NUTRITION

THE UNIVERSITY of EDINBURGH
The Royal (Dick) School
of Veterinary Studies

The Jeanne Marchig International Centre for Animal Welfare Education

What you will learn: How different *production* systems impact on welfare of dairy cattle

Welfare considerations related to the nutritional management of dairy animals

Potential approaches to mitigate nutrition-related problems

Potential opportunities to promote positive welfare through nutrition

Grass vs. conserved feeds

Cattle raised on pasture and those confined may face different nutritional challenges that will impact their welfare. Dairy cattle are ruminants; their digestive system is highly adapted to a unique mode of digestion, characterized by pre-gastric retention and fermentation by symbiotic microbes (in the rumen), that allows them to efficiently access nutrients from fibrous feeds. Therefore, they can process large amounts of feed substrate over the day.

This process works well if there is sufficient herbage to consume. However, it can be challenging for dairy cows raised in more intensive systems with no access to pasture or roughage. They are normally fed concentrate, which is less fibrous, and more rapidly ingested, fermented and digested than grasses and other forage. Feeding concentrate to cattle is not an issue itself, but if animals have limited opportunity to spend time eating, or accessing roughage, they may show signs of reduced welfare. Concentrate-based diets contain greater levels of rapidly fermentable carbohydrates that if consumed in greater quantities with low fibre can change the fermentation pattern in the rumen, reducing ruminal pH to below normal fermentation conditions (rumen acidosis), which have a significant impact on microbial activity, rumen function, and animal productivity and health.

Cattle may also select components of their diets, called 'sorting', regardless of whether consuming pasture or when eating concentrate diets. Such selection is not only driven by palatability differences in feeds provided but may also be driven by the animal's desire to balance nutrient intake and avoid toxins. However, in intensive systems the arrival of fresh food can cause competition between cows, and some may be less able to consume preferred diets with a TMR if they are less successful at accessing the feed and other cows have consumed the more nutritionally tasty components. In these situations there is need for both adequate bunk space as well as feed.

Water is the most important essential nutrient that animals consume, and water intake is closely related to feed intake. Lactation requires a greater water intake to match output than at other times, and milking cows are therefore at a greater risk of thirst if water availability is limited. Additionally, factors that influence water quality and subsequent palatability will affect the willingness of cattle to consume water and optimize their intake of both feed and water. Water scarcity is a common issue in many parts of the world, particularly in subsistence dairying systems where infrastructure to provide and store water is often limited.

Cattle are grazers and can consume large amounts of herbage over the day. Under grazing conditions, cattle will engage in grazing behaviour between 6 and 13 hours per 24-h period. This feeding time is split into several smaller meals occurring throughout the day, with the largest meals occurring in the early morning and late afternoon. In extensive or subsistence systems, the consistent availability of good quality forage can be limited, and cows may experience hunger if the diet is not adequate to meet their needs. This can particularly be a problem for high-yielding animals, with a high metabolic rate, who may not be able to consume sufficient grass to meet their dietary needs. For predicted feed gaps, appropriate storage of hay, crop residue, straw, etc. is needed, but this can be a major challenge for smaller/smallholder settings, both in terms of adequate conditions for storage and physical space.

Dairy cattle raised in more intensive systems are fed on conserved feeds, which are less fibrous and much more rapidly fermented and digested than grasses and other pasturage. As a result, they will consume a larger amount of total feed in a shorter amount of time compared to when they are grazing. For example, dairy cattle fed a total mixed ration (TMR), containing 50% forage (on a dry matter basis), will spend 3–5 hours eating per day.

Lactating dairy cows are motivated to orally manipulate (and consume) feed even when their rumens are filled with concentrates, suggesting that cattle may have a behavioural need to perform foraging behaviour even when metabolically satiated. When cows are limit-fed, they may display oral stereotypies associated with frustration of feeding motivation and possibly hunger (see more in: **Behavioural Interactions**).

