Effective Forage and Starter Feeding Strategies for Preweaned Calves

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Take Home Messages

- Providing the necessary nutrition to sustain rapid growth rates (>750 g/d) during the first 2 months, not only should result in a more efficient (economically), but also in a more effective (greater milk performance) heifer rearing program
- About 225 kg of additional milk in the first lactation could be expected for each additional 100 g/d of growth during the first 2 months of life
- Oats, which are commonly included in starters, have low palatability, and thus their inclusion in formulation of starter should not be forced.
- Offering chopped, poor quality hay to young calves should drastically increase total solid feed consumption and growth rate
- When forage consumption is less than 5% of the total solid feed intake, gut fill is negligible
- The early post-weaning period is the most profitable development stage that calves or heifers will undergo during their entire growing period
- Depriving calves from forage during the preweaning phase may offer yet another physiological and dietary adaptation challenge to young calves during the transition
- Solid feed intake is increased and the level of stress decreased when calves are grouped at preweaning (when milk allowance is halved)

Introduction

Feeding methods and management practices applied to today's dairy replacement calves will influence the performance (and economic returns) of dairy herds in 2015 onwards. Due to this relatively long lag, most producers and dairy consultants tend to devote less-than-desirable efforts and attention to calf and heifer rearing. Contrarily to the situation in lactating cows, where management is based on records of milk yield, milk composition, feed intake, body condition, etc..., the most common situation in heifer rearing is that management is based on "feeling" rather than being based on methodic data collection and record keeping. This article will review several nutritional aspects aimed at improving performance of calves, minimizing health disorders, and setting the stage to achieve first calving at 23-24 months of age with a body weight (BW) above 650 kg (before calving).

■ Setting The Stage For The Future

Nowadays, it is clear that nutrient supply and hormonal signals at specific windows during development (both pre- and early post-natal) may exert permanent changes in the metabolism of humans (Fall, 2011), as well as changes in performance, body composition, and metabolic function of the offspring of livestock (Wu et al., 2006) through processes generically referred to as fetal programming and metabolic imprinting. Thus, it is likely that today's cow, with high milk yield but also reproductive and metabolic challenges, is not only a consequence of genetic selection, but also the result of the way her dam was fed and the way she was fed early after birth and the way the cow was reared as a calf and to a lesser extent as a heifer (Bach, 2012).

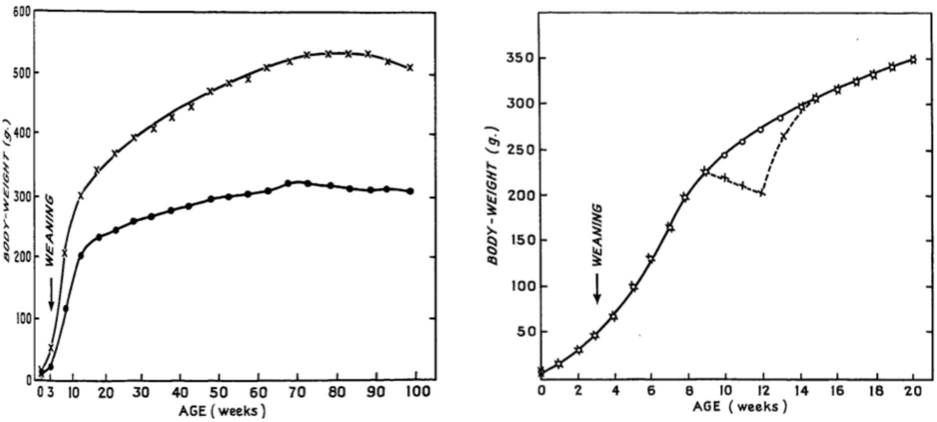

Figure 1. Effect of a 3-week feed restriction applied at two different stages of development (Adapted from McCance, 1962).

The first weeks of life seem to have long-lasting consequences on the physiological function of neonates. The pioneering work of McCance (1962) illustrated that limit-feeding rats during the first 21 days of life resulted in a lifetime programming of growth pattern that was less than that of rats fed properly. More interestingly, when the same dietary restriction was applied for 21 days but at a more advanced age, the intervention had no lasting effect because the underfed rats showed compensatory growth gains when re-fed at normal levels (Figure 1).

