10

Solid feeds for milk-fed calves

This chapter discusses the ingredients and the formulation of solid feeds for milk-fed calves.

The main points in this chapter

- Calves have high requirements for energy and protein. When purchasing calf-rearing concentrates, they must be formulated for the calves' requirements and not for those of milking cows.
- When formulating such a ration, it is important to obtain accurate analyses of energy and protein contents of the ingredients.
- Concentrates and drinking water should be made available from the first week of milk rearing. Milk-fed calves should be offered fresh concentrates every day.
- Ideally, limited roughages should be offered during the milk-rearing phase to stimulate rumen development.
- Calves can be successfully weaned off milk when consuming 0.75–1.0 kg/calf/day of concentrate.
- Weaned calves should weigh at least 70 kg and be seen to be ruminating.
- The 12-week live weight for Friesians can vary from 85 to 125 kg, depending on milk intake and the success of the transition phase from milk to solid feeds.
- A realistic target for Friesian heifers is 95–105 kg at 12 weeks of age.
- Specially formulated calf concentrates are not readily available in many Asian countries, so farmers should enrich existing cow milking concentrates with additional protein.

This chapter deals with the nutritive value of solid feeds and their formulation into diets for milk-fed calves. Calves require feeds rich in energy to promote high feed intakes and good animal performance. The energy value of feeds is measured in terms of their metabolisable energy or ME concentration (as discussed in Chapter 4). Feed energy is usually provided by carbohydrates, which come essentially in two forms: material inside plant cells such as starch (in cereal grains) and sugars (in high-quality pastures), and digestible material in the cell walls such as cellulose. As their rumens develop, calves can

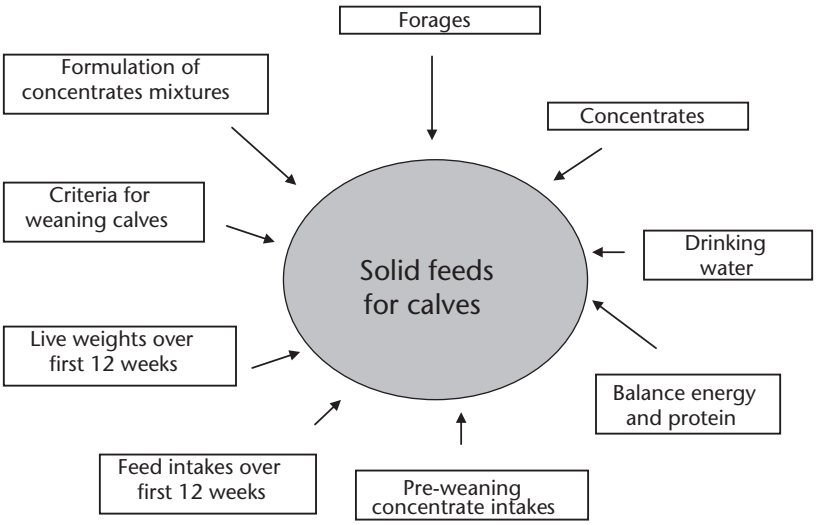

Figure 10.1. Decisions to make when considering solid feeds for calves

begin to digest the energy themselves, but require the rumen microbes to digest and use the plant cell walls.

Calves and heifers also require feeds that are high in crude protein (CP) and supply undegradable dietary protein (UDP) as well as rumen degradable protein (RDP). RDP originates from the feed nitrogen – both true protein and non-protein nitrogen – which is broken down in the rumen into ammonia to provide one of the basic nutrients for rumen microbes to grow and produce microbial protein. This microbial protein together with any feed protein escaping rumen digestion (the UDP) then passes into the abomasum for digestion by the calf's own gut. These processes have been described in more detail in Chapter 4. The key decisions to make when considering solids feeds are summarised in Figure 10.1.

10.1 The nutritive value of solid feeds

Most dairy cattle nutritional reference books contain tables of nutritive value of feeds and supplements. The following two tables provide a summary of some of the common forages (Table 10.1) and supplements (Table 10.2) fed to dairy stock in Asia (Moran 2005). These tables describe feeds on the basis of their ME, CP and neutral detergent fibre (NDF) contents. The values are in ranges to take into account differences in the agronomic growing conditions and stage of maturity in forages and the degree of processing of by-products.

