

Calf milk replacers

This chapter discusses the considerations to make when deciding on a calf milk replacer (CMR) feeding program.

The main points in this chapter

- Despite their convenience when milk feeding calves, very few tropical dairy farmers use CMR as an alternative to feeding whole milk.
- Very cheap CMRs are all too frequently of poor quality.
- CMR must be made from quality ingredients and various visual criteria can be used to assess its overall quality.
- The fat and protein content of CMRs can be used to quantify their nutritive value relative to whole milk.
- This should be used to decide on cost relative to the value of whole milk.
- It is important that farmers understand the mixing strengths when preparing CMR for feeding calves.
- Milk-fed calves require about 500 g/day of milk solids.
- CMR and whole milk behave differently during digestion in the abomasum, so require different feeding protocols.
- If fed too frequently, CMR can lead to abomasal-induced milk bloat.
- CMR can also be used to boost the concentration of whole milk.

Calf milk replacers (CMRs) provide a convenient way to feed pre-ruminant calves. They can be stored long term as powder and mixed with water just prior to feeding. Calves can then be milk reared anywhere and at any time without having to source liquid whole milk. Provided the CMR is formulated correctly from good-quality ingredients and fed according to the instructions, which are usually on the CMR bag, calves can grow equally well when reared on CMR and their rumens can develop just as well as they would on a diet of whole milk.

Because manufacturing CMR directly from whole milk is an expensive process, and because whole milk has a high market value, the bulk of the ingredients for commercial CMR are either by-products of dairy processing or non-dairy products. Obviously, the

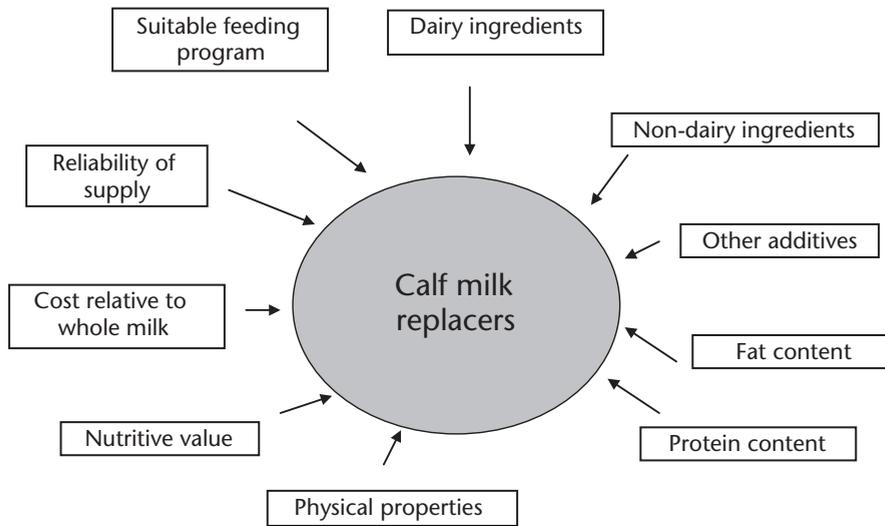


Figure 9.1. Considerations when selecting a suitable calf milk replacer

cost of CMR must be competitive with whole milk for dairy farmers to consider using it when they have copious supplies of fresh milk from their own cows. Despite this, most dairy farmers in the tropics only use whole milk in their calf-rearing systems. Many of them are unaware that CMR can be a cheaper form of liquid feed. Others may have tried it but had a bad experience (say from a batch of poor-quality powder or a limited supply), so then choose only to use whole milk in their rearing systems. Because they do not have to pay cash for their whole milk, in contrast to purchasing CMR, dairy farmers often perceive CMR as an expensive alternative.

In many tropical countries, the supplies of CMR are often unreliable, while its quality can be very variable. Much of the CMR fed on these small farms is imported, mainly from Europe, so it is likely that this should be a quality product, because the CMR manufacturers would have to produce a quality product for their domestic market. Some of the economic factors involved in feeding CMR compared with whole milk are discussed in Chapter 15. Considerations when selecting a suitable calf milk replacer are summarised in Figure 9.1, while a detailed manual on preparing and feeding of milk replacers (and starter feeds) has recently been published by Krishnamoorthy and Moran (2011).

