Advancements in Automated Feeding for Calves: Where We Are Today and Where We'll Be Tomorrow

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Take Home Messages

- Recent nutrition research has shown the advantages of offering more milk to replacement heifers, a feeding strategy which favours the use of automated feeders for calves on dairy farms.
- The advantages of implementing computer controlled automation in dairy calf management include labour efficiency, increased feeding frequency, gradual weaning, improved animal welfare and the collection of data to make economic and animal welfare decisions on the farm.
- When implementing an automated feeding system it is essential to consider management strategies that limit feeder competition and cross-sucking.
- The data collected with automated technologies can be used in the future to implement novel nutrition concepts such as “precision-feeding” and “phase-feeding”.
- Automated feeding opens the doors to many possibilities for maximizing the potential of automation to improve farm economics and animal welfare.

Introduction: A New Style Of Feeding Calves

Dairy calves have traditionally been limit-fed milk or milk replacer at approximately 10% of bodyweight in an attempt to reduce preweaning feed costs, increase calf starter intake, and stimulate rumen development. In contrast, when calves are fed ad libitum, they typically consume milk at an average closer to 20% of bodyweight, although there are large differences

between individual calves (de Passillé et al., 2015). Even on the 2nd day of life, most calves will drink well over 4 L/d of milk, with the calves drinking the most milk being less likely to fall ill before weaning (de Passillé et al., 2015). Over the past decade there has been a movement to offer un-weaned calves more milk or milk replacer based on evidence of improved health, growth rates, feed efficiency and animal welfare in the pre-weaning phase (Jasper and Weary, 2002; Soberon et al., 2012). Interestingly, there is no evidence that feeding more milk leads to calf diarrhea which is in contrast to what is often assumed (Lorenz et al., 2011). In fact, the Canadian Code of Practice for the Care and Handling of Dairy Cattle now recommends that all calves receive 20% of bodyweight as milk or milk replacer (National Farm Animal Care Council, 2009).

Feeding larger amounts of milk or milk replacer for rapid preweaning growth enables heifers to achieve breeding size earlier, thereby decreasing age at first calving and costs associated with raising replacement heifers (Davis Rincker et al., 2011). In a recent study, Soberon et al. (2012) showed that pre-weaning average daily gain is positively correlated with milk production in the first three lactations. It was determined that for every kg of preweaning average daily gain, heifers produced 1,113 kg more milk during their first lactation. In a reanalysis of previous studies, Bach (2012) also showed that increased growth rates before weaning were associated with greater milk production during the cows' first lactation. These findings support the concept that early life nutrition can impact physiological outcomes later in life. This concept has been termed metabolic imprinting. The mechanisms controlling metabolic imprinting have been studied in medical and livestock sciences, but not in dairy cattle. Understanding how early life nutrition and management can impact lifetime metabolism, physiology, reproduction and health, in addition to overall milk production would prove extremely valuable for dairy producers in order to establish sound feeding and management regimes.

Despite the benefits for growth and milk production, recent on-farm surveys suggest that intensified milk feeding programs for calves are not widely used in Western Canada (Bartier, 2013). Feeding larger volumes of milk or milk replacer does not require automated calf feeders, but it does favour their use as it allows calves to consume milk in more frequent, smaller meals, spread throughout the day. Undoubtedly, automated calf feeders save manual labour and enable precision management tools, such as programmed weaning and automated collection of data that can be used to predict health events (i.e., frequency and timing of visits to the feeders, drinking speed, body temperature, and weight gain). If managed correctly, automated calf feeding technologies and intensified preweaning feeding schemes can improve farm profitability and animal welfare. However, there are several advantages and challenges of automated feeders that need to be considered when using them on dairy farms.