Table 10.3 classifies feeds on the basis of their average CP and ME contents thus provides a ready reckoner to consider when seeking feeds to balance heifer diets that may be low in dietary energy or protein.

The rumen capacity of weaned heifers does not reach mature proportions until 5–6 months of age and, unless pasture quality is high, at least 10 MJ/kg DM, feed intakes and growth rates are restricted by limited rumen volume. With heifers weighing less

Table 10.1. Nutritive values of some common Asian forages

Forage	DM (%)	ME (MJ/kg DM)	CP (%)	NDF (%)
Grasses or legumes				
Napier grass (immature)	13–15	8–9	11–15	60–70
Napier grass	18–25	7–9	10–12	65–75
Rhodes grass	20–25	7–9	8–10	65–75
Guinea grass	20–25	7–9	10–12	65–75
Para grass	25–30	7–9	10–12	65–75
Forage sorghum	13–15	7–9	11–15	65–75
Native pasture	25–35	7–9	8–10	60–70
Leucaena leaf	28–32	7–9	18–26	40–50
By-products				
Maize stover	18–25	7–8	6–8	60–70
Cassava hay	85–90	8–9	22–25	50–60
Peanut leaf and stem	26–30	9–10	18–20	50–60
Soybean leaf	26–30	10–11	20–24	50–60

Table 10.2. Nutritive value of some common Asian supplements

Feed	DM (%)	ME (MJ/kg DM)	CP (%)	NDF (%)
Energy				
Cassava chips	85–90	12–13	2–3	5–10
Maize grain	85–90	13–14	10–12	8–10
Rice bran (good quality)	85–90	11–12	13–14	25–35
Rice bran (poor quality)	85–90	8–10	8–10	30–50
Sweet potatoes	30–35	12–13	5–6	20–30
Cassava waste (fresh)	20–24	7–8	2–3	20–25
Wheat pollard	85–90	11–12	14–16	30–40
Brewers grain	25–30	10–11	25–30	50–60
Commercial concentrate	85–90	11–12	15–18	12–25
Protein				
Soybean meal	85–90	13–14	45–50	25–35
Coconut meal	85–90	12–13	15–25	40–50
Cottonseed meal	85–90	12–13	40–45	30–40
Palm kernel cake	85–90	11–12	14–16	60–70
Soybean curd (fresh)	13–15	13–14	20–25	25–35
Urea	100	–	280	–
Forage				
Rice straw	85–90	6–7	4–6	65–75
Urea-treated rice straw	85–90	8–9	7–8	65–75
Banana stem	5–8	9–10	3–4	60–70
Sugar cane tops	25–30	7–9	5–6	65–75

Table 10.3. Classification of Asian supplements and basal forages according to their energy and protein contents

Energy/protein classification	Poor energy (<8 MJ/kg DM of ME)	Moderate energy (8–10 MJ/kg DM of ME)	Good energy (>10 MJ/kg DM of ME)
Poor protein (<10% CP)	Rice straw Maize stover Sugar cane tops Cassava waste	Rice bran (poor) Most grasses Sweet corn cobs Banana stem Urea-treated rice straw	Cassava chips Paddy rice Molasses Sweet potatoes Pineapple waste Maize silage
Moderate protein (10–16% CP)	–	Brown rice Well-managed grasses Soybean Immature grasses	Maize grain Sorghum grain Rice bran (good) Wheat pollard Palm kernel cake
Good protein (<16% CP)	Urea	Whole cottonseed Shrimp waste Cassava hay Most legumes Legume hays	Brewers grain Coconut meal Soybean curd Commercial concentrate Protein meals Legume leaves

than 200 kg, dietary fibre content has a greater influence on intake and growth than energy content, whereas above 200 kg, heifer performance is less affected by ration fill characteristics. Consequently, high energy supplements are usually required to maintain good growth rates in young weaned heifers.

