drinking of sufficient colostrum difficult. Furthermore, calves born weak or having difficult births may not even stand for several hours. As already mentioned, the Ig concentration of the colostrum may be low, meaning that calves have to voluntarily drink large volumes at a time when both cow and calf would prefer to rest.

Because the gut absorbs less Ig following this first drink, it is preferable to prevent the cow from suckling her calf unless the colostrum is guaranteed to be high quality. There will also be room in the calf's stomach for the administration of additional selected colostrum.

Calves fed by teat, bucket or stomach tube absorb Ig with equal efficiency. The presence of its dam during artificial feeding can improve Ig absorption. The colostrum should be warmed to body temperature, so that calves will not require additional body energy during its digestion. This will prevent shivering of calves after drinking cold fluids, which is common in cold and wet weather.

Researchers in Australia have found that the absorption of colostral Ig can vary from 15 to 60% in calves born at the same time. This may be linked to the calves' ability to clot the colostrum in the abomasum. If it fails to clot, it passes to the small intestine where absorption is less efficient.

In this Australian study, 43% of newborn calves failed to form a clot from 2 L of milk within 1.5 hr of feeding. Three factors were found to reduce clotting ability in the abomasum. Firstly, colostrum may not clot as readily as normal milk. Secondly, newborn calves produce rennin of lower clotting ability than that of older calves. Thirdly, amniotic fluid from the dam is usually present in the abomasum, and this can inhibit rennin activity. The addition of rennet was found to improve clotting ability and Ig absorption.

5.3.1 Financial benefits from good colostrum feeding practices

Data from a large-scale US calf-rearing unit allowed for the calculation of the financial benefits arising from optimum colostrum management (Fowler 1999). When comparing performance of 335 calves with low immunity (0–9.9 mg/mL of Ig) to those of 1663 calves with high immunity (>10 mg/mL of Ig), there were four major benefits as follows:

1. **Calf weight gain.** Low-immunity calves gained 10.3 kg compared with 11.3 kg in high-immunity calves. Valuing each kg live weight gain at US$1.50, each high-immunity calf returned at least US$1.50.
2. **Feed conversion.** Low-immunity calves required 2.35 kg feed/kg live weight gain compared with only 1.95 kg feed/kg live weight gain in high-immunity calves. Over 4 weeks, the high-immunity calves consumed 5.4 kg less feed, when valued at US$1.05, representing a saving of US$5.70/calf.
3. **Incidence of scours.** Low-immunity calves had 6.3 scour days compared with only 4.9 scour days in high-immunity calves. Costs of antibiotics and electrolytes were US$10.80 for low-immunity and US$7.10 for high-immunity calves, a difference of US$3.70. These costings did not take into account any additional veterinary bills to treat the scouring calves.
4. **Calf deaths.** Mortality rates were 20.7% in low-immunity calves compared with only 8.6% in high-immunity calves. Valuing each calf at say US$100 each, savings were US$12.10 per high-immunity calf.

The total savings arising from optimum colostrum feeding practices then amounted to US$23, or nearly a quarter the value of each replacement heifer calf. Readers can convert these US values to local currency using the currency converter in Appendix 4.

5.4 Summarising good colostrum feeding management

In summary, the important principles of good colostrum management are:

1. Use colostrum from mature cows that produce less than 8 L at their first milking.
2. Use only first milking colostrum.
3. Feed 4 L to large calves or 3 L to smaller calves at first feeding.
4. Feed colostrum as soon as possible, at least within the first 3 hr after birth.
5. Do not let calves suckle their dams.

A US organisation, the Bovine Alliance on Management and Nutrition (BAMN) has developed a series of farmer guidelines for calf management with one specifically on colostrum (BAMN 1995). Their guidelines for colostrum management are presented in Table 5.4.

Table 5.4. Current recommendations for post-calving management of dairy herds in the United States (BAMN 1995)

Item	Do	Don't
Calving area	Ensure cows calve on a clean calving pad or on clean pasture	Forget to separate springing cows from the herd or forget to clean pens between cows
Separating calves	Separate calf from dam as soon as possible	Leave calf with dam for more than 1 hr
Colostrum collection	Clean cow's udder and teats before milking Milk out cows as soon as possible after birth (within 1–2 hr) Collect colostrum in clean, dry container	Collect colostrum from a dirty udder Wait 6 hr or more before milking Mix colostrum with transition or hospital milk
Colostrum quality	Measure colostrum quality before feeding Use only good-quality colostrum Use fair- or poor-quality colostrum and transition milk only as nutrition for older calves	Feed colostrum from cows tested positive for Johne's disease, leucosis or mycoplasma Use thin, watery colostrum, especially from heifers Use bloody or otherwise abnormal colostrum Feed poor-quality colostrum at the first two feedings
Colostrum storage and handling	Chill colostrum immediately after collection Refrigerate colostrum at 4°C for less than 24 hr Freeze good-quality colostrum in 1 or 2 L containers Thaw colostrum carefully to preserve antibodies	Pool colostrum Store colostrum at room temperature Store frozen colostrum longer than 1 yr Thaw colostrum in extremely hot water or in a microwave under high power for >1 min at a time (as this destroys antibodies)
Colostrum feeding	Feed first feeding of colostrum as soon as possible (within 1 hr) Use fresh colostrum from the dam, if good quality Use one of the following options to feed colostrum: A. Feed 2–3 L in the first feeding and again within 8 hr B. Feed 4 L via oesophageal feeder within 1 hr of birth Use an oesophageal feeder regularly if the calf will not consume sufficient colostrum; clean and disinfect feeder between calves	Use colostrum from cows that are leaking colostrum prior to or at calving Use bloody or mastitic colostrum Wait for the calf to stand and nurse Allow the calf to nurse the dam Feed less than 2 L per feeding Use a broken or dirty oesophageal feeder Use the same oesophageal feeder for sick calves and for feeding colostrum
Other management tasks	Dip navels in or spray them with tincture of iodine as soon as possible Put calf in an isolated, dry and draft-free environment Continue to feed lower-quality colostrum or transition milk for 2 or 3 days after birth	

Farmers who do not practice good colostrum feeding management may find their calves still remain healthy and grow well. Certainly, some calves with low blood Ig levels are healthy and productive. This reflects the importance of other aspects of calf rearing, such as good hygiene, lack of climatic stress, empathy from rearers and good management of milk feeding. However, as our expectations for good pre-weaning calf performance increase, the importance of improving immunity against disease becomes paramount. It is highly unlikely that dairy farmers can develop a calf-rearing system with minimal health problems and that routinely produces weaned heifer replacements weighing 100 kg at 12 weeks of age without a sound colostrum feeding program.