Managing the Pre-weaned Calf

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Take Home Messages

- Performance of the young calf lags behind that of other animal species
- Traditional feeding programs have emphasized limited feeding of liquid nutrients in an effort to encourage early weaning and reduce cost
- Research is demonstrating that limit feeding systems may increase the risk of impaired immune function when environmental conditions are not optimal.
- As compared to a traditional limit feeding program a higher plane of nutrition enhances feed efficiency, meaning less cost / unit of gain.
- Transfer of the immunity to the calf via the dam's colostrum continues to be a challenging aspect of calf management. Feeding 4 liters of colostrum containing >50 g IgG/ L within 6 hours of birth increases efficiency of absorption. Reducing bacterial content of colostrum through careful pasteurization or expedited handling and feeding of colostrum further improves efficiency of IgG absorption.

Introduction

For many years traditional calf rearing programs have stressed early weaning (<6 weeks of age), accelerated development of the rumen and low cost. Recent research has caused a reexamination of this management strategy. Numerous surveys of calf management (NAHMS, 2007) reveal that calf mortality during the milk feeding period (7.8%) continues to be a problem. Additionally, other studies indicate that over 30% of calves are treated for some type of illness prior to weaning. Finally, limit feeding systems require that the calf directs essentially all nutