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Nutritional Management of Artificially Reared Calves

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SUMMARY

- **Good colostrum management is crucial to protect calves from disease and ensure their survival. There are a number of factors which affect whether calves ingest sufficient colostrum, and how well this is absorbed**
- **Providing higher levels of milk or milk replacer results in better growth rates, greater long term productivity and improved health and welfare**
- **Consistency and good hygiene in milk feeding are critical in successful calf rearing**
- **Calves less than four weeks of age should be fed milk twice daily. The long term economic costs from reduced productivity as a result of inadequate early feeding far outweigh any short term benefits in feed or labour costs of once daily milk feeding.**
- **Provision of clean, dry creep feed and clean, palatable water are key to maintaining good growth rates**

Context

The early nutritional management of new born calves has a major impact on health and survival. Mortality and disease in artificially reared calves reduces profitability and efficiency, and has a negative impact on animal welfare.

Half of recorded losses of calves born in the dairy sector occur in the first six weeks of life when milk is the predominant feed. The true figure is higher, as calves may also die before they are registered. A study published in 2008 from 19 dairy herds carried out over 10 years found that 20 percent of female calves died before first service, many of these during the milk fed period.

This technical note provides up-to-date, evidence based advice on the following topics:

- Colostrum management
- Milk feeding
- Creep feeding
- Weaning
- Water provision
- Monitoring growth as an indicator of success

Colostrum management

Calves are born without the antibodies (immunoglobulins) required to protect them from disease. They rely on colostrum to provide the antibody they need for the first few weeks of their life. It is critical that they receive a sufficient quantity of first milked colostrum within the first six hours of life.

Research indicates that on average 35 percent of calves have inadequate transfer of antibodies from the dam. In some dairy herds levels of failure or partial failure of antibody transfer can be much higher.

Factors that can contribute to failure of passive transfer include:

- Calving ease
- Colostrum quality
- Colostrum cleanliness
- Time of administration
- Quantity of colostrum administered
- Method of administration

These are discussed in more detail in the following sections.

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Failure of antibody transfer has short and long term effects on calves including:

- Higher risk of disease and death in the young calf
- Higher disease risks after weaning
- Reduced liveweight gain
- Lower first lactation yield
- Premature culling

Hygiene, housing, concurrent disease and other stressors must be managed alongside robust colostrum policies. Where passive transfer is adequate, provision of additional colostrum to the new-born calf does not further reduce disease and mortality.

Calving Ease

A difficult birth can impact on a calf's ability to ingest and absorb colostrum. It increases the time to standing and reduces the suck reflex, making it less likely that the calf will suck unaided. Calves that experience a difficult birth are also less able to absorb antibody when tubed and may have suboptimal antibody despite good quality care.

Early intervention in difficult calvings is essential, both to assist the calving and to care for any calf that has had a difficult birth by administering colostrum at the earliest opportunity.

Where more than 4% of births require assistance it is important to review the factors that contribute to this. These are essentially late lactation and dry cow nutrition, condition scores and bull selection.

Colostrum Quality

High yielding dairy cows may have poorer quality colostrum and this is exacerbated by delayed milking. This is not the case in all animals, and the best advice is to test colostrum and make decisions on the basis of this reading.

Colostrum antibody concentration falls after calving, decreasing by a third after 14 hours. To maximise colostrum quality cows should be milked promptly after calving. Having calving pens close to the parlour (or mobile milking equipment); safe flooring and good nutritional control of milk fever are important factors in achieving this.

Leaking of colostrum means that the best quality colostrum is lost, and the colostrum harvested at milking is of poorer quality. Select from cows which have not leaked colostrum prior to calving, and use only first milked colostrum for the critical feeds.

Prompt milking maximises colostrum quality, but little can be done to further improve the initial antibody concentration in colostrum from individual cows. Testing can help to select the highest quality colostrum to store. This can be done either using a colostrometer, or a Brix densometer (figure one). The densometer tends to be more accurate than the colostrometer for this purpose. Colostrum with a reading of 22% or more on the Brix densometer can be used or stored, while colostrum below this should be discarded, or used for follow-up feeds if colostrum is fed for a few days. If using the colostrometer, readings in the green zone (more than 50 mg/ml) indicate good quality colostrum.

Figure one: A densometer can be used to measure colostrum quality

Colostrum Cleanliness

The standards of hygiene during collection and storage significantly influence the quality of colostrum reaching the calf. Bacterial contamination and growth reduce antibody absorption across the gut wall.