9.1 The composition of milk replacers

A good-quality milk replacer should be similar in chemical composition to whole milk. It should contain the nutrients that calves can digest and in the right proportions. Most milk replacers form a clot in the abomasum and so provide a slow release of nutrients to the duodenum. There are others that do not clot in the abomasum and are primarily digested in the intestines.

Milk replacers are generally formulated from by-products of dairy processing, together with animal fats plus added vitamins and minerals. Whole milk powder consists



Farmers learning how to mix calf milk replacer solution (Vietnam).

mainly of lactose (36–40% of DM), fat (30–40% of DM) and milk protein (28–32% of DM). The protein is principally made up of casein, but also includes the whey proteins, albumin and globulin.

The by-product of butter making is skim milk, which consists mainly of lactose and all the milk proteins; it has only half the energy value of whole milk. Whey, the by-product of cheese making, consists only of lactose, albumin and globulin, and is even lower in nutritive value. When used as the basis of milk replacers, additional fats are required.

Commercial milk replacers usually contain 20–24% protein. Young calves can only digest proteins of milk origin, such as those from skim milk and buttermilk powders. The degree of processing of these powders affects the calves' ability to digest this protein. Excessive heating denatures the protein, leading to poor clotting in the abomasum and rapid passage of milk into the duodenum. Spray-dried milk powders, manufactured at lower temperatures than roller-dried milk powders, are the preferred source of powder for milk replacers.

Milk replacers should contain 15–20% fat and the type of added fat used will influence its utilisation by the calves. Tallow (a by-product of abattoirs) is the most common fat to include because vegetable oils, which contain high levels of polyunsaturated fats, can cause scouring in young calves. Tallow is preferred because it has a similar fatty acid composition to milk fat and is cheap. Tallow is one of the few animal by-products that can be fed to ruminants. The fat must be incorporated carefully so that the powder dissolves easily in water and the fat globules become sufficiently small



A calf waiting for its feed of calf milk replacer.

so that they do not separate out in the solution following mixing. Lecithin is usually included to assist with the incorporation of added fats and to improve their utilisation in milk replacer powders.

High-quality milk replacers have a fibre content of less than 0.1%. Fibre originates from plant material commonly used to increase protein levels in milk replacers. For every 0.1% increase in fibre content in replacers, about 10% of the total protein has been derived from plant, rather than milk, sources.

A typical milk replacer contains 70–80% milk solids, 17–20% animal and vegetable fats (for example tallow), 2% lecithin, traces of minerals (copper, zinc, manganese, cobalt, iron and iodine) and vitamins (A, D, B₁₂, K and E) with added antibiotics or antibacterial drugs.

The inclusion of antibiotics in milk replacers is a matter of concern, particularly to producers rearing their own calves born on-farm. New diseases, such as a different type of scour-causing bacteria, can be introduced through bought-in animals. This is why antibiotics are added to some replacer powders. In theory, calves should not routinely be given antibiotics because the sooner any disease outbreak can be identified and diagnosed, the sooner the calves can be treated. Low-level antibiotic feeding will mask a low level of disease, so that by the time calves show any symptoms, more intense treatment may be required. Furthermore, regular use of antibiotics will increase the risk of cull calves being sold for slaughter with detectable levels of antibiotic residues in their carcasses.

Most cases of scours are caused by poor feeding management, rather than infectious agents, so antibiotics, which will not be effective against viral or protozoal scours anyway, serve little purpose in most cases. By continually feeding antibiotics to calves, bacteria can develop resistance to them. This means that, if a bacterial disease does break out, the antibiotics prescribed by the veterinarian may not be able to control the resistant bacteria.