Colostrum

Colostrum management is the most important management factor determining calf health and survival. The calf is considered 'immunologically naïve', that is, it is born without immunoglobulins, or antibodies and so is initially vulnerable to infection. Calves are thus entirely dependent on absorption of maternal immunoglobulins from colostrum after birth for their initial protection from diseases.

Bovine colostrum consists of a mixture of lacteal secretions and constituents of blood serum, mostly immunoglobulins and other serum proteins. The absorption of maternal immunoglobulins through colostrum ingestion during the first 24 hours after birth, called 'transfer of passive immunity', helps to protect the calf against common disease organisms until its own immature immune system becomes functional. A successful transfer of immunity can reduce the risk for preweaning morbidity and mortality, and mortality in the postweaning period, improve rate of weight gain, reduce age at first calving, and improve first and second lactation milk production. Benefits from colostrum may be attributed to protective immunoglobulins as well as high levels of nutrients and bioactive compounds that stimulate postnatal growth and development.

It is recommended that calves should be fed 12% of their body weight (BW) of colostrum at first feeding (6 L for a Holstein calf) to ensure a sufficient absorption of immunoglobulins. If calves consume an adequate concentration of immunoglobulins, they are classified as having successful passive transfer.

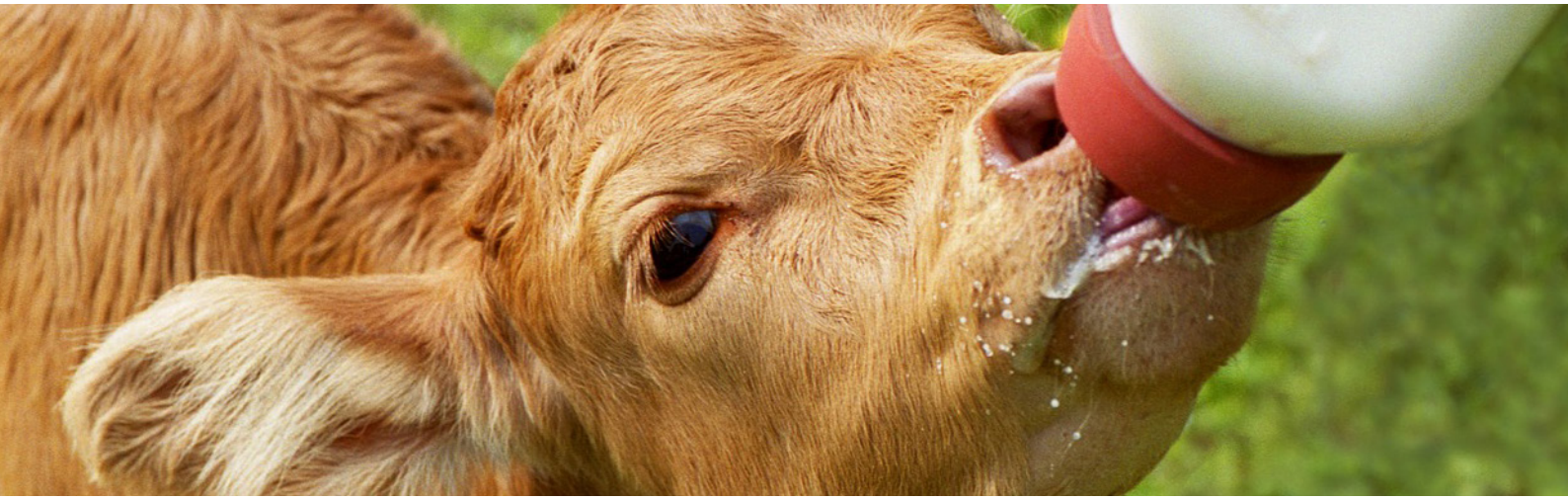
In contrast, if they are deprived of adequate colostrum, they are considered to have had a failure of passive transfer, which increases mortality risk. Calves' blood can be tested to ensure that a sufficient concentration of immunoglobulins (IgG) in serum has been achieved. Failure of passive transfer is considered to have occurred if IgG is less than 10 g/L at 24 and 48 hours after birth.

