PRACTICAL ECONOMICS OF "ACCELERATED" CALF FEEDING PROGRAMS

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Labor costs per animal and costs per unit of gain are higher in the preweaned calf that at any other time in the animals life. Reducing these costs without compromising the health of the animal is a critical goal for the producer.

Physiologically, the newborn calf is not a functioning ruminant. The abomasum, which represents the largest portion of the stomach of the newborn calf, is the primary functional unit of the gastric region. The sucking reflex allows milk to bypass the rudimentary rumen and reticulum via the reticular or esophageal groove directly into the abomasum where digestion is initiated. Milk is coagulated in the abomasum through the action of the enzyme rennin, and digestion and absorption proceeds very much like that in the nonruminant.

Nutrient Specifications of Milk Replacers

Milk or milk replacer should be viewed strictly as a nutritional supplement to dry feed. Milk replacer intake allows the calf to receive adequate nutrients for survival until rumen capacity and function allow enough nutrients to be derived from dry feed intake. Milk replacer has been traditionally fed at a rate of one pound (dry matter basis) per head per day until the time of weaning. The provision of one pound of a 20% protein, 20% fat milk replacer provides a 90 pound calf with about 2.5 Mcal of energy, which under ideal conditions would meet maintenance needs of the calf and allow 0.5 pounds of gain per day. Maintenance needs are increased under conditions of heat stress or cold stress, so this level of milk replacer intake wills not always even support growth under all conditions.

A good milk replacer powder should contain a minimum of 15% fat, and it may contain more than 20%. The higher fat level tends to reduce the severity of diarrhea and produce additional energy for growth. Fat levels a high as 30% are often fed in cold weather to increase energy availability to the calf during a period of higher energy need. However, feeding milk replacers with fat levels higher than 15% also significantly reduces voluntary starter intake, thereby decreasing energy intake of the calf, so the decision regarding optimal fat level in a milk replacer is not a simple one. Good quality animal fats are preferable to most vegetable fats. However, soy lecithin, especially when homogenized, is an acceptable fat source and improves mixing qualities of the replacer.

Most high quality milk replacers contain 20 to 22% protein with most of the protein being derived from milk products or by-products of milk processing. Whey protein concentrate is currently the most common milk-based protein utilized in milk replacers. Milk proteins contain very high quality protein and are more digestible than most proteins from other sources.

Many vegetable protein sources have been utilized in milk replacers to reduce costs, however, whey- or skim milk-based milk replacers are the standard to which all other milk replacers are measured. Substitution of vegetable proteins for whey proteins in milk replacers results in decreased calf performance, especially during the first 2-3 weeks of life. Chemically modified soy protein, soy isolates, and soy concentrates are good, but as plant proteins they are still less digestible and more allergenic than milk protein. Meat solubles, fish protein concentrate, distillers' dried solubles, brewers' dried yeast, oat flour, and wheat flour are considered inferior protein sources in milk replacers.

Advances in collection and processing of blood from the meatpacking industry have increased the availability of relatively inexpensive food-grade blood proteins. Spray-dried red blood cells and spray-dried plasma proteins both contain highly digestible proteins that are similar to milk proteins in both quality and digestibility. Inclusion of these protein sources decreases the cost of milk replacers, yet results in similar rates of gain when these replacers are fed to calves. Currently, the cost of gain is less expensive for calves fed milk replacers containing blood proteins, making these alternative protein sources an attractive option for producers seeking to maximize profit.

Although milk replacers have traditionally contained 20% protein, this level is not based on the nutrient needs of the calf. Recent research has suggested that higher levels of protein may more nearly meet the requirements of the milk-fed calf. In response to this research, many companies are currently marketing *"accelerated growth"* programs based on 28% protein milk replacers. For calves not yet consuming appreciable amounts of calf starter, these higher protein milk replacers will more nearly meet the requirements of the calf and allow improved growth. This is not surprising; the dam's milk is approximately 27% protein and 30% fat on a dry matter basis. Since most milk replacers contain 20-22% protein and 20% fat, they only provide about ¾ of the protein and 2/3 of the fat that whole milk provides. Most milk replacers formulated for "accelerated" programs contain between 26 and 30% protein and 15 to 20% fat. Although the protein level is very similar to that of whole milk solids, fat levels are lower than those found in whole milk. This protein to fat ratio is designed to maximize lean tissue growth rates.