Antibiotics are also added to milk replacers to stimulate feed intake. Because antibiotics deliver the greatest improvement when management and hygiene are not the best, their routine use can give a false sense of security, which is followed by a generally poor job in calf raising.

Powders based on milk by-products are expensive and attempts to reduce their costs through using alternative protein and energy sources have been largely unsuccessful. Soybean or soya flour is a vegetable protein by-product successfully fed to older animals, but it contains an antigen that inhibits protein (in this case, trypsin) digestion in milk-fed calves. This anti-trypsin antigen can be destroyed by heat treatment prior to inclusion in replacer powders, but results from calf production trials to date are not promising.

Calves cannot digest starch in their diet until their rumen is functioning. As little as 2% starch in milk substitute diets will depress growth and increase scouring in very young calves. CMRs with high levels of starch are not suitable for such animals. The content of starch and the proportion of milk protein to total protein should be detailed on the CMR bag.

Long-term storage of CMR powders is important. They must be packaged properly to keep out air and moisture. They should be vacuum sealed in a plastic bag then enclosed in a light-proof bag. Even with this protection, they are best used within 6 months of purchase. Good-quality powders include an antioxidant to reduce the deterioration of fat during storage.

9.2 Describing quality in milk replacers

In the 1970s, a panel of Australian dairy specialists developed a set of standards for milk replacers to ensure their suitability for calves less than 3 weeks old. This has been updated by Heinrichs (2002). These standards were as follows:

- The powder should contain between 15% and 20% fat and at least 24% protein.
- An antioxidant should be added to reduce oxidation of the fat during storage.
- The fat should be homogenised so that 90% of the fat globules have a diameter of less than 4 microns.
- The milk powder should contain not more than 0.1% crude fibre and the starch content should be stated.
- The proportion of milk protein of the total protein should be stated.
- The milk powder should be supplemented with 6000 IU of vitamin A, 600 IU of vitamin D and 10 mg of vitamin E per kg (IU stands for international units, which are used to measure concentrations of vitamins in feeds).
- The milk powder should contain 100 mg per kg of iron, unless intended for veal production.

More recently, a US organisation called the Bovine Alliance on Management and Nutrition (BAMN) has developed a series of farmer guidelines for calf feeding. Their guidelines on milk replacers (BAMN 1997) uses the following quality parameters.

9.2.1 BAMN guidelines for dry powder

- **Colour.** The colour should be cream to light tan, free of lumps and foreign material. If the powder is orange-brown in colour and has a burned or caramelised smell, the product has undergone Maillard browning (non-enzymatic browning) as a result of excessive heat during storage. If the product has ‘browned’, there will be some loss of nutrient quality and product palatability.
- **Composition.** The powder should not contain lumps of CMR or any foreign material.
- **Odour.** The powder should have a bland to pleasant odour. A burnt smell indicates heat damage. If it has an odour of paint, grass, clay or petrol, the fat portion of the product may be rancid.

9.2.2 BAMN guidelines for reconstituted liquid

- **Mixing.** The product should go into solution easily. Milk replacer should be mixed until all the powder is in solution or suspension without clumps of undissolved powder on the surface of the solution or at the bottom of the bucket. Ingredients that are in suspension, but are not soluble, will settle out of solution (form a sediment) if allowed to stand without agitation. This sediment layer will be more apparent as the fibre content and/or level of added minerals and/or medication increases. In some feeding situations (automatic feeders, nipple bottles, etc.), milk replacers containing significant amounts of insoluble components may not be acceptable. Care should be taken not to over mix. If agitation is continued after the product is in solution, excessive foaming can occur or the fat portion of the product may separate and form a greasy layer on the surface.
- **Colour.** The colour should be cream to light tan.
- **Odour.** The odour should be pleasant, with no ‘off’ odours noted.
- **Flavour.** The flavour should be milky with no ‘off’ flavours. Some milk replacers are supplemented with organic acids. These will have a ‘tangy’ (sweet tart) taste. This should not be confused with a sour taste, which indicates rancid fat.