■ Why Consider Automated Feeding

Labour Efficiency

The clear advantage of automated feeding is a dramatic reduction in the labour needed to feed calves on farm. It has been estimated that the time commitment required to feed a calf is 10 minutes per day when manually fed (2x per day), compared to one minute with an autofeeder (Kung et al., 1997). With a herd of 200 milking cows and a culling rate of 35%, approximately 80 replacement calves will need to be fed per year. For this number of calves it is recommended to use one milk autofeeder which is approximately $15,000 (personal communication with Jan Ziemerink from Foerster-Technik). Using these assumptions with labour costs at $20/hour, the investment of a computer system could be regained within one year (80 calves x 8 wk on milk x 7 d/wk x 10 min/d = $15,000).

The above calculations assume there are no additional advantages in calf growth and health when the calves are fed with automated milk feeders (Kung et al., 1997). The time saved at feeding can be re-invested in overall calf management, which further improves profitability. Soberon et al. (2012) and Bach (2012) both highlighted that small increments of improvement in average daily gain and health will reflect a greater amount of future milk production. Therefore, any advancements resulting in improved health and growth during the preweaning period can have large implications in future economics when cows enter the milk line.

Calf Physiology – Feeding Frequency and Sucking

At birth, the rumen of the calf is undeveloped and the forestomach is almost entirely comprised of the abomasum, commonly referred to as the true stomach (Figure 1). The abomasum is similar to our true stomach, as it creates the necessary acidic environment to initiate the digestion of food. This is made possible in the calf by the esophageal groove reflex, which shunts milk past the rumen and deposits it into the abomasum. When calves are left to nurse from their dams, they typically feed up to ten times a day in the first weeks of life, gradually taking fewer, but larger meals (Jensen, 2003). This is in striking contrast to the traditional feeding schemes where calves are only offered milk 2 times per day, sometimes via bucket feeding (no nipple).

A major advantage of using automated milk feeders is that several small meals can be offered over a 24 h period, which gives the calf more control to express its natural behaviour. Calves offered milk ad libitum from automated feeders will typically drink between 7 – 12 times a day (Borderas et al., 2009a), which is more similar to nursing. In addition to animal welfare benefits, increasing feeding frequency when calves are fed larger volumes of

milk improves digestion and the efficiency of feed to growth conversion (van den Borne et al., 2006). Increasing feeding frequency may also provide benefits to digestive health when compared to feeding two times a day. Ahmed et al. (2002) determined that increasing the number of meals raises luminal pH and reduces ulceration of the abomasum. If large quantities of milk are fed in two meals per day, the abomasal capacity may be surpassed. In severe circumstances, when the size of the abomasum is not sufficient to hold the meal size, the milk may overflow to the reticulorumen. This is often referred to as “ruminal drinking” and if prolonged, may result in bacterial fermentation of the milk, which may lead to ruminal acidosis and impaired abomasal curd formation and infection.

Another important advantage with autofeeding is that all milk is fed through a nipple and allows for an increase in time spent sucking per day. Stimulating increased sucking by prolonging the duration of the meal can improve digestion and reduce cross sucking in calves fed in a group by an automated feeder (Jensen, 2003). Another interesting point to consider is that sucking activity, in connection with ingestion of milk, contributes to satiety (de Passillé et al., 1993). This increased satiety ultimately underscores yet another advantage to controlling milk flow and allowing calves more time to feed through an automated feeder.