Even when at their best, tropical pastures fall short of being the complete feed for young stock under 6 months of age. Multiple suckled calves can balance the deficiencies in grass by frequent drinks of milk and thus sustain high growth rates. However, even with limited access to milk, growth rates of young calves fed pasture alone suffer from restricted nutrient intakes, particularly dietary energy. This will be discussed later in this chapter.

The three tables of feed quality highlight the wide variation that can occur in energy and protein levels within any particular type of feed. When formulating rations for young stock, or for any livestock, estimates of the quality of the diet are only as good as the information available on the ingredients. It is important that accurate values of energy and protein contents of the feeds actually being fed are used in ration formulation.

10.2 Feed intake and calf performance pre-weaning

The contribution of solid feeds to the performance of young calves fed limited milk or milk replacer can be quite large, particularly when they are weaned at very early ages. For example, in a survey of 30 calf feeding trials in the US with weaning ages averaging 32 days (ranging from 19 to 45 days), calves averaged 0.3 kg/day of concentrates (ranging from 0.1 to 0.5 kg/day) and grew at 0.3 kg/day prior to weaning (ranging from 0.1 to 0.5 kg/day).

Table 10.4 summarises data on concentrate intakes and growth in calves fed 450 g of milk replacer in 3.8 L of water each day for 21 days and then half this amount until

Calves can be fed limited amounts of clean and palatable hay prior to weaning.

weaning on day 28. Roughages were not fed during this period. The table presents average values each week together with the range for poor to good calves.

10.3 Feed intake and calf performance throughout the rearing period

Once calves are successfully weaned, concentrate intake rapidly increases. Figures 10.2, 10.3 and 10.4 show concentrate intakes and growth rates in Friesian bull calves reared indoors on either *ad lib* or limited milk replacer from week 1, when they are bought at

Table 10.4. Concentrate intakes and growth rates in pre-weaned calves

Age (weeks)	Concentrate intake (kg DM/day)		Growth rate (kg/day)	
	Mean	Range	Mean	Range
1	0.1	0–0.1	0.1	0.1–0.2
2	0.2	0.2–0.3	0.1	0.1–0.2
3	0.5	0.4–0.7	0.5	0.4–0.7
4	1.0	0.9–1.2	0.6	0.5–0.7
Average for 4 weeks	0.5	0.4–0.6	0.3	0.3–0.4

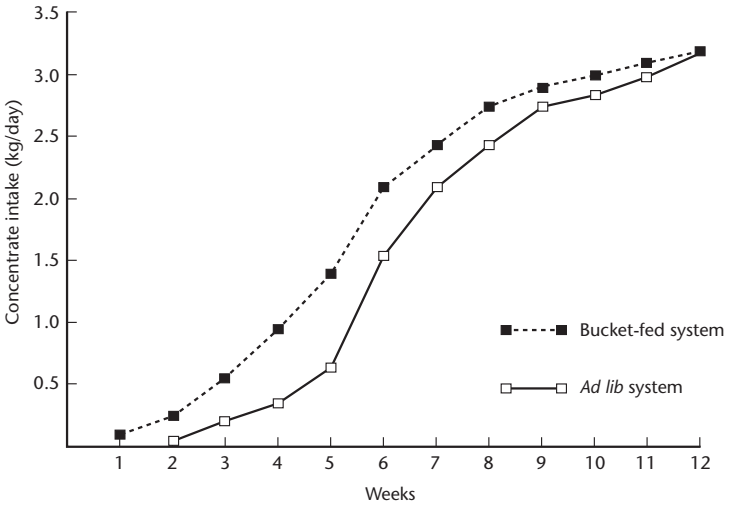

Figure 10.2. Daily intakes of concentrates when fed *ad lib* from week 1 to week 12 in Friesian bull calves fed either *ad lib* or limited milk replacer until week 5

about 10 days of age. The calves fed *ad lib* each consumed 30 kg milk replacer; those on limited once-daily feeding only consumed 12 kg.