Colostrum is more commonly considered a source of immunity than a source of nutrients; however, right after birth, the first nutrients consumed by calves are from colostrum. In addition to nutrients, colostrum is also rich in growth factors and hormones, and thus it could also have a potential impact on future performance. The pioneering work by DeNise et al. (1989) demonstrated a positive and significant relationship between plasma IgG concentrations and future milk production of calves that were allowed to suckle their dams for the first 24 hours of life. DeNise et al. (1989) acknowledged that this association was probably not due to IgG directly, and suggested that it was probably linked to *other factors* in colostrum that could influence subsequent production. An example of the importance of *other factors* can be found in the elegant study by Hough et al. (1990). These authors nourished cows during the last third of pregnancy to 100 or 60% of their nutrient requirements. Interestingly, despite the fact that maternal nutrition did not affect colostral IgG concentrations, calves born to non-restricted cows that received colostrum from restricted dams tended to have lower serum IgG concentrations at 24 hours of life than those receiving colostrum from cows well nourished. Tri-iodothyronine participates in IgG absorption at the intestinal level, and lower colostral tri-iodothyronine concentrations exhibited by the nutrient-restricted mothers, compared with control dams, could be one of the reasons why serum IgG concentrations decreased. An intriguing example of the potential long-term effects of colostrum was reported by Faber et al. (2005), who described 10 and 15% increases in mature equivalent milk production during the first and second lactations, respectively in cows that received 4 L instead of 2 L of colostrum at birth. The long-term effects of colostrum feeding are most likely related to important constituents, such as IGF-I, IGF-II, insulin, growth hormone, epidermal growth factor, leptin, and prolactin. These hormones could participate in lactocrine mechanisms to elicit modifications of several hormonal axes in the calf.

It seems though, that the metabolic imprinting effects of early life nutrition do not end after colostrum feeding. The analysis of a dataset including data from 900 animals raised in a contract heifer operation in Spain and followed into 3 different dairy herds revealed a significant positive relationship between average daily gain (ADG) during the first 65 d of age (with ADG ranging from 0.37 to 1.12 kg/d) and future milk yield (Bach and Ahedo, 2008). From Figure 2, it can be concluded that, on average, calves gaining about 1 kg/d could be expected to produce about 1,000 kg more milk during their first lactation than calves reared on a traditional system gaining about 500 g/d. The results agree with those more recently reported by Soberon et al. (2012) and the meta-analysis conducted by Bach (2012) that concluded that about 225 kg of additional milk in the first lactation could be expected for each additional 100 g/d of growth during the first 2 months of life. Furthermore, two recent prospective studies indicate that growth rate is positively correlated with survivability to second lactation (Bach, 2011; Heinrichs and Heinrichs, 2011). Therefore, providing the necessary nutrition to sustain rapid growth rates (>750 g/d) during the first 2 months, not only should result in more efficient (economically), but also in more effective (greater milk performance) heifer rearing. Improved growth rates can be achieved by implementing enhanced-growth feeding programs that consist of supplying relatively large amounts of milk replacer.

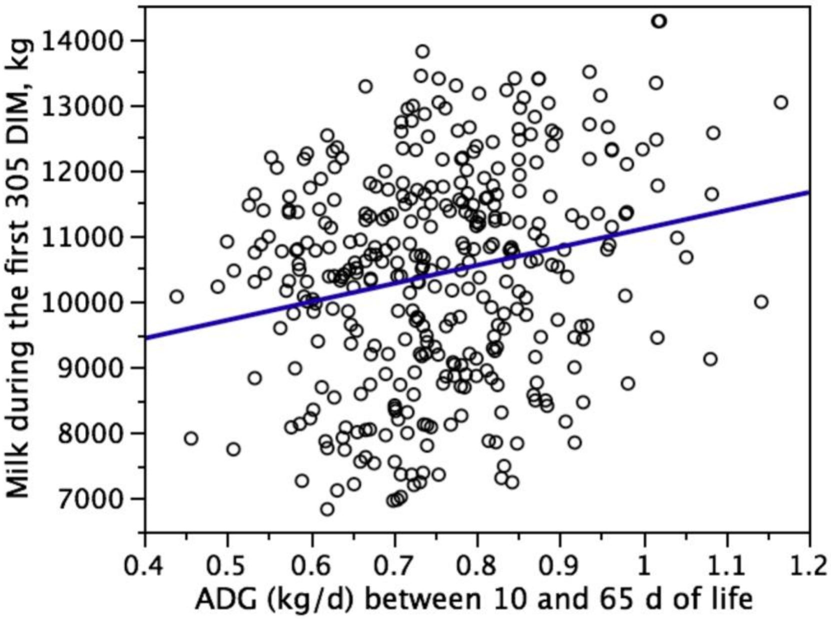

Figure 2. Relationship between daily gain during the first 2 months of life and milk production during the first 305 DIM of the first lactation (Adapted from Bach and Ahedo, 2008).