In conventional dairy farms, calves are separated from their dams shortly after birth and moved to an individual pen. Absorption of immunoglobulins in calves is optimal in the first 4 h after birth, declines rapidly after 12 h and ceases approximately 24 h postpartum. Therefore, calves should be fed colostrum as soon as possible after birth. Delivering colostrum by a nipple bottle or oesophageal tube feeder can facilitate that sufficient volume of colostrum is delivered.

Producers feeding colostrum by nipple bottle should be prepared to deliver any remaining colostrum using a tube feeder, or provide a second bottle feeding within 6 hours, for those calves that do not voluntarily consume their whole ration.

A belief, in some parts of the world, that colostrum ingestion can cause scouring is sometimes given as a reason to not provide adequate colostrum for young calves. There is also belief in some regions not to feed colostrum to calf till placenta is expelled. However, this is incorrect and the benefits of sufficient colostrum ingestion soon after birth have been clearly shown.

Milk allowance and starters



Calves have little capacity to digest solid feed before 3 to 4 weeks of age and thus rely mainly on milk for nutrients. There are two main feeding systems: providing milk by buckets (often offered twice a day) or automatic milk machines, which calves can access at will, but the amount the calf can drink per day is set as a daily allowance by the farmer. Feeding programmes often limit the daily supply of milk for dairy calves to 10% of bodyweight (BW) at birth (around 4 L/d for Holstein), to encourage early intake of calf starter. However, dairy calves provided free access to milk will typically consume more than twice this amount.

Holstein calves allowed to suckle their dams, for instance, can consume approximately 6 kg/d of milk in week 1 and 12 kg/d in week 9. In addition, Holstein calves fed by a milk feeder can have an average intake of >9 L/d when offered12 L/d of milk allowance. Indeed, when offered milk ad libitum, calves typically consume about 20% BW/d, double the amount of the daily supply commonly given by most conventional farms.

Calves fed limited volumes of milk show behaviours indicative of hunger, such as more visits to the milk feeder, more vocalisations and higher pitched calls compared with calves fed more milk. Calves fed less milk will likely compensate for the lack of nutrients by consuming more starter before weaning, which can ease the transition from milk to solid feed and decrease weaning distress.

However, this compensation is likely due to hunger and does not justify offering a low amount of milk to calves. Thus, feeding higher milk rations requires management to increase calf interest in solid food before weaning. Solid feed intake increases rapidly after weaning even for calves fed larger quantities of milk (up to 12L/d) and, with appropriate weaning management, the BW advantages in calves fed more milk is not lost after weaning.

There is a misconception that feeding a large amount of milk is associated with a greater incidence of diarrhoea or scouring in calves. Nutritional scours can occur if there is a failure of adequate milk digestion in the abomasum (‘fourth stomach’ where milk digestion occurs), which is related to two major causes: poor colostrum feeding management and stress in the calf. However, the high incidence of infectious diarrhoea is more related to poor sanitary, management, and housing conditions than to level of milk intake.

In subsistence systems low volumes of milk are fed to calves because households want to sell the milk for income or consume it at home. In these settings, colostrum and early milk of cows can also be fermented and stored for ongoing calf feeding. Limitations for the adequate provision of milk to calves are based around constraints of animal owners to either access and/or afford to provide adequate feed to the cow.

Teat access

Bucket feeding is a common feeding method for calves that are housed individually or in small groups, and it is claimed to be a quick and easy method to feed calves. However, bucket-fed calves can finish each of their 2 L of milk meal in less than a minute. In contrast, calves nursing their dam may have several sucking bouts per day, each one lasting about 10 minutes. Even when dam access and milk allowance are restricted, calves can still have more feeding bouts in a day by comparison to bucket feeding.