Concentrate intakes increased rapidly following weaning at 5 weeks, particularly in calves previously fed *ad lib* milk replacer. By 12 weeks, both groups of calves were eating similar amounts of concentrates. Daily intakes are shown in Figure 10.2 and cumulative intakes in Figure 10.3. Each animal required 130–150 kg of concentrates over the full 12-week period but this would be reduced to 100 kg or less if they were grazed by say, 8–10 weeks of age.

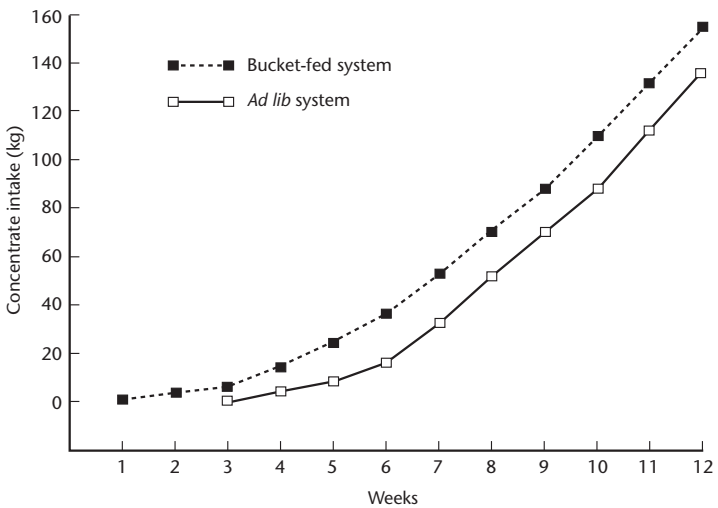

Figure 10.3. Cumulative intakes of concentrates when fed *ad lib* from week 1 to week 12 in Friesian bull calves fed either *ad lib* or limited milk replacer until week 5

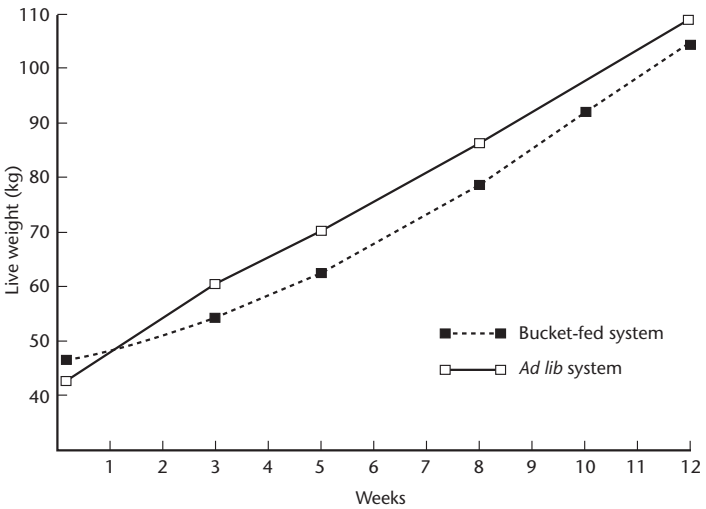

Figure 10.4. Live weights in Friesian bull calves fed *ad lib* or limited milk replacer until week 5 together with *ad lib* concentrates from weeks 1 to 12

Figure 10.4 shows live weights of calves in the two rearing systems. It is of interest that the extra gain made by the *ad lib* fed calves was all achieved in the first 3 weeks of rearing. One useful measure of quality of management of calf-rearing systems is calf live weight at 12 weeks of age, which would normally mean after 11 weeks of rearing. This single measure takes into account the feeding and management during milk rearing, weaning and early post-weaning growth.

The 12-week weight in calves can vary from 85 kg or less to more than 125 kg, depending mainly on milk intake and the success of the transition phase from milk to solid feeds. Live weights of 95–105 kg at 12 weeks of age would indicate a well-managed calf-rearing system.