The best single criterion for evaluating milk replacer is calf performance. If it is poor, more detailed evaluation of management, calf health and milk replacer quality is necessary to determine the reason for the poor performance.

9.3 The nutritive value of milk replacers

The energy content of milk replacers primarily depends on their fat content. The added fat is less digestible than milk fats, so milk replacers generally contain less energy than whole milk supplying the same amount of milk solids.

Formulae are available to calculate the metabolisable energy (ME) contents of milk products and two of these are presented below for the benefit of producers wishing to calculate the energy values and energy costs of the variety of feeds used for rearing calves (Moran 2002).

The ME content of whole milk can be calculated as follows:

$$\text{ME} = \frac{[(35.9 \times \text{F}) + (19.1 \times \text{P}) + 88.8]}{\text{TS}}$$

where ME is metabolisable energy in MJ/kg DM of whole milk

F is milk fat (%)

P is milk protein (%)

TS is total milk solids (%).

Table 9.1 lists the ME content of whole milk at various fat, protein and total solid contents. This table presents protein, rather than the solids-not-fat, content because many dairy farmers are now paid on the basis of fat and protein yields. The solids-not-fat content can be converted to protein content by assuming a constant amount of milk lactose and minerals in whole milk, as follows:

$$\text{P} = \text{SNF} - 5.8$$

where P is milk protein (%)

SNF is solids-not-fat (%)

Table 9.1 shows that the ME content of whole milk can vary from 20 to 26 MJ/kg DM, depending on its composition.

The ME content of milk replacer can be calculated as follows:

$$\text{ME} = (0.23 \times \text{F}) + (0.06 \times \text{P}) + 14.1$$

where ME is the metabolisable energy in MJ/kg DM

F is the fat percentage in milk replacer DM

P is the protein percentage in milk replacer DM.

Table 9.2 lists the ME content of milk replacer at various fat and protein contents. To allow comparisons with other feeds, these contents are determined on a DM basis whereas the DM content of air dry milk replacer is 96%. This table shows that the ME of commercial milk replacers can vary from 19 to 21 MJ/kg DM, depending on its

Table 9.1. Metabolisable energy content (MJ/kg DM) of whole milk varying in concentrations of fat, protein and total solids (percentage of whole milk)

Total solids (%)	Protein (%)	Fat (%)			
		3.5	4.0	4.5	5.0
12.5	2.5	21.0	22.5	23.8	25.3
	3.0	21.7	23.2	24.6	26.0
	3.5	22.5	23.9	25.4	26.8
13.0	2.5	20.2	21.6	22.9	24.3
	3.0	20.9	22.3	23.7	25.0
	3.5	21.6	23.0	24.4	25.8

Table 9.2. Metabolisable energy content (MJ/kg DM) of milk replacers varying in concentrations of fat and protein (percentage of DM)

Protein (%)	Fat (%)			
	16	18	20	22
20	19.0	19.4	19.9	20.4
25	19.3	19.7	20.2	20.7
30	19.6	20.0	20.5	21.0

composition. These calculations may underestimate the contribution of lactose to the energy value of milk replacer, particularly in powders with lower than normal fat content.

The nutritive value of milk replacer (of a given composition) relative to that of whole milk (of a given composition) can be calculated by comparing these two tables.

Furthermore, these tables can be used to calculate the amount of milk replacer or whole milk required by rapidly growing young calves.

The ME requirements for calves was discussed in Chapter 4 and illustrated in Table 4.1. Milk-based diets are used more efficiently for growth than solid feeds, hence the ME requirements of milk-fed calves are slightly lower than those presented in Table 4.1. For example, 100 kg milk-fed calves growing at 0.5 kg/day each require 21 MJ/day of ME and this is 4 MJ/day of ME less than if they were weaned. For the same growth rate, 50 kg calves each require 15 MJ/day of ME, while 75 kg calves each require 18 MJ/day of ME.