An additional consideration in "accelerated" programs is the provision of more milk replacer solids daily. The justification for the increased feeding rate is, in part, based on an attempt to mimic what a calf would normally consume when nursing. Typically, calves left on their dams will nurse between 6 and 10 times per day and consume between 16 and 24% of their body weight per day after the third of fourth week of life. Therefore, a calf that weighs 100 pounds typically consumes 16 to 24 pounds of milk per day or between 2 and 3 pounds of dry milk solids per day. Therefore, "accelerated" programs for calves provide 2 to 2.5 pounds of powder, roughly twice the amount provided in conventional programs. These programs allow calves to more nearly fulfill their genetic potential for rapid and efficient lean growth during the first few months of life. Rate of gain may reach 2 pounds per day by the end of the second week. Calves fed in these programs not only gain weight faster, they also require less milk replacer powder per pound of weight gain. Fat levels above 15% in these higher protein milk replacers provide no advantage in lean growth, but do lead to greater fat deposition and decrease the intake of calf starter.

Feeding recommendations for accelerated programs vary somewhat between different milk replacer manufacturers. Most programs limit the feeding rate during the first week of life to 1.5 to 2% of body weight in dry milk replacer powder. From week 2 to weaning, this level is increased to 3% of body weight and, in addition, the milk replacer is mixed to provide a greater amount of solids per day (15 to 18% solids). The week prior to weaning, the amount of milk replacer is decreased dramatically to encourage starter intake.

There is no question that accelerated programs allow calves to grow faster, leaner, and more efficiently. This does not mean that these programs are more profitable way to raise calves, however.

There are several management considerations that can impinge on the ability of calves to respond to accelerated programs. Inadequate colostrum intakes will reduce the degree of response to an accelerated program, reducing the economic benefits associated with this more costly feeding program. In addition, poor sanitation or inadequate ventilation is both associated with poor responses to intensified feeding. Water must also be available free choice for calves fed at such high protein intakes to ensure that excess urea is excreted rather than retained. Management also has to be able to accommodate multiple feeding levels among groups of calves. Finally, under marginal management conditions, mortality rates can increase for calves on accelerated feeding programs.

The reasons why some of these factors adversely affect calves fed accelerated programs are not yet fully understood, but some early research has begun to address these questions. Although it may seem counter-intuitive that high levels of nutrition may increase the risk of disease or death, it is certainly not a new concept. High intakes of protein are a potential risk factor in any diet, but especially in very young animals with limitations on both their ability to metabolize ammonia to urea and their ability to excrete urea. Calves on accelerated programs have higher levels of plasma urea nitrogen than calves on conventional milk replacers, especially during the first few weeks of life. They also excrete more nitrogen into the bedding, increasing the potential for ammonia to be volatilized into the ambient air, especially under conditions of poor ventilation. It is still not known whether they also have higher levels of blood ammonia (which are highly toxic), or how much undigested protein (and/or lactose) is escaping the small intestine (potentially feeding pathogenic bacteria). It does appear that calves raised under marginal sanitation conditions or in facilities with marginal ventilation have a greater risk of dying, especially during the second week of life when intake levels of milk replacer are dramatically increased in these programs.

One study to address these questions utilized 120 Holstein calves purchased from sale barns and exposed to a pathogenic challenge. Wood shavings contaminated with coronavirus were mixed with clean shavings and added to each hutch prior to arrival. Most calves on this study were classified as having failure of passive transfer. After arrival, half of the calves were fed a conventional milk replacer and half were placed on a typical accelerated feeding program. Calves on the accelerated program had greater morbidity and mortality compared to calves fed conventionally. Morbidity, measured as the number of days that calves had diarrhea, was increased by 53% for calves on the accelerated feeding program. Fourteen calves on the accelerated program died at an average of 12.6 days of life, while 3 calves fed conventionally died at an average of 14.0 days of life. Calves on the accelerated program averaged only about 1.3 pounds per day average daily gain under these conditions, while the conventionally fed calves only averaged slightly over 1 pound per day.

A smaller study conducted by our research group at Iowa State supported these findings. Although the conditions were far less challenging. The study was conducted in a dairy facility utilizing an older, poorly ventilated barn to raise calves. Despite the marginal facilities, calf mortality was less than 1% over the previous year. Forty-three calves were fed either a conventional (22:20) milk replacer (14 calves) or placed on two versions of an accelerated feeding program (29 calves). Seven of the 29 calves on the accelerated programs died during the second week of life, while one calf on the conventional program died (at 54 days of age). The cause of death for four of the seven calves that died on the accelerated program was determined to be Clostridia despite the fact all calves were vaccinated for Clostridia as part of the experimental protocol. Under these marginally challenging conditions, average daily gains were 1.45 pounds per day for the accelerated program calves and 1.15 pounds per day for conventionally fed early-weaned calves.

Researchers in the first study speculated that the abrupt change in feeding rate might have contributed to increased morbidity and mortality of the calves on the accelerated program. There is some evidence from other work to support this suggestion. High feeding rates of milk replacers are associated with increased fecal scores, particularly within the first 2 weeks of life. High feeding rates also have been reported to lead to increased days treated for illness in several studies, but not all. Although many proponents of accelerated programs claim improved health and stronger immune systems, the only research to date suggests no beneficial impact of high feeding rates on antigen specific responses of vaccinated dairy calves.