10.4 Criteria for weaning calves

Different fashions in calf husbandry in different areas of the world have tended to favour different ages as optimal for weaning dairy calves, from as early as 4 to as late as 12 weeks after birth. However, the trend over the last 20 yr has been towards weaning as early as possible. There are several good reasons for this:

- The feed energy in whole milk or CMR costs up to four times more than the feed energy in concentrates and up to 20 times more than the energy in grazed pasture or hand-harvested forages.
- Liquid feeding is very labour intensive and time consuming.
- Facilities for rearing calves from birth to weaning, such as pens, are more costly than those required after weaning and the shorter the period, the fewer the pens required.
- Disease control, particularly scours, is easier to manage in weaned calves.

One of the most important practical considerations in the pre-weaning period is to ensure that the calf stays alive and that it does not succumb to disease severe enough to

set back its growth. Therefore the most economical feeding system prior to weaning may not necessarily be the one that costs the least in food and labour.

Although the rumen of a 3–4-week-old calf may be as effective as that of an adult animal, the rumen capacity should be the major determinant for weaning. This depends on dry feed, hence (indirectly) on milk intake. For example, an aggressive calf that drinks more milk than its pen-mates will probably eat less concentrates and roughage. At the same age, it may be heavier than its pen-mates, but its rumen will be less developed. Therefore, this particular animal should be weaned at an older age.

Calves can be successfully weaned onto dry feed when eating 0.5 kg/day of concentrates. This limit should be increased to 0.75–1.0 kg/day, because farmers do not want their calves to have any post-weaning setbacks. Individual concentrate intakes are difficult to estimate in group-housed animals. However, this level of intake normally occurs around 6 weeks of age. Weaned calves should weigh at least 70 kg and be seen ruminating.

The bigger the calf when entering the rearing unit, the quicker it can be weaned. For every 10 kg increase in initial live weight, it should take 7 days less to reach the same intake of concentrate.

10.5 Tips to stimulate concentrate intakes

There are several management strategies available to stimulate calf starter intakes in milk-fed calves. These include:

- Ensure that calves have access to high-quality starter.
- Provide adequate clean water.
- Increase the amount of feed offered to ensure it is continually available.
- Reduce the amount of fine particles that separate out from pelleted calf starter.
- Calves reared in groups learn to eat calf starter earlier than individually reared calves.
- Calves with good immunity levels, arising from good colostrum feeding management, eat calf starter earlier than those with failure of passive transfer.
- 'Step-down' milk feeding or reducing the quantity of milk or CMR offered at say 3–4 weeks of age, can stimulate starter intake.
- Feeding long hay can stimulate starter intake, but not always.
- Minimising heat stress, if it is a problem, will increase starter intake.
- Minimising any negative effects of birds, flies and other pests on starter quality, pen hygiene and calf health, will increase starter intake.

10.5.1 Palatability

One important factor with calf concentrates is palatability: calves must like to eat it. Palatability is influenced by several factors such as flavour, texture and ingredients. Flavour is most often added by including molasses, which can be included in pellets or spraying on a textured feed. The amount of molasses influences handling, and adding too much can cause the feed to stick together in hard clumps, especially in cold weather. Mould and staleness contribute to unacceptable flavours. Certain ingredients can

adversely influence flavour such as high levels of additives like urea, sodium bicarbonate or ionophores (compounds used to improve the efficiency of rumen digestion).

Texture is important because calves prefer textured feed to ground meals. Powdery or dusty feeds are less palatable and these can be found in feeds with poorly formed pellets which contain a lot of 'fines' or small particles that separate out of the pellets.

10.6 Formulating concentrates for weaned calves

The first concentrate mixes offered to milk-fed calves are often called starter rations. It is becoming more common for farmers to use commercially produced pellets rather than mix them from raw ingredients on farm. This is because they must be highly palatable, fresh when fed and specifically formulated to provide the correct balance of nutrients for the transition period from milk to solid feeds.

These rations should contain at least 18% crude protein and 12 MJ/kg of ME. The inclusion of rumen buffers, such as sodium bicarbonate, in calf starters has also been shown to improve intakes and growth rates. They are frequently packaged in small-sized (3–5 mm) pellets. This reduces dust and ensures that calves cannot select out any ingredients they like and reject others.

