

The evolution of calf nutrition

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Abstract

The milk-feeding period is a front and center welfare concern, as well as a huge economic opportunity for producers and veterinarians alike. Calf nutrition has progressed from a simple, one-size-fits-all approach to a more sophisticated understanding of the role that early nutrition has in health and future productivity. Still, calves are the only age group where it is not routine to have a nutritionist who formulates the diet, provides feedback and evaluation of animal performance, and is responsible for outcomes of the program. Veterinarians could step in to provide this service. In this presentation, I discuss what incorporating calf nutrition into a dairy practice might look like, as well as some tools available to help accomplish it. Topics discussed include the role and economic value of improving early feed efficiency; research on the value of early nutrition for health and future productivity; and tips and strategies to implement increased milk feeding programs, including starter and weaning management.

Key words: calf, milk replacer, growth, starter, weaning

Introduction

Calf nutrition has progressed from a simple, one-size-fits-all approach to a more sophisticated understanding of the role that early nutrition plays in growth, health, and future productivity. The industry has moved away, slowly, from the idea that calf nutrition is “one bag of milk replacer per calf and all the starter they’ll eat” to evaluating the desired performance objectives and designing a feeding program to achieve the goals. Still, calves are the only age group where it is not routine to have a nutritionist who formulates the diet, provides feedback and evaluation of animal performance, and is responsible for outcomes of the program.

The milk-feeding period is certainly a front and center welfare concern, as well as a huge economic opportunity for producers and veterinarians alike. The old “convention” of feeding a pound or a pound and a quarter of milk replacer to calves is slowly being replaced by intakes of more nutritious milk replacer that perhaps are twice as great, which approach “natural” intake levels. The last National Animal Health Monitoring System (NAHMS) study conducted in 2014 found that the average amount of milk fed on U.S. dairy farms was 5.7 L/d per calf, which would equate to about 740 g/d (1.6 lb) of milk solids.¹ It is likely that average has continued to increase in the near decade since that study was performed, with many farms feeding 6 to > 8 L of milk or milk replacer daily. NASEM² stated that the minimum amount of milk to be fed should be 1.5% of birth body weight (BW) as milk solids, which for a 95-lb (43 kg) Holstein heifer would be > 1.4 lb (0.64 kg) of solids or more than 11 lb (5 kg) of whole milk. Clearly, this minimum is being surpassed on many farms.

Given this diversity of feeding practices, who will monitor on-farm programs to ensure that goals are being met in a cost-effective manner? Most nutritionists and veterinarians are not trained in calf nutrition, but the opportunity to make a difference on farms is clear and obvious. Dairy veterinarians with a production medicine focus could step in to provide this role.

Incorporating calf nutrition and management into a dairy practice

Some potential roles of the practitioner wishing to become a calf nutrition and management specialist include the following:

1. Establish protocols for colostrum management and help oversee their implementation. Provision of adequate amounts of high-quality colostrum as soon as possible after birth remains the single most important management task in promoting health and growth. Meticulous sanitation at all steps from collection through feeding is critically important. Clinicians can sample blood from a cohort of newborn calves to assess transfer of passive immunity, using recently revised guidelines.³
2. Work with the producer to establish a feeding program to meet the farm’s goals, and help monitor its effectiveness. This includes selection of milk or milk replacer, feeding rates and starter as well as ensuring accurate and repeatable mixing and feeding on the farm. Veterinarians should seek additional education in calf nutrition to fulfill this role.
3. Establish and monitor health protocols and help to troubleshoot health problems. This is the traditional role of the veterinarian on most farms. Clinicians should help establish protocols for vaccination and treatment of calves. Learn to read the softer feces from feeding more milk as different from scouring.
4. Measure outcomes of the program, including mortality, morbidity and adequate growth. Check scale weights at birth, weaning and pre-breeding. Calves should double their birthweight by 8 weeks (weaning time). If producers are struggling with post-weaned heifers, check heifer weights at 12 weeks; they should be triple the birthweight. Feed cost per unit of bodyweight gain should be calculated and used as the economic indicator of progress in the program.
5. Ensure that the calf program blends seamlessly into the heifer rearing enterprise. Either take ownership for the heifer nutrition and management or work with the herd’s nutritionist that is responsible for those roles.