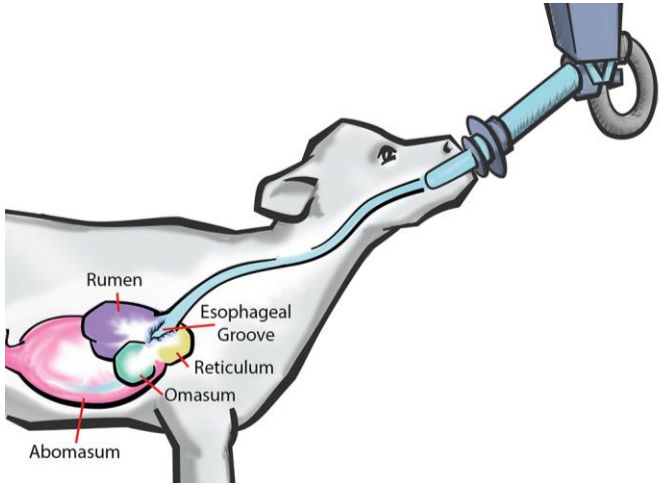

Figure 1: Calf Digestive Physiology

Gradual Weaning

Historically, feeding larger volumes of milk or milk replacer has been thought to lead to reduced starter intake, delayed rumen development and reductions in growth rates during weaning. When larger amounts of milk are fed to calves, less starter will be consumed preweaning. Reduced starter

consumption can be associated with a depression in growth during weaning, thereby reducing some of the growth advantages from feeding higher planes of nutrition (Jasper and Weary, 2002). Despite being associated with reduced weight gain and increased cross-sucking (Nielsen et al., 2008), abrupt weaning is still commonly practiced in our industry.

It has been well documented that gradual or "step-down" weaning improves animal growth and is preferred to abrupt weaning. For example, Sweeney et al. (2010) demonstrated that abruptly weaned calves showed the best preweaning gains, but the poorest post-weaning gains when weaned at six weeks and that ten day gradual weaning had the best overall results at this age of weaning. In another study, gradual weaning of calves reduced cross-sucking and unrewarded occupancy of the milk feeder compared to abrupt weaning when weaned at eight weeks of age (Nielson et al., 2008). When manually feeding calves twice per day, the aim of a step-down approach is typically to remove one meal, for a week or two. In this system, an automated milk feeder allows the number of steps and the duration of each step to be changed automatically, which makes for a more "gradual weaning".

Automated milk feeders provide more opportunity to feed calves milk for a longer time without greatly increasing the labour demands of the farm. Delaying the age at which calves are weaned from milk using automated feeders also reduces the drop in energy intake and the behavioural signs of hunger (such as frequent unrewarded visits to the automated milk feeder) that result from weaning (de Passillé et al., 2011). Automated milk feeders that can recognize individual calves, when used in conjunction with automated concentrate feeders, also enable us to individualize weaning by adjusting the weaning age and timing according to when each individual calf reaches a targeted intake of solid feed, which can prevent the growth check that can occur at weaning (de Passillé and Rushen, 2012). These examples underscore how data generated from an automated feeding system can improve the performance and welfare of calves during weaning.

Group Housing

There is a trend in dairy production to move toward larger production units and group housing of animals of all age groups, including preweaned calves. Traditionally, preweaned calves were raised individually to minimize contact with herd mates and reduce the spread of disease. However, research suggests that disease and mortality rates can be as good when calves are housed in small groups, as when they are housed individually (Losinger and Heinrichs, 1997). Furthermore, researchers are now showing the benefits of housing young calves together, as it can improve feed intake and growth before and during weaning, largely due to the calves learning to feed from other calves (De Paula Vieira et al., 2012). The current automated feeding technologies available on the market all require group housing, so socializing

with cattle that are older may provide opportunities for the calf to be “trained” by herdmates. However, poor management of groups with automated feeders can result in increased health problems (Svensson and Jensen, 2007). The potential risks that impact calf health and performance in group-housed settings need to be further explored, as information is still sparse and inadequate.

■ Considerations for Automated Milk Feeding for Calves

Group Dynamics

Computer-controlled milk feeders represent a costly investment and although it is possible to feed up to 40 calves on one feeder, it is recommended to reduce that number dramatically to ensure good growth, health and welfare. The concerns around overcrowding the feeder include competition for access to the feeder, which not only can reduce intake, but also leads to higher levels of stress. In fact, competition is only seen when calves are fed low levels of milk. When milk allowance is 10 liters, there is rarely competition at the feeder and the number of unrewarded visits is low.