Bacterial contamination is influenced by:

- Udder cleanliness
- Teat preparation
- Hygiene of collection buckets
- Storage
- Hygiene of feeding equipment

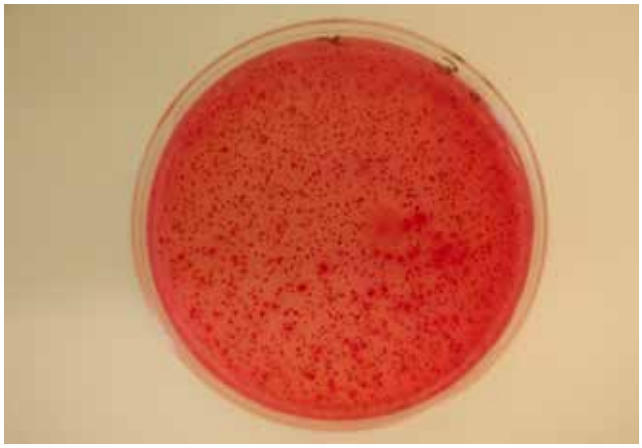
Colostrum should be collected to the same hygienic standard as milk going in to the bulk tank.

Advice for colostrum storage:

- Don't store colostrum in buckets at room temperature, as bacteria multiply rapidly.
- Refrigeration only slows bacterial growth. Colostrum stored in the fridge should be used within 24 hours.
- Label stored colostrum with the dam identity and date of collection.
- Pasteurisation or chemical treatment can reduce, but not eliminate bacterial contamination. They improve antibody absorption and prolong storage times.
- Freezing is a cheap and effective option for longer storage. Bags or bespoke containers provide a wide surface area for rapid thawing.
- Thaw below 60°C to prevent antibody damage.

Laboratories can culture colostrum samples to assess the level of contamination. This is useful when investigating failure of antibody transfer (see figure two).

Figure two: Bacterial contamination of colostrum impairs absorption. Culture of colostrum samples can be carried out to assess this. Each of the darker areas is a bacterial colony. This plate contains a large number of bacterial colonies and indicates that the colostrum sample was highly contaminated.



Time of Administration

After birth, the length of time during which a calf's intestine can absorb antibodies is limited. Closure of the transport mechanisms accelerates following the first feed or following ingestion of bacteria and is minimal after 24 hours.

It is essential to provide a sufficient volume of good quality colostrum as soon as possible after birth, ideally within two hours and definitely within six hours.

A low volume or low quality first feed will impair the absorption of any further antibodies. The first feed should be the highest quality available.

Figure three: Prompt administration of colostrum is crucial in maximising calf immunity

Quantity of Colostrum Administered

The impact of poorer quality colostrum can be offset in part by providing a greater total volume. The quantity required is greater than a calf would voluntarily suck in one meal. Voluntary feeding may be reduced after two initial three litre feeds but this should not prompt a reduction in colostrum volume given. The initial doses will provide plentiful energy in addition to antibodies.

Best advice is to feed three litres of first milking colostrum within six hours (and ideally two hours) with a further three litres fed within the first twelve hours. Very small calves, for example Jersey calves, will require less.

Provision by stomach tube or bottle is more successful in delivering a sufficient volume of colostrum than natural suckling alone.

Method of Administration

Dairy cows tend to have poor mothering ability and calves may find it difficult to access the teats of a larger udder. Research shows that 69% of dairy calves left with their mothers have inadequate transfer of antibody. This was reduced to 10% with early intervention by bottle feeding or stomach tubing.

Calves left to suck the dam themselves also have an increased risk of Johne's disease and *Salmonella* infection.

Policies for colostrum feeding and timing of separation from the dam should be set as part of the herd health plan.

Measuring the Success of a Colostrum Policy

The success of the colostrum policy is easy to monitor using blood tests in animals less than seven days old. Serum refractometry and ZST testing are both simple and cheap methods which provide a guide to antibody levels in the calf. Specific ELISA tests for directly measuring immunoglobulins are becoming more widely available.

Antibody levels in the blood should be measured routinely as part of regular calf health monitoring. This means that a problem can be detected quickly, before levels of disease and mortality begin to increase. On a herd basis at least 80% of sampled calves should have absorbed adequate levels of antibodies.

If blood antibody levels are not measured routinely then this should be undertaken when levels of navel ill, diarrhoea and pneumonia are high, or increasing. Blood sample healthy, rather than sick calves, as dehydration affects the validity of the test.

Continued Feeding of Colostrum

The immunoglobulin concentration of colostrum falls rapidly with each milking after calving. Colostrum from anything other than the first milking should not be used for calves in the first 12 hours of life. However, colostrum can benefit calves more than 24 hours of age by providing antibodies locally in the gut and a greater density of energy than milk or milk replacer. Continued colostrum feeding up to seven to ten days of age may offer additional health benefits to calves but disease risks e.g. Johne's disease and Mycoplasma bovis, must be considered.