Feeding calves milk through a nipple/teat allows the calf to express similar behaviour in terms of the frequency and duration of milk meals. In addition, when a calf is born, the abomasum ('fourth stomach') is the only one that is functioning and ready to digest milk. Teat feeding promotes a calf body position (stretched neck) that triggers a reflex which closes a groove in the rumen (oesophageal groove), which directs the milk straight into the abomasum where can be digested. If a calf drinks from a bucket (with the head down), the oesophageal groove may not be activated and the milk will go into the rumen. As the rumen is not functioning yet, the milk is not digested, ferments and can cause the calf to scour.

Therefore, teat/nipple feeding is preferable when feeding calves. Teat access can slow intakes, improve milk digestion, and helps the calves to satisfy their motivation to suckle and consequently reduces cross-sucking (see more in: **Behavioural Interactions**). When teat feeding it is important to ensure that the height of the teat is at normal nose height to the calf and that the calf keeps their neck and head up while drinking.

Key points to good calf feeding management:

- Offering daily milk allowance that meet nutrient requirements (i.e., 20% of BW until at least 4 weeks of age) to prevent prolonged hunger in calves.
- Offering this allowance in at least two daily milk feedings, until at least 4 weeks of age, or ideally in an automatic feeder which allows the calf to choose when to suck, until gradual weaning is initiated.
- Allowing calves to feed from a nipple/teat will improve milk digestion and promote natural behaviour.

Weaning

A smooth transition from liquid feed (milk or milk replacer) to solid feed (grains or forage) is important to reduce weight loss and stress at weaning. Calves fed by the cow consume approximately 6 to 12 kg/d of milk via a teat, in several meals per day, and are gradually weaned by the cow over a period of several weeks. Under natural conditions this may not take place until calves are around 10 months of age and already consuming large quantities of other foods. In this situation, the weaning process normally involves a gradual reduction in milk intake, accompanied by increasing social independence from the dam and increasing intake of solid food.

In dairy calves, however, separation from the dam has already occurred at a young age and typically weaning refers only to the nutritional component, changing from milk to an alternative diet.
In contrast to weaning in nature, dairy calves normally cease being provided with milk at much younger ages, around 8 weeks of age. If the milk is removed abruptly or reduced gradually before the calves can ingest enough solid feed to compensate, they may experience hunger. Weaning calves by gradually reducing milk availability is preferred to abrupt weaning because it enables the calves to gradually increase their intake of solid feed. Weaning according to solid feed intake is a more efficient way to achieve continued growth and likely result in less hunger throughout the gradual weaning process.

Abrupt weaning results in a greater reduction in growth compared with gradual weaning in both restricted-fed and non-restricted-fed calves. In contrast, gradual weaning methods that encourage consumption of solid feed during the preweaning period (e.g. step-down-method) can reduce the lag between demand and supply of nutrients after weaning and prevent reductions in growth. Calves provided access to higher volumes of milk early in life can double their nutrient intake compared with those fed amounts equivalent to approximately 10% of BW, and these calves are able to gain more weight (1 kg/d) compared with restricted-fed counterparts (0.45 kg/d) during the preweaning period.

Stress caused by weaning will change not only behavioural responses, but also hormonal mediators of stress, and immune function of calves. Dairy calves may face additional stressors during weaning period such as changes in the social and physical environments (i.e., group housing or moving to an unfamiliar pen). It is important to avoid additional stressors around weaning time, whenever is possible, to prevent negative impacts on calves' immune system and consequent welfare. In more subsistence systems, weaning is done at an older age (anywhere between 3 and 6 months), but adequate feed alternative to meet nutritional needs and expose calves to novel feeds can be very variable and possibly limited.

Key points for a successful weaning:

- Gradual reduction of milk intake while increasing intake of solids.
- Restricted milk allowance in young calves will not stimulate solid intake but may contribute to hunger.
- Increase the offer of solids first and do not start weaning until an increase in solid feed intake has occurred.
- Avoid changing calves to a new environment or group at weaning. It is preferable to wait a few days.

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E: JM.Welfare@ed.ac.uk
W: edin.ac/animal-welfare-centre

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