An important tool available to assist in feeding and management is the NASEM² system and model. The text provides a state-of-the-art review of dairy calf nutrition and feeding. The equations developed in this publication accurately predict average calf growth with different feeding programs, and can illustrate the effects of heat and cold stress on performance. Use the computer model that comes with the publication, or a spreadsheet adaptation of the model.

The role and value of early feed efficiency

Neonatal dairy calves have a tremendous capacity to grow rapidly and efficiently, which historically has not been capitalized on by the industry. Higher milk feeding rates promote more rapid growth, which increases feed efficiency (gain/feed intake) by diluting out the maintenance requirements. Jasper

and Weary⁴ found that calves allowed ad libitum access to milk from birth consumed enough nutrients to grow at a rate of 2.2 lb/d (1.0 kg/d) during the first 2 weeks of life, compared with 0.79 lb/d (0.36 kg/d) for calves fed milk at 10% of BW. Feed efficiencies (gain/feed) of > 0.80 can be achieved by young calves when they are fed large amounts of milk, equivalent to the efficiencies achieved by young pigs and lambs.⁵

Why is higher feed efficiency important? As animal scientists, we should be concerned with getting maximal value out of feed resources at any stage of life. This decreases the cost of BW gain, which should be our economic metric rather than feed cost per day. Boosting early growth and feed efficiency results in calves reaching breeding size sooner and with less feed input. Calves fed more milk are healthier and able to withstand the effects of infection better than underfed calves.⁶ And, perhaps most importantly, evidence continues to accumulate that healthier calves that grow more rapidly end up producing more milk in first lactation, and subsequent lactations, than slower growing calves.⁷ Practitioners should help producers view calves and heifers as an investment rather than as a cost center.

Dr. Mike Overton presented an elegant economic analysis of intensified liquid feeding vs. conventional limited feeding.⁸ Using a conservative approach to modeling total costs and returns from feeding an intensified milk replacer program, they found a total net benefit of \$205 per heifer from an intensified growth program compared with conventional.

One of the most important advancements in calf management over the last 25 years is the explosion in research related to behavior and welfare. Research in this area has demonstrated clear indications of hunger in calves fed conventional milk feeding programs, including increased vocalization and restlessness.^{9,10} Such signs are not evident in calves fed greater amounts of milk.¹¹ With increased scrutiny of calf raising practices by consumers, we should not allow underfeeding.

Strategies to implement increased milk feeding programs

For farms feeding pasteurized whole milk, a simple and conservative program is to increase the amount of milk fed from 4 L/d to 6 L/d. According to NASEM², this increase is enough to change metabolizable energy (ME)-allowable growth from 0.84 lb/d (0.38 kg/d) to 1.54 lb/d (0.70 kg/d), with gain/feed increasing from 0.54 to 0.77. Some producers will increase the amount fed to 8 L/d or more at 2 to 3 weeks of life, with further improvements in average daily gain and feed efficiency.

Milk replacers should contain greater crude protein (CP) content than traditional 20% or 22% formulas. They should approach the CP content of whole milk, or 25-26% CP on a dry powder basis. A 24% CP formula supplemented with lysine, methionine and threonine will provide similar performance as a 25 or 26% CP formula. An easy milk replacer feeding program is to feed the calf 1.5% of birth BW as powder during the first week, then increase to 2% of BW for weeks 2-6, followed by reductions of the amount fed during weeks 7 and 8 (see later section on weaning).

The “gold standard” for calf milk replacers remains all-milk protein formulas, usually based on whey protein concentrate and dried whey, although some manufacturers occasionally use dried skim milk. Spray-dried bovine plasma is a good non-milk ingredient and increasingly is used as a component of milk replacers for its good growth performance and health benefits.¹²

Soy protein concentrates and hydrolyzed wheat gluten also can be used in smaller amounts (generally less than 50% milk protein replacement). Soy flour should not be fed to young calves because of its high content of anti-nutritional factors.