An additional consideration for any feeding program is the cost. Since protein is the most expensive nutrient in any feeding program, it is not surprising that higher protein milk replacers are more expensive than lower protein milk replacers. This increased feedstuff cost, combined with the higher feeding rates in the accelerated programs and greater labor costs associated with hand-feeding milk replacer, results in much greater costs per calf and costs per pound of gain for accelerated feeding programs compared to early weaning programs.

Several studies have directly compared the economics of these programs, however, these were also studies performed in challenging, or at least less-than-ideal conditions. Under these conditions, costs per calf are approximately $40 to $55 more, and costs per pound of gain were 15-45 cents cheaper for the conventionally fed calves.

Using data from different trials (not side-by-side comparisons) performed under closer-to-ideal conditions, however, Table 1 compares the growth and economic performance of both accelerated calves and early weaned calves, and compares these numbers to the average performance of Holstein heifers on dairy farms.

Table 1.

Variable	National Average	Accelerated	Early Weaning
Birth weight, pounds	95	95	87
Weaning age, days	56	56	31
ADG, pounds	0.98	2.1	1.5
Eight-week weight, pounds	150	212	165
Milk replacer intake, pounds	64	121	30
Starter intake, pounds	74	45	130
Gain: Feed ratio	0.40	0.70	0.49
Milk replacer cost, $	54	121	25
Starter cost, $	13	9	24
Total feed cost, $	67	130	49
Feed cost per pound of gain	1.20	1.12	0.63

These data clearly indicate that although calves on accelerated programs can be expected to markedly outperform conventionally fed calves, the high costs associated with increased milk replacer feeding makes this a more costly program than early weaning programs.

We conducted a small study on the economics of using a high protein milk replacer in an early weaning program. As might be expected, the costs and performance were intermediate to those of calves on either conventional early weaning programs or conventional accelerated feeding programs.

So what is the optimal feeding program for pre-weaned calves? This clearly depends on the goals of the producer. Accelerated programs, as currently promoted, maximize lean weight gains and other growth parameters while improving feed efficiency. They also increase costs and may increase health risks under less-than-ideal management conditions. With starter costs at roughly 1/5 of milk replacer costs, it is difficult to economically justify any feeding program that extends the period of milk replacer feeding.

In general, early weaning (at 21 to 35 days of age) will reduce feed and labor costs. Thus, the most effective means of reducing the costs of raising preweaned calves is to provide a feeding program that meets the nutrient requirements of the calf while simultaneously and rapidly stimulating rumen development. The provision of up to 2% of BW of a 28% protein, 20% fat milk replacer intake (2 pounds of milk replacer daily for a 100-pound calf) during the period prior to normal starter intake is potentially justified by the improved growth rates of these calves. After 7-10 days, reducing intake (to 1% of BW) of the same milk replacer should encourage starter intake. Weaning should then be determined by starter intake, as described below. The timing of all changes in the feeding program should be flexible based on calf health, environmental conditions, and economic factors.

STIMULATING RUMEN DEVELOPMENT

Stimulation of rumen development is dependent on fermentation of ingested feedstuffs to volatile fatty acids. The physical form of the feed is not important, however, concentrates are more effective in stimulating papillae growth than forages. All volatile fatty acids are mitogenic to the rumen epithelium, but butyrate is the most important VFA in this respect. Although forages are not necessary for rumen development during this period, a threshold level of abrasiveness is required to prevent abnormal papillae formation and excessive keratinization of rumen tissues. Thus, while concentrate intake drives rumen growth and development, a minimal level of forage inclusion in the ration is suggested to enhance the functional development of the rumen. As early as 7 days of age, both bacteria and protozoa may be established in the rumen. Adult concentrations are reached by 2 weeks of age. By 5 weeks, fermentation can proceed on a body weight basis at the same rate as in adults. These changes in rumen function are reflected in the growing calf by increasing blood urea (rumen ammonia is converted to urea in the liver), increasing blood acetate levels (from rumen acetate), and blood ketone bodies (ß-hydroxybutyrate and acetoacetate are produced in the rumen epithelium from rumenally produced butyrate).

Calf starter should be available to the calf during first week and replaced daily. Because starter intake drives rumen development, the primary goal of the producer should be to manage the calf in the manner that best encourages starter intake. Starter intake is negatively correlated with the energy intake from milk or milk replacer and increased provision of liquid feeds is not advisable for calves over 10 days of age because limiting energy intake from milk replacer stimulates starter intake in older calves.