Assuming they are consuming negligible solid food, 50 kg calves growing at 0.5 kg/day while fed milk replacer containing 20% fat and 25% protein (or 20.2 MJ of energy/kg DM), each require 740 g DM/day or 770 g/day of air dry powder. If drinking whole milk containing 4% fat, 3% protein and 13% total solids (or 22.3 MJ of energy/kg DM), each calf requires 670 g milk DM/day or 5.2 L/day. This particular milk replacer then only supplies 91% of the ME for the same amount of DM as this particular whole milk. The daily ME requirements for 75 kg calves growing at 0.5 kg/day would be supplied by 930 g of air dry milk replacer or 6.2 L of whole milk.

9.4 The relative cost of milk replacers

Producers must decide whether to feed CMR or whole milk to their calves. This decision is often based on the relative cost of the two feeds. This can be calculated on the basis of cost for supplying the same total solids (for example, Australian cents per kg DM) or cost for supplying the same feed energy (Australian cents per MJ of ME).

If milk replacer was available for A\$65 per 20 kg bag, it would cost 325 c/kg air dry powder or 337 c/kg of powder DM. If it contained 20% fat and 25% protein, it would provide 20.2 MJ of energy per kg DM, and the feed energy supplied would cost 16.7 c/MJ of ME.

Let us assume that whole milk containing 4% fat, 3% protein and 13% total solids, thus providing 22.3 MJ of energy per kg DM, was the alternative liquid feed being considered. Milk replacer would be cheaper only when whole milk cost more than 337 c/kg DM or 43.8 c/L. With milk payments based on milk composition, these calculations

become more complex because dairy farmers must consider milk fat, protein and total milk volume. Such calculations are discussed in more detail in Chapter 15.

9.5 Using milk replacers to rear calves

When planning a rearing program based on milk replacer, it is best to order a bulk supply of the replacer because it is often cheaper per bag than smaller lots. Quality control during processing can sometimes be questioned with less well-known brands of replacers, particularly when milk powders become available on the market at extreme discount prices. The generalisation that ‘you get what you pay for’ holds true for such products. For example, one particular source may be offering cheap CMR because it was subjected to excess heating during processing.

Between 55 and 65% of the total cash costs of replacement heifers is attributable to feed, with much of this occurring post-weaning (Moran 2009). In this context, saving A\$5–10/calf on lower cost milk replacers does not seem to be a good economic decision if its poorer quality places the calf at greater risk of nutritional ill health.

It is important that calf rearers understand mixing strengths when preparing milk replacers for feeding. The mixing instructions usually refer to the quantity of powder within a given volume of reconstituted mix, not the amount of water added to the powder. For example, the instructions may be to mix 250 g of powder in warm water and make up to 2 L. If 2 L of warm water were added to the 250 g of powder, the volume of the final mix would be 2.25 L and the calf would have to consume more liquid for the same nutrient intake.

In this first case, making 250 g of powder up to 2 L produces a solution with a strength of 1 in 8 or 12.5%, whereas adding 2 L to 250 g of powder would give a strength of 1 in 9 or 11.1%. The important point is to make sure that the correct amount of milk replacer is measured, or preferably weighed out, for the number of calves being fed. Having a large tank or several very large containers, such as plastic garbage bins, in which to mix the CMR solution makes the job much easier. It is best to have a written recipe for various numbers of calves, so CMR can be mixed for x calves simply by adding y L of water to z kg of CMR powder. This can be made even easier by having standard buckets for measuring the water and converting y L of water to q buckets of water. If dealing in half or quarter buckets, one of the buckets should be calibrated in half and quarters. A thermometer is also essential to ensure the correct temperature of the final CMR solution. Using hands to estimate temperature of the CMR solution is notoriously inaccurate, particularly on cool mornings.

Once weighed out into a bucket using a spring balance or kitchen scales, the powder should be placed in a calibrated vessel containing some of (but not all) the water, then mixed, either mechanically or by using a hand whisk. The final amount of water is then added to give the correct volume and temperature. It is very important that a consistent feeding temperature be used. For warm solutions, this should be around body temperature: about 36°C, but no more. Some brands of milk replacer can be mixed in cold water and this will be indicated in the instructions written on the bag.