Computer controlled milk feeders typically provide portions of milk to calves (0.5 – 3 liters) in multiple meals per day. The time lag between each meal is approximately 30 – 240 minutes, which may lead calves to visit the feeder more often without any allocation of milk - termed an unrewarded visit if their milk allocation is low. A higher number of unrewarded visits may disturb calves that are drinking or block other calves (or cause competition) within the group from receiving their rewarded visit.

In a study comparing 24 and 12 calves per feeding station, it was determined that feeding up to 24 calves per feeding station did not impact milk ingested or growth, but there was a higher level of unrewarded visits and signs of social distress (Jensen, 2004). In the same study, offering the same milk allowance in four, rather than eight milk portions lowered the occupancy of the feeder. This suggests that larger portions may lower competition for access to the feeder if all other factors remain equal (Jensen, 2004). Increasing the total amount of milk or milk replacer fed to calves will also reduce the number of unrewarded visits, improving the efficiency of feeder use, as well as reducing the likely competition (Borderas et al., 2009a). Similarly, housing calves in smaller groups can also reduce the incidence of disease. In a study conducted by Svensson and Liberg (2006) that compared growth rates and health records of 892 calves, it was determined that pens with 12 – 18 calves had higher incidence of respiratory illness compared to calves housed in groups of 6 – 9 animals.

In addition to group size, determining a strategy for introducing the youngest calves raised in individual pens to a dynamic group structure can present challenges. Jensen (2007) found that 6-day old calves required more training from the stockperson and had difficulty accessing the feeder than 14-day old calves. However, farmers prefer grouping calves as early as possible in order to reduce the labour of feeding. Little research has been done to determine how rapidly calves adapt to drinking milk from automated feeders or what factors may facilitate this adaptation. It was recently shown by Fujiwara et al. (2014) that although younger calves struggled initially, many had the ability to adapt quickly, especially those that show high vigour in the first week after birth. Thus, it is important to monitor the performance of individual calves when they are first introduced into the group. More research is needed to help understand how early-life vigour and intake is related to improved adaptation to an automated feeder (de Passillé et al., 2014).

Non-Nutritive Sucking

Calves raised separately from their mothers are prone to exhibit more non-nutritive sucking. Calves can be seen to suck objects in the pen, but when housed in groups, generally suck other calves in the same group – a behaviour referred to as cross-sucking. Cross-sucking is not only relevant from an animal welfare standpoint, but it can be harmful to herdmates and probably linked to inter-sucking in heifers and dairy cows (Keil et al., 2000). To that end, several studies have been conducted to uncover strategies to minimize cross-sucking when calves are fed with automated feeders.

The first approach to reducing non-nutritive sucking behaviour is to feed more milk. It has been shown that prolonging milk ingestion time by feeding calves through artificial teats with smaller orifices or reducing the milk flow through automated feeders can effectively reduce cross-sucking (Jensen, 2003). Another strategy is to use feeder stations with a closed stall, as calves stayed longer in the feeding stall following milk ingestion, showed longer bouts of non-nutritive sucking directed to the teat after milk ingestion, and performed less cross-sucking in the first 15 minutes after milk ingestion (Weber and Wechsler, 2001) Also, gradual weaning will reduce cross-sucking in group housed cattle fed through an automated feeder.

■ The Future of Calf Auto-Feeding

Precision and Phase Feeding

With the rising costs of labour world-wide and the increasing amount of technologies being implemented on dairy farmers today, it can be expected that the implementation of calf automated feeding technologies will grow significantly in the future. Automated feeding provides several animal welfare

advantages, which can be promoted to ease the scrutiny dairy producers have faced in recent years. Automated feeding technologies represent a wholesale change in the way we approach feeding. Traditionally, we have been in complete control of calf milk feeding by restricting feeding times and amounts. With automated feeding technologies, there are more opportunities to let the calf control its own feeding pattern. All calf researchers would agree that there is tremendous variation between calves, especially in the first days of life. Providing the calf with an individualized feeding protocol and using this information to customize a feeding scheme to improve lifetime performance is a missed opportunity. Individualized medicine and nutrition is becoming a hot topic in human nutrition, but is not yet even a consideration for calves.