Colostrum – Key Advice

- Plan the colostrum policy with veterinary advice.
- Milk cows as soon as possible after calving.
- Prepare the teats and udder for this milking to the same standard as would apply for routine milking.
- Test colostrum quality.
- Refrigerate any colostrum not used immediately.
- Pasteurisation, chemical treatment and freezing increase storage times.
- Thaw at less than 60°C.
- Sterilise tube feeders or bottles.
- Provide three litres of colostrum within the first six hours (ideally two hours) after birth and a further three litres within the first 12 hours.
- Continuing feeding colostrum or milk from the first six milkings to calves until seven to ten days of age can have additional health benefits, but in some herds carries an increased risk of disease transfer.

Milk Feeding

Quantity

Traditional milk feeding of calves focused on providing low levels of milk (two litres twice daily) or milk replacer (400g to 500g per day) to encourage starter intake. However, providing higher levels of milk replacer has significant benefits for calf health, productivity and longevity in the herd.

Benefits of enhanced milk feeding:

- Greater pre-weaning growth rates.
- Improved feed conversion efficiency.
- Reduced disease incidence.
- Improved welfare.
- More rapid recovery and better growth during a disease outbreak.

The importance of greater pre-weaning growth rates reaches beyond the rearing period: for every 0.1kg increase in average daily liveweight gain prior to weaning, heifers produce 107kg more milk in their first lactation. They calve at a younger age and are more likely to achieve the target calving age of 22 to 24 months that is optimal for yield, fertility and longevity. Such improvements in the efficiency of the process reduce rearing costs significantly.

Table one shows the growth rates which can be achieved at different levels of milk feeding.

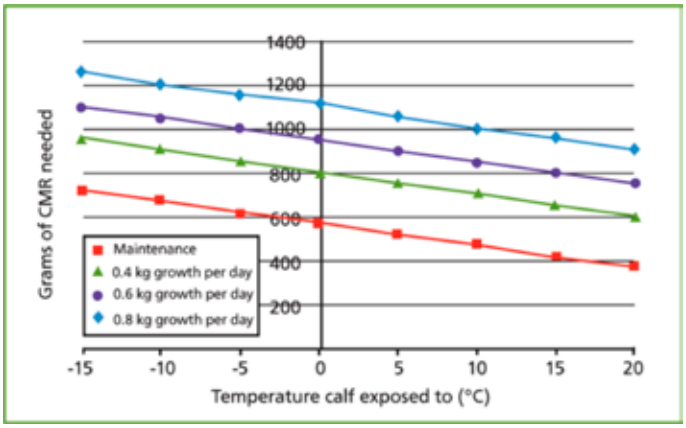
Achieving high levels of milk feeding and improving growth rates:

- Feed whole milk or the equivalent in milk replacer to at least 15 percent of bodyweight.
- Calves can comfortably be fed whole milk at up to 20% of bodyweight giving growth rates of approximately 1 kg per day, compared to 0.45 kg in milk restricted calves.
- Energy density of milk replacers can vary, but in general, feeding milk replacer at 125 g per litre is equivalent to whole milk.
- The energy requirements of calves are markedly affected by external temperature. Increase feeding volume by 20% in the winter to achieve consistent growth rates throughout the year.
- For calves fed milk replacer, either the volume or concentration can be increased at low ambient temperatures. Use figure four as a guide to the weight of powder required per day to achieve the target growth rates at varying temperatures.

Table one: Growth rates achievable at different levels of milk feeding for a 45kg calf below three weeks of age. These figures apply to calves at 15°C and are adapted from Cooper and Watson, 2013. Figures are correct for a 20MJ/kg DM milk replacer.

Grams of milk replacer fed	Growth rates (kg/day)
400	0
650	0.4
800	0.6
950	0.8

Figure four: Grams of 20MJ/kg dry matter calf milk replacer required to support differing levels of growth rates in a 45kg calf less than three weeks of age. Taken from Cooper and Watson, 2012 (calculations based on NRC, Nutrient Requirements of Dairy Cattle, 2001).



Addressing concerns about high levels of milk feeding:

- **Suppressing starter intake** - Calves in the first three weeks eat very little concentrate feed so appetite suppression is not relevant. Calves fed milk at low levels cannot consume enough starter feed to equal the nutrient intake of calves fed milk at higher levels.
- **Difficulty weaning** – This can be managed by stepped or gradual weaning where the reduction in milk intake is accompanied by a surge in concentrate intake.

Quality

Milk or milk replacer may be fed to calves.