▪ Nourishing The Calf

Liquid Feeding

The first action to perform is to ensure that the newborn calf receives an adequate amount of antibodies and nutrients to avoid falling ill at early stages of life. Both immunity and nutrients should be provided through adequate amounts of good quality colostrum. After birth, once colostrum has been provided, the calf should be transferred into an individual hutch without possibility of licking other calves. Nutrition at this age should be based on water, whole milk or milk replacer (MR), and a starter.

Water should be made available to calves at all times. Milk or MR does not reach the rumen (it goes directly into the omasum), and thus only water will provide the necessary moist environment that bacteria need to colonize the rumen. Insufficient provision of water limits starter intake and thus growth. Calves need to consume, in addition to the milk or MR, 4 to 6 L of water for every kilogram of starter.

Milk or MR provides the main source of nutrients for the young calves. Feeding whole milk is usually non-economical and may pose problems of consistency of nutrient composition. On the other hand, MR represents an economic advantage and has a very consistent composition (if prepared carefully). However, MR provides less energy to the calf than whole milk, thus growth performance might be comprised. A good MR should contain 25% crude protein and 19% fat. There is a commercial tendency to substitute milk protein with vegetable protein in the MR with the aim of reducing costs, however, digestibility of these MR tends to be lower than those with high proportions of milk protein, and thus animals tend to grow less and present more diarrhea problems. Typically, MR are fed at a dilution rate of 12.5% (similar to the solid contents of milk). However, ADG can be doubled by following intensive liquid feeding programs that consist of feeding MR up to a 17% dilution and offering up to 8 L/d of MR. This type of program requires, however, a good monitoring of starter intake to ensure that animals do not fall back after weaning. Ideally, intensive feeding programs should use a high-quality MR with 27% crude protein (CP) and about 15-17% fat. It is important that during cold weather MR are fed at a greater dilution rate (i.e., 15% instead of 12.5%) to provide more energy to calves to cover the increased maintenance requirements.

An “ideal” feeding program for calves would consist of feeding 6 L/d at 12.5% dilution rate (in winter in can be increased to 15%). Offering 8 L/d may compromise intake of starter (Bach et al., 2013b) and also if fed twice daily may foster insulin resistance in calves (Bach et al., 2013a). At the age of 56 days, calves can (and should) be preweaned by reducing the offer of liquid feeding to only one 3 L dose per day, and completely wean them at 63 d. It is expected that calves would be consuming about 1.8 kg of starter at 56 days and more than 2.5 kg at 63 days, which should ensure that they could maintain greater than 1 kg/d after weaning.

Attaining Maximum Growth with Solid Feed

If rapid growth (>750 g/d) early in life is sought, feeding increased amounts of milk is necessary. However, calves fed high milk allowances tend to struggle during transition onto solid feed, and part of the growth advantage achieved before weaning may be lost due to (1) diminished consumption of nutrients, and (2) reduced digestibility. Early dry feed consumption fosters early rumen microbial development, resulting in a greater rumen metabolic activity

(Anderson et al., 1987). Thus, the high level of MR in calves following an enhanced growth feeding program may delay the start of dry feed consumption, and consequently, it may delay rumen development. In fact, duodenal microbial flow of calves following an enhanced-growth feeding program was lower than that of calves fed conventionally (Terré et al., 2007), suggesting the existence of a poor rumen microflora population that may result in a decreased rumen metabolic activity, and it may negatively affect starter digestibility at weaning.

Therefore, promoting solid feed intake is of pivotal importance when feeding more generous milk allowances to calves. Starter feed consumption can be improved by including ‘palatable’ ingredients in the formulation of the starter. Miller-Cushon et al. (2014) evaluated the palatability of several energy and protein ingredients commonly used in starters. The conclusions of that study were that corn gluten feed and corn gluten meal should be avoided, and wheat, sorghum, corn, soybean meal should be prioritized to increase palatability of starters. Oats, which are commonly included in starters, were found to have low palatability, and thus their inclusion in formulation of starter should not be forced. In terms of nutrients, a good starter should contain 18% CP and 3.2 Mcal/kg of metabolizable energy, although starters containing 20% or more CP may have some benefits right after weaning when rearing calves on intensified milk regimes to provide sufficient metabolizable protein and ensure amino acids do not limit growth.