Another clear advantage is that the data collected from autofeeders can be used to detect illness and develop therapeutic strategies. Housing calves in larger groups is thought to be associated with higher risks of digestive and respiratory diseases; farmers also typically find it more challenging to detect illness in calves that are group-housed compared to individually housed animals. Although sick calves can be detected by monitoring daily milk intake using automated feeders, by this stage it may already be too late to treat the sickness. Svensson and Jensen (2007) determined that calves suffering from a disease (respiratory or digestive) participated in more unrewarded visits during the first diseased days, providing the first indication of sickness before a reduction in overall intake. However, the degree that illness will be apparent in reduced milk intake or reduced visits to the feeder will depend on how much milk is being fed to the calves: Borderas et al., (2009b) found a decrease in milk intake with illness when calves were fed milk replacer ad libitum but not when fed restricted amounts (4 l/d).

Once a disease has been detected autofeeders allow for targeted provision of medication or nutritional bioactives to sick calves. This individualized approach is rarely used, but can be accomplished by adding ingredients for specific calves through a medicator (current models can add 1-20 grams of ingredient per litre). The concept of feeding calves on a more specific basis is termed “precision feeding” and will become more common in the dairy industry, especially with the recent growth in automated milking systems. Automated feeding systems for calves also offer more opportunities to feed calves tailored diets, based on age, during the first months of life. Hammon et al. (2002) published a study illustrating where calves in the first weeks of life were offered transition milk and the others offered milk replacer through the same autofeeder and group pen. The outcome of the experiment showcased that calves improved their performance if they consumed more colostrum and transition milk. The concept of feeding animals in early life, specific diets rich in all chemical and bioactive nutrients is “phase-feeding”. The phase-feeding concept is standard in poultry and swine feeding and has not been employed in dairy calf rearing. With current and new automated technology

development yet to be implemented in the field, there are many opportunities to develop new feeding strategies for calves.

Researchers in Western Canada are increasingly utilizing and studying automated technologies due to their vast potential in the dairy industry (Figure 2). The newest autofeeders, which offer the ability to feed milk or milk replacer (termed combination feeders) and pelleted calf starters, are currently being implemented at the University of Alberta and the University of British Columbia. A new technology in calf autofeeding, termed the calf-rail (Figure 2A), can automatically feed individually housed calves milk multiple times during the day. This technology is already being implemented on farms in Germany; the Dairy Research and Technology Centre at the University of Alberta is the first to employ this technology in Western Canada. This system is designed for producers that prefer the benefit of managing calves in individually housed calves preweaning before moving to group-housed calves. Additional technologies that are implemented at the University of Alberta and University of British Columbia include the water meters, feed bunks to measure texturized feed and forage consumption in realtime, and body scales at the feeding station. These technologies are not only helpful for research, but may be valuable at the farm level to detect diseases from water and feed intake patterns, especially during weaning.

Figure 2. Novel technologies in Western Canada implemented at the University of Alberta Dairy Research and Technology Centre (Edmonton, Alberta) and University of British Columbia (Agassiz BC). A) Calf-Rail technology for automated feeding of calves housed in individual pens at the University of Alberta B) Automated milk, concentrate and hay feeders at University of British Columbia.

The number of technologies and the amount of information we can collect from calves from automated technologies will increase in the future. These technologies will provide the data needed to develop and employ individualized nutritional and management strategies. However, in order to use these new technologies to their full potential, more research needs to be conducted. Although initially the main reason for feeding with autofeeders was to save on labour costs, their potential for customizing individual feeding schemes, improving overall calf management, and effectively enhancing consumer perception, makes their future in our dairy industry bright and prosperous.

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