Advantages of feeding whole saleable milk:
May be cheaper than milk replacer depending on milk price.

Advantages of feeding milk replacer:

- More consistent than whole milk, which may reduce scours.
- Reduced risk of disease, which can be of great significance.

The quality of milk replacers on the market varies. The ingredients are listed in order, but the exact proportions are rarely given.

Know what to look for:

- Protein and fat levels – 20-26% crude protein and 16-20% fat.
- Target growth rates of 0.8 kg per day or over require 26% crude protein. 20% is adequate for growth rates of 0.45 kg per day.
- Plant based proteins have reduced digestibility, particularly for calves under three weeks. Fibre levels over 0.2 percent suggest plant proteins are included.
- Soya protein contains anti-nutrient factors and can cause scours when fed in excess. It also lacks some amino acids.
- Pea proteins tend to sediment out and buckets should be inspected for residues.
- There is no evidence that skim based powder is superior to high quality whey-based products.
- Ash levels above 8 percent indicate poorer quality ingredients which could cause diarrhoea.

Frequency

Calves must be fed twice daily. Although both feeds do not need to consist of liquid milk, calves under four weeks of age do not consume enough starter feed to constitute a second meal. Fed once daily, calves are unlikely to drink the whole volume unaided, milk is consumed at a faster rate and digestion is impaired.

Calves under four weeks must be fed milk at least twice daily. The only exception to this is ad lib feeding, when calves do not consume their whole allowance at once and can return several times throughout the day to feed. Aside from the legal requirement there is a robust economic argument to support this practice. The long term economic costs from reduced productivity as a result of inadequate early feeding far outweigh any short term benefits in feed or labour costs of once daily milk feeding.

Method

Milk may be fed by bucket, teat or automatic calf feeder. Automatic feeders allow the calf to drink frequently and consume a greater total volume, while reducing labour requirement. For any system a teat is preferable to bucket feeding as the sucking action means that the oesophageal groove is more likely to close and divert milk to the abomasum. Calves fed from buckets without teats tend to drink more quickly and milk is more likely to enter the rumen, where it can start to ferment causing dehydration, bloat and acidosis. This can be fatal, but also has a significant impact on the general well-being of the calf and leads to reduced growth rates.

Ensuring good digestion:

- Place teats at nose height for calves to help oesophageal groove closure.
- Don't widen the teat holes. Slow drinking increases saliva production and aids digestion.
- Follow milk replacer instructions carefully. Add water to the powder to make a litre, rather than adding powder to a litre of water.
- Weigh rather than scoop because density varies between batches.
- Higher concentration feeding is possible (up to 150g per litre) with good quality ingredients. Feeding at levels above 150g per litre can lead to diarrhoea.
- Milk should be prepared below 50°C to avoid damaging milk proteins and fed at 39 to 40°C. Feeding cold milk impairs digestion and palatability and the cold milk is more likely to enter the rumen.
- Consistent temperature, feeding times, concentration and volume should be adhered to.
- Fresh water must always be available.

Housing calves in groups rather than individually improves growth rates and feed intake, but competition can affect smaller calves, particularly with automatic feeders, as there is increased competition for the teats. This can be managed by working with small stable groups of ideally six or fewer per pen with a maximum of two weeks age difference within a group.

Hygiene

Cleanliness of milk feeding is critical to ensure good calf health.

- Utensils such as buckets, jugs or mixing equipment should only be used in the calf house.
- Buckets and teats should be washed and disinfected between calves.
- Teats on automatic feeders spread bacteria and viruses between calves and must be washed and disinfected frequently. Disease spread can be markedly reduced by changing each teat twice a day for a clean and disinfected teat, necessitating two teats for each feeding point.
- Inspect and change worn teats regularly.

Figure five: Robust cleaning and disinfection regimes are crucial to prevent the spread of disease between calves.

Whole milk, particularly waste milk or pooled milk can be an effective way to spread infection with Johne's disease, Salmonella Dublin or Mycoplasma bovis from the cows to the calves. Furthermore calves fed on waste milk have reduced growth rates and an increase in the numbers of antibiotic resistant intestinal bacteria.

Pasteurisation will reduce the bacterial load in milk, but will not sterilise it. The disease risk is reduced but not removed. Bacteria levels rise dramatically, sometimes to pre-pasteurisation levels if milk is put into inadequately cleaned and disinfected buckets. Pasteuriser function should be monitored by measuring bacterial loads pre and post pasteurisation. Waste milk containing antibiotic residues should not be fed, even if pasteurised.