Several recent studies (Khan et al., 2011; Castells et al., 2012, 2013; Montoro et al., 2013) have shown that another effective method to foster solid feed intake of calves, contrary to what it has been traditionally recommended, is to provide ad libitum access to poor quality (nutritionally) chopped straw or chopped grass hay. In the last century, it was believed that feeding a fiber source to young dairy calves was necessary because it improved rumen health and that if no forage was provided to calves, low fiber content of the complete starter should be avoided (Jahn et al., 1970; Thomas and Hinks, 1982). But, later, in the 70’s, the concept of textured starter was introduced. It was then assumed that with textured starters no additional feeding of forage was needed. Furthermore, the use of fibrous feeds has been discouraged since then because of the limited fiber digestion during the preweaning period, and because the potential accumulation of undigested forage material in the rumen could decrease voluntary intake of concentrate (Drackley, 2008). However, several authors (Thomas and Hinks, 1992; Phillips 2004; Suárez et al., 2007; Castells et al., 2012) have reported either an increase in starter intake or no effect on total feed consumption with the inclusion of dietary forage. Castells et al. (2012) offered an 18% NDF and 19.5% CP pelleted starter in conjunction with different sources of chopped forage to young dairy calves, and reported that feeding chopped grass hay or straw improved total dry feed intake and rate of growth, without impairing nutrient digestibility and gain to feed ratio. In contrast, when the forage fed was alfalfa hay, these benefits were not observed.

There have been concerns, however, about the potential confounding effects of gut fill when introducing forages to young calves (if gut fill increases, BW is artificially increased). Several studies (Hill et al., 2008) have argued that feeding forage (hay and straw) to preweaned dairy heifers reduces starter and overall dry matter consumption. It is important to note that, in the studies by Castells et al. (2012, 2013), when calves were fed ad libitum chopped alfalfa hay, forage intake was 14% of total solid feed intake, whereas when calves were offered chopped oats hay, forage consumption did not surpass 4% of total solid feed intake. Previous studies have shown that a high proportion of forage in the diet of calves drastically increases gut fill, but not when forage intake is less than 5% of the total solid diet. For instance, Stobo et al. (1966) limit-fed a starter feed and offered hay at different proportions (from 4 to 61% of total solid feed intake) and reported an increase in gut fill from 23.5 to 32.5% of total BW. Similarly, Strozinski and Chandler (1971) and Jahn et al. (1970) reported an increase in gut fill from about 7-10% to 20-24% when feeding 0 or 5% to a 60-90% inclusion of hay in the diet of calves. More recently (Castells, 2013) conducted a meta-analysis and concluded that there were no differences in gut fill between calves consuming no forage and calves consuming forage up to 5% of the total solid feed consumption. Thus, it can be safely concluded that when forage consumption is less than 5% of the total solid feed intake, gut fill is negligible and thus advantages reported in performance and efficiency when supplementing chopped forages to calves are not an artefact due to gut fill. Interestingly (and contrary to what it could be expected a priori), provision of chopped oats hay to calves improved rumen passage rate of digesta and tended to improve ADG over time, without incurring increases in gut fill (in fact, gut fill was reduced by feeding oats hay) when compared with calves that were fed a pelleted starter (Castells et al., 2013). The increase in passage rate and decreased gut fill can be mainly explained by a substantial increase in total dry matter intake (about 23% more than the intake observed in calves fed a pelleted starter feed alone (Castells et al., 2012). In the same study it was also reported that forage provision to calves increased almost 4-fold the number of volatile fatty acid transporters in the rumen, a condition that should minimize rumen acidosis by actively removing acid from the rumen fluid.

Last, depriving calves from forage during the preweaning phase may offer yet another physiological and dietary adaptation challenge to young calves during the transition when presented with forage for the first time. Phillips (2004) reported that calves fed fresh grass during the milk-feeding period spent more time eating on a pasture compared with those that received no forage before weaning.

■ Transitioning Successfully

After weaning, it is recommended to begin the transition with the same starter and chopped forage the animals were weaned on, and then change them to a ration that will progressively increase the proportion of fiber through the inclusion of forage, starting with about a 5% and finishing by the age of 4 months with a 15-20% forage inclusion level. These forage increments should be performed weekly or biweekly. The amount of energy and CP during this phase should be about 2.73 Mcal/kg of ME and 17% CP.