Relative Size of Bovine Stomach Compartments (%)

Compartment	Birth	3-4 months	Mature
Rumen	2.5	60	80
Reticulum	5	5	5
Omasum	10	10	7-8
Abomasum	60	25	7-8

Calf starter should contain 18-20% CP (as fed basis) and 80% TDN and may also include coccidiostats to decrease the incidence of subclinical coccidial infections. The physical form of the feed is as important at this stage of life than the nutrient content. To encourage intake, calf starter must have a coarse texture with minimal fines to reduce dustiness. Pelleted “complete” feeds are often fed to encourage a balanced intake of all feed ingredients in a palatable form, however, pellets that are too hard will not be as readily consumed as a softer pellet. Often molasses is added (up to 7.5%) to calf starters to increase palatability and decrease dustiness. Higher protein levels in calf starter are not warranted to meet the nutrient requirements of the calf. Calves consuming adequate amounts of an 18% protein (as fed basis) calf starter meet the apparent protein requirements of the calf; higher protein calf starters (22 to 24%) do not improve calf performance.

Hay intake should be limited for several reasons. Lowly digestible, overly mature legumes are not fermented as rapidly or masticated as effectively at this age; rumen retention is prolonged and dry matter intake is decreased. In addition, the severe limitations in rumen capacity limit overall dry matter intake and even relatively low intakes of forage may limit starter intake and therefore slow rumen development. Therefore, the highest quality hay should be fed to calves (preferably an immature grass hay or grass-legume mix), particle size and texture should be closely monitored, and the quantity fed should be limited to no more than 10% of the dry feed provided until after weaning. About 5 pounds of chopped hay per 50-pound bag of calf starter will enhance rumen function and improve feed efficiency without limiting feed intake.

Fresh water should always be available to the calf from birth. Young calves, especially under conditions of heat stress, can dehydrate very rapidly. In addition, free water intake is crucial for maintaining a normal rumen environment because the water in milk or milk replacer bypasses the rumen. Calves offered water during the liquid feeding period (birth to 4 weeks) tend to consume more starter and perform better than calves fed liquid only. Thus, a lack of water availability limits dry feed intake and slows rumen development. Water intakes in hot summer weather, especially in dry climates, can easily exceed 5 gallons a day, so water may need to be provided several times a day. Provision of water is especially challenging during cold winter months for calves reared outdoors; it should be replaced three times daily in extremely cold weather to insure no impairments in starter intake. Rotating the use of multiple water buckets for each calf makes this recommendation more practical to implement.

Since starter intake drives rumen development, intake can be monitored as an indirect reflection of “readiness to wean”. Weaning at a specific level of starter intake is the best weaning criteria. Calves with birth weights over 100 pounds at birth should be consuming at least 2 to 2.5 pounds of starter per day for several days prior to weaning. Calves with birth weights between 50 and 100 pounds should be consuming 1.5 to 2 pounds of starter for several days prior to weaning, and calves with birth weights under 50 pounds should be consuming 1 to 1.5 pounds of starter for several days prior to weaning. Again, the calf must have a digestive system with adequate capacity so that the quantity of food eaten will sustain it. Producers should continue to feed calf starter until intake reaches 2 kg/day, then switch to less expensive feed. In addition, maintaining calves in the same housing system for several weeks after weaning prevents sucking on other calves, reduces stress, and allows producers to note signs of stress or illness more easily.

SOME HOUSING CONSIDERATIONS

Sanitation and minimizing contacts are the keys to controlling pathogen exposure in young calves. Sanitation begins in the maternity stall; a calf born in a dirty environment is off to a compromised start. Choice of bedding and adequacy of bedding throughout the pre-weaning period are critical to calf health. Calves should be housed in a well-ventilated, well-drained area. Calves can be successfully raised using many different types of housing systems, however, it is easier to control pathogen loads or exposure in individual housing systems. Well-ventilated housing systems are extremely crucial to calf performance because calves are highly susceptible to respiratory pathogens.

Adequate space between calves (several feet) is also important in this regard as it minimizes calf-to-calf transmission of airborne pathogens. Raising calves in elevated stalls or on gravel without bedding allows fecal pathogens to be removed from the immediate environment of the calf frequently and thoroughly. Other types of housing that require bedding must be kept as dry, sanitary and well bedded as possible, especially when disease outbreaks occur. Controlling exposure also requires that people to whom the calves are exposed practice good hygiene. Calf care should be the first consideration of the herd veterinarian, prior to caring for the older stock, to prevent transmission of pathogens within the herd. Similarly, workers doing calf chores should avoid spreading pathogens for other areas of the farm or from calf to calf by developing a chore routine that keeps these principles in mind. Calf raising areas should be isolated from other animals on the farm, and drainage should flow in a direction away from the calf housing area.