Milk feeding – key advice:

- Calves less than four weeks of age must be fed whole milk or milk replacer twice daily.
- Feed whole milk to at least 15 percent of bodyweight daily or the equivalent in milk replacer.
- Six litres of milk replacer per day at 125g per litre in summer and 150g per litre in winter should achieve growth rates around 750g per day.
- High level milk feeding increases growth rates, lowers disease incidence, improves welfare and lifetime productivity.
- Difficulty weaning at high levels of milk feeding is avoided by a gradual or stepped weaning.
- Teat fed calves absorb nutrients more effectively and have a lower risk of rumen drinking.
- Milk should be fed at 39 to 40°C.
- Consistency of volume, concentration, temperature and time of feeding are important.
- Good hygiene is essential.
- Waste milk should not be fed.

Creep and Forage Feeding

Rumen development contributes to increased appetite and is promoted by feeding pelleted or mixed concentrate calf starter feed from the first few days.

Important factors to consider when choosing a starter ration include:

- It must be highly palatable and contain highly digestible sources of protein and carbohydrate.
- Ingredients such as soya, wheat, barley and molasses are highly palatable, while maize gluten, rice, rape, peas and sugar beet pulp are less palatable.
- Fibre digestion is limited and carbohydrates should be in the form of starch, pectins and other soluble fibres or sugars.
- Fibre sources within the ingredients (e.g. sugar beet pulp or rolled oats) contribute to stabilising rumen acidity.
- Inclusion of fats above three percent will reduce intakes.
- Urea should not be feed to calves under 3 months of age or until the rumen is fully developed.
- 18 percent crude protein (fresh weight) is sufficient (National Research Council).
- Dairy cow compound feeds of similar protein level are unsuitable due to lower digestibility and palatability of the ingredients and altered mineral composition. Standard copper inclusion in dairy cow diets is 20mg per kg DM and a guideline for pre-ruminant calf diet is 2mg per kg DM. Calves absorb copper from the diet at a much greater rate than adult cows increasing the risk of copper toxicity from dairy cake feeding.

There is no consistent evidence that provision in pelleted or coarse mix form influences intakes, but larger pellet size can have a positive effect. The presentation of the feed will affect uptake and it should be fresh, dry and freely available at all times. Buckets and other concentrate delivery systems should be inspected twice a day and any spoiled food removed and the system cleaned as required.

Forage makes a minimal contribution to the nutritional intake of a pre-weaned calf or to stimulating rumen papillae development. However, long fibre has a role in increasing the capacity and muscularity of the rumen. It also provides oral stimulation for calves which helps to prevent abnormal behaviour.

Just providing straw as bedding is not sufficient. A small quantity of clean palatable hay or straw off the floor is recommended from two weeks of age.

Figure six: Providing fresh, dry creep feed encourages ruminal development

Creep and Forage Feeding - Key advice

- Provide fresh, clean, dry starter feed from the first few days.
- Ensure the ingredients are highly palatable and digestible.
- Dairy cow cakes are not suitable.
- Provide small amounts of clean, palatable hay or straw from two weeks.

Weaning

The transition from milk to solid feed can cause weight loss and stress. Concentrate intake rather than age or weight is the key factor and should be a minimum of 1kg per day prior to weaning. Ideally calves should have eaten 1kg of concentrates per day for the three days prior to weaning.

A gradual or stepped approach to reducing milk intakes is recommended, particularly where higher feed rates have been adopted. This is easily achieved in automated systems but is also possible in conventional systems by halving the level of milk feeding for one to two weeks prior to weaning. It triggers a rapid increase in starter feed intake and helps to prevent a check in growth rates.

Avoid group and housing changes and other management procedures around the time of weaning to limit stress.

Weaning - Key Advice

- Wean when starter intakes are 1kg per day for at least 3 days.
- Reduce milk feeding prior to weaning.
- Avoid coinciding additional stresses.

Water Provision

It is a legal requirement for water to be provided to all calves from birth.

Water is consumed by calves regardless of their level of milk feeding and availability of water is closely linked to the intakes of starter ration.

One feeding study found calves without access to water had a 31 percent reduction in starter intake and a 38 percent reduction in daily liveweight gain. Improved growth rates have been observed in calves on both low and high volume milk systems where water is provided ad libitum.

Water consumption does not cause scours, but animals with diarrhoea will drink more to make up what they are losing through the diarrhoea.

The source and delivery system must be hygienic and water testing is widely available. In a two bucket system, the starter ration, not the water should be removed during milk feeding.

Figure seven: The provision of clean, palatable water increases starter intake and improves growth rates

Water - Key Advice

- Provide fresh, clean, ad lib water to all calves from day one regardless of milk intakes
- Test water quality

Further Reading

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