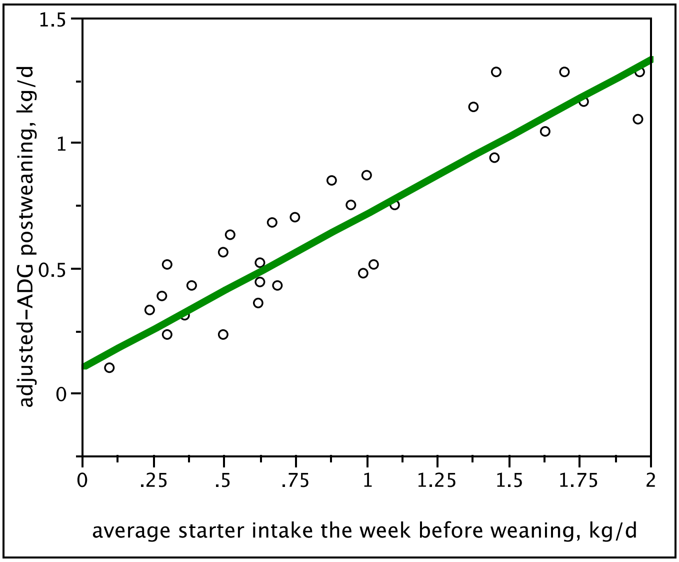

Figure 3. Linear relationship between daily starter intake the week before weaning and study-adjusted ADG the week after weaning of calves from different studies: adjusted-ADG post-weaning = 0.115 + 0.615 daily starter intake before weaning; R^2=0.82; *P* < 0.001; *n*=30 from Anderson et al., 1987; Jaster et al., 1992; Quigley et al., 1994; Quigley et al., 1996; Chua et al., 2002; Jasper and Weary, 2002; Quigley et al., 2006; Terré et al., 2006a; Terré et al., 2006b; Terré et al., 2009; Sweeney et al., 2010; Castells et al., 2012.

With a proper nutritional scheme, transition calves (few days before and few weeks after weaning) can easily grow about 1.2-1.3 kg/d and do it very efficiently (about 40% efficiency) resulting in the most profitable development stage that calves or heifers will undergo during their entire growing period. High intake of starter before weaning helps to ensure intake and sustain a desirable growth rate after weaning (Kertz et al., 1979). Davis and Drackley (1998) proposed that calves should be consuming 0.8-0.9 kg/d of starter after weaning to meet calf needs for maintenance plus a modest weight gain. However, if an ADG of about 1 kg/d is desired, calves should not be weaned until they consume at least about 1.5 kg of dry feed (Figure 3). Weaning earlier is totally possible, but growth will be compromised.

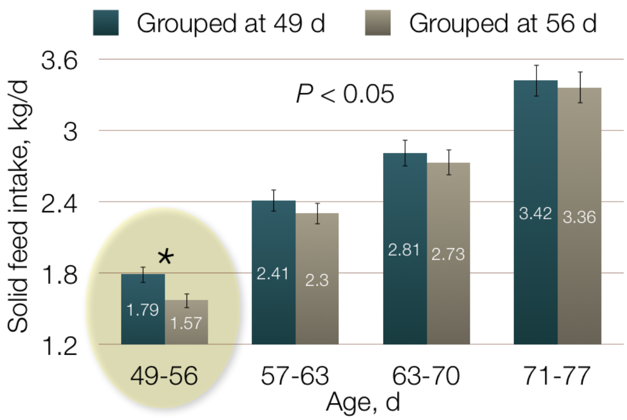

Figure 4. Solid feed intake of transition calves kept individually (for one additional week) or placed in groups of 8 animals at pre-weaning (49 d of age) time (Adapted from Bach et al., 2010).

Last, weaning has usually been associated with a period of stress. To minimize the stress around weaning, it is commonly recommended to keep calves individually housed for an additional 1 or 2 weeks following weaning. However, a study conducted at the University of Minnesota (Ziegler et al., 2008) compared performance of calves that were weaned and immediately moved to groups of 10 animals with those weaned and kept in individual stalls for an additional 14 d. The study reported no differences in performance during the first 112 d following weaning. Similarly, a study (Bach et al., 2010) involving 240 female calves assessed the impact of grouping animals before weaning on ADG and health. Half of the calves were moved at 49 d of age (when MR was reduced from 2 to 1 daily dose) to super-hutches holding 8 calves; and the other half remained individually housed for an additional week after reducing the MR from 2 to 1 daily dose. Calves grouped at 49 d of age had a greater ADG and BW at 56 d of age as a result of a greater total solid feed consumption compared with those grouped at 56 d of age (Figure 4). More relevant, the study showed that calves weaned in groups had a lower number of respiratory episodes than those weaned individually, which would indicate that the level of stress (and thus debilitation of the immune response) was reduced when calves were grouped. It is important to note that MR (or milk) should be offered in a trough (no nipples) to avoid inter-sucking while calves are group-housed.

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