Several practises are used to encourage very young calves to nibble starter rations at an early age. These include placing a small amount of pellets in each milk bucket, assuming this is the milk feeding system used, as they finish their daily allocation of milk. Calves may not initially eat more pellets but intakes can increase in later weeks by over 25% and this has been shown to improve growth rates to 4 weeks by 40%.

Young calves should only have fresh pellets available. They should be offered a new batch of pellets each day, while those left from the previous day can be fed to older weaned calves. Twice daily feeding of concentrates is often recommended to give the slower eating calves a better chance of having their full daily ration. Fresh water must be available from the start.

The use of ground forage or coarse grain materials (such as husks) in calf diets has had limited research attention. Solid feed intake and live weight gains have been found to be greater in calves offered textured feed, intermediate for ground feed and lowest for pelleted feeds (Margerison and Downey 2005). Calves have also benefited from including 10–15% of their solid feeds as chopped hay, but this would pose problems for manufacturing and packaging of calf concentrate formulations.

One problem with milk rearing calves at pasture is encouraging them to eat starter pellets at an early age. Calves seem to prefer fresh grass (particularly in high-quality spring pasture) to pellets. Feeding the starter rations in textured form, by including molasses, flaked as well as rolled cereal grains, together with some coarsely chopped, highly palatable hay, may be one way of overcoming low concentrate intakes in very young calves reared at pasture.

When starter rations are combined with straw, penned calves eat more pellets because of a more stable level of acidity in the rumen. Research in Australia has shown that giving young calves access to straw increased their pellet intakes by 15% and their growth rates by 25%. Providing calves with better quality hay will increase roughage

intake at the expense of the pellets and so reduce growth rates. The better the quality of roughage, the less pellets eaten. Other forms of roughage, such as cottonseed or oat hulls, could be used.

It must be emphasised that to be effective, the roughage must be coarsely chopped and not finely ground or milled before inclusion in the pellets. Excellent calf performance has been achieved by grinding roughage through a 22 mm screen (10 mesh) and incorporating the complete diet in 5 mm diameter pellets. The handling of chopped straw or other fibrous by-products by feed companies would require additional processing and equipment.

Growing heifers need to be supplemented with the correct mineral and vitamin package. Calcium and phosphorus are vital for the development of large-framed animals with strong healthy bones. Phosphorus also promotes feed intake. Minerals are important nutrients that can affect fertility and hence the ability of heifers to calve down within 24–30 months of age. The minerals most associated with infertility include copper, zinc, selenium, iodine and phosphorus.

10.6.1 Sourcing calf concentrates in Asia

Throughout Asia, the majority of formulated supplements for milking cows are formulated to 16% CP, even though on closer investigation (Moran 2005), they are frequently below this content. For convenience, many SHD farmers also feed these concentrates to their young stock. Such formulations are far from ideal because, for optimal growth and health, milk-fed calves and weaned heifers require 18% CP in their total diet (basal forage plus supplements). Depending on the quality of the basal roughage fed post-weaning, 18% may be insufficient for the concentrates. The only alternative is then to enrich the available cow milking concentrates with additional protein to increase them to at least 18–20%. These concentrates should not include urea because milk-fed calves cannot use non-protein nitrogen.

Very rarely can small holder farmers purchase higher protein formulated concentrates and in many cases they are not even aware of the benefits for their young stock in supplementing available milking concentrates with additional protein supplements.

High protein concentrates may be available, but at great expense, because they have been formulated for pig and poultry, incorporating high-quality protein ingredients. It would be ideal if a few large-scale feed mills, either owned by dairy cooperatives or agribusiness, could formulate calf and heifer mixes with higher protein contents, using better quality energy sources and additional minerals and vitamins for optimal growth of young stock. Compared with the higher demand of concentrates specially formulated for milking cows, the formulation of smaller batches of calf/heifer mixes would not be cost effective for small dairy cooperatives. Specially formulated calf concentrates are becoming available in some SE Asian countries, such as Malaysia. The economic benefits of such feeds will be discussed in Chapter 15.