Desired fat content in milk replacer remains variable and somewhat controversial. Milk replacers usually contain much less fat than whole milk solids (15-20% vs. 29% for whole milk) for economic reasons and because the fats used in milk replacer formulation (lard, tallow and coconut) tend to suppress dry feed intake. A content of 15% fat will result in leaner calves than a formula with 20% fat. For Jersey calves, milk replacers often contain 25% to 28% fat.

Milk replacers should be mixed so that they are 12-15% solids by weight. Greater concentrations can be used, but water management on the farm must be excellent to avoid osmotic effects that cause diarrhea. Osmolarity should be less than 500 mOsm/L.

Clinicians should be aware that calves fed the same volume of milk replacer will grow less than when fed the same volume of milk, simply because the milk replacer contains less energy than whole milk. Whole milk solids contain about 2.4 Mcal ME/lb (5.3 Mcal ME/kg), whereas milk replacers generally contain about 2.1 Mcal ME/lb (4.6 to 4.7 Mcal ME/kg). For 100 lb (45-kg) calves fed 6 qt/d (6 L/d) of milk replacer or whole milk at the same solids concentration, this difference would result in about 0.28 lb/d (125 g/d) less growth when fed milk replacer rather than whole milk.² If the amounts of solids are adjusted so that energy and protein intakes are similar, calves will grow the same on milk or milk replacer.¹³

Calf starters

Calf starters play a hugely important role in early calf nutrition. They supply additional nutrients, but more importantly provide the fermentation substrate for rumen microbes to produce the volatile fatty acids (VFA), of which butyrate is the most important for rumen epithelial (papillae) development. At birth the rumen and reticulum are undeveloped, but VFA (butyrate) stimulate the growth and differentiation of epithelial structure. The functional epithelium absorbs the VFA, in turn helping to increase the pH in the rumen. As pH increases to 6.0, fiber-digesting microbes are able to survive and function, initiating the digestion of forages and non-forage fiber sources.

Consequently, the most important property of a calf starter is that the calf wants to eat it. Palatability and acceptability are influenced both by the ingredient composition and the physical form of the starter. Although differences are small, a well textured starter generally favors greater intake than an all-pelleted starter. Pellet quality is important in either case, as calves do not like fines in the starter. Ground (mash or meal) starters also can be well utilized, although initial intake may be slower. Small particle size does not seem to be an issue if the particle size is uniformly small rather than dusty.¹⁴

Corn and wheat promoted greater starter intakes than oats and barley,¹⁵ with rice and sorghum also being less effective than corn.¹⁶ Soybean meal was the best-consumed protein source.¹⁷ Corn by-products such as corn gluten feed or corn gluten meal were less acceptable than other ingredients. While corn distillers grain was highly acceptable by calves, its low lysine content makes it a poor ingredient for young calf nutrition.

Calf growth has generally been greatest on high starch (> 35% of the DM) formulas, but the resultant rumen pH is very low, often

averaging slightly above 5.0 for much of the day.¹⁸ Concern about these effects on rumen health has resulted in many calf starter formulas now being 22% to 28% starch, more similar to diets for functioning ruminants. Content of NDF should be above 12%. Protein content of the starter has been considered adequate at 18% as-fed (20% of DM), but recent studies have shown benefits to calf growth when higher CP starters (22% as fed or 25% of DM) were fed with greater intakes of milk.^{19,20} A sugar content of 10 to 12% is favorable for rumen development because sugars ferment to a high proportion of butyrate. Sugars can be provided from molasses, dextrose, and milk by-products such as whey.