An alternative to weighing is to use a measure, often provided by manufacturers, where one measure of powder is equal to one feed for each calf. In this case, the measure

must be regularly checked, because milk replacer powders can vary considerably in bulk density and errors of up to 20% can arise.

Depending on the number of calves being fed, the liquid replacer can be measured out by hand into buckets for individual calves, poured into troughs for communal feeding or into large feeding drums if *ad lib* systems with teat feeding are being used. It can be pumped into individual buckets using a petrol bowser dispenser connected to a large reservoir. With one person feeding, say 50–100 calves, the feeding time will average about half a minute per calf.

The provision of hot water for feeding and washing up afterwards is an important practical consideration. The temperature of cold water can vary from 4°C (in winter) to 15°C (in summer). Heating the water to 70°C and mixing it with tap water, roughly in the ratio of 2:1, produces a final mix of about 40°C. This can be judged by hand, but ideally should be tested each time with a thermometer.

Because milk replacer contains dried milk powders and non-milk products, it behaves differently from fresh whole milk once it enters the abomasum. Curds of whole milk, being more digestible, are broken down more quickly in the abomasum, thus allowing the calf to have more frequent drinks. However, curds of milk replacer must be given more time in the abomasum for their complete digestion.

Milk replacer should be fed less frequently than whole milk. Too frequent feeding of too much milk replacer can lead to abomasal-induced milk bloat. This occurs when the newer clot envelopes the old, partially digested clot of milk replacer, reducing the opportunity for gases to escape and causing distension of the abomasum. It can also lead to overfilling of the abomasum and the spilling over of unclotted replacer into the intestines: a certain cause of calf scours. Twice daily feeding of small quantities of milk replacer can successfully rear calves, but once daily feeding is likely to create fewer problems.

Another role for milk replacers in calf rearing is through boosting the concentration of whole milk. The rationale is that calves can be fed smaller volumes of whole milk, yet consume similar or higher intakes of energy and protein. This would be beneficial to small calves when introduced to once daily feeding. It is essential to provide sufficient drinking water to satisfy the greater thirst of calves when fed whole milk plus milk replacer.

Research with different concentrations of milk replacer have shown that the optimum milk DM concentration for calf growth and feed utilisation is about 15%. Because whole milk contains 12–13% total solids, in theory only 25 or 30 g of powder should be added to each litre of whole milk. However, successful systems have been developed using once daily feeding of 500 g of replacer in 2.5 L of water or of 300 g of replacer in 2 L of colostrum or whole milk.

9.5.1 The final word on milk replacers

- Milk replacers are the substitutes for milk that provide a convenient way to feed pre-ruminant stock.
- They are generally made up of ingredients such as skim milk powder, vegetable or animal fat, buttermilk powder, whey protein, soy lecithin and vitamin-mineral premix.

-
- A small proportion of other ingredients like glucose, non-milk protein and cereal flour can also be used.
 - Pre-ruminant stock of less than 3 weeks of age should preferably be on milk replacer made of all milk protein.
 - Milk replacers can be stored long term as powder and reconstituted by mixing with water as recommended.
 - Young stock can grow equally well when reared on milk replacer and their rumens can develop just as well as they would on a diet of whole milk.
 - The cost of milk replacer must be competitive with whole milk for livestock farmers to consider using it when they may have copious supplies of fresh milk from their own farm.
 - In a mixed farming system, surplus fresh milk from one ruminant species can be reconstituted to formulate milk replacer for another ruminant species.
 - If by-products of whole milk, such as skim milk or whey, are produced on farm they can also be used as a partial replacer for whole milk or can be reconstituted as a milk replacer with the addition of required ingredients.
 - Despite these options, most farmers in developing countries only use whole milk in their pre-ruminant rearing systems.
 - By increasing awareness about the potential of preparing milk replacers and feeding to pre-ruminant young stock, this will lead to improved survivability and growth of pre-ruminant stock.

This page intentionally left blank