Small amounts (< 5% of total DM or ~0.3 lb/d [~150 g/d]) of chopped forage can be offered to calves before weaning, particularly those fed a pelleted starter and not bedded on straw. This forage can be something like wheat straw or grass hay, which have been shown to improve total starter intake and average daily gain.²¹ Free-choice access to alfalfa hay should NOT be provided, because calves may consume enough hay (poorly digested) to decrease intake of the easily fermentable starter grains. Avoid free-choice alfalfa until the calf is about 6 months of age.

The weaning transition

Weaning is a major stressor in the calf's life. By definition, there is a major change in diet, away from milk to total reliance on solid feed and free water. Usually there is a change in housing around weaning, perhaps to group housing that may be the calf's first experience at living with herdmates. Removal of milk feeding twice daily upsets the daily routine of calves, creating additional social stress. It is perhaps not surprising that weaning often compromises welfare, causing growth slumps, adverse behavioral stress, and increased disease, particularly respiratory and coccidiosis.

While the housing and social stressors may be somewhat unavoidable, the nutritional stressors can be minimized by ensuring that the calf is able to consume and digest sufficient starter before complete weaning. Preweaning starter intake is strongly related to postweaning growth.¹⁹ To minimize growth slumps and health challenges around weaning, calves should be consuming 3 lb/d (1.3 kg/d) of starter before weaning. Insufficient intake indicates that the rumen has not had adequate time to develop the absorptive papillae of the rumen and a microbial population able to digest fiber.²²

Many factors affect the intake of calf starter around weaning. One of the most important is starter composition and quality, and its management, which was discussed in a previous section. Common problems are excessive starch content, unpalatable ingredients and excessive fines or poor pellet quality.

Greater rates of milk feeding decrease starter intake,²³ which is not surprising since calves have a maximum dry matter intake (DMI) just like older ruminants. Increased milk solids will therefore decrease the amount of starter consumed.

With increased milk feeding, we need to re-evaluate the historical emphasis on early weaning. Weaning at 8 weeks of age instead of 6 weeks will allow calves to increase their intake of starter to adequate levels before the weaning transition.^{24,25}

It is important to provide a gradual reduction in milk offered, and "cold" weaning should be avoided.²⁶ With automated feeders it is simple to program a gradual decrease in milk offered. With manual high milk feeding programs, providing at least 2 weekly steps down in amounts offered will smooth out the weaning transition.²⁷

Providing ad libitum access to forage, especially alfalfa, should be avoided as it may decrease starter intake. As mentioned earlier, forage is poorly digested in the young rumen and contributes very little to nutrient supply.

Another problem is water availability and its management. Milk bypasses the rumen whether fed by nipple or bucket. Calves need free water, which enters the rumen, to support microbial growth and fuel lean tissue growth. Calves should have water available from birth, and it should be kept clean and fresh.

Finally, avoid "stacking" stressors on the calves. Separate weaning from other management tasks such as dehorning and vaccination. Do not move the calves at the time of weaning. Pay attention to environmental stressors (extreme heat or cold) at the time of weaning.

Post-weaning nutrition

Intake of calf starter will increase rapidly after weaning, reaching an intake level of about 3.0% of BW as DM.² After adjustment to the weaning transition, calves can gain 2.6 to 3.1 lb/d (1.2 to 1.4 kg/d). Continue feeding starter for 2 weeks post-weaning, perhaps with a small amount of hay as discussed earlier. Following this, calves can be switched to a lower-cost grower ration with minimal amounts of forage. A TMR can be introduced when the calf is about 4 months old. Now the calf is ready to progress through the heifer growth scheme.

Concluding comments

The last 20 years has seen huge advancements in calf nutrition and management. Adopting higher rates of milk or milk replacer feeding brings tremendous biological advantages to the calf, both in the short-term and later in life as a milking cow. We now understand how to implement such programs without compromising weaning and post-weaning growth. We need to work with producers to implement such practices. Much of the on-farm challenges in implementation seem to be related to a lack of patience by the producer with the weaning phase of the system. Veterinarians have the opportunity to become calf nutrition and management experts, watching over the babies on farms to ensure their welfare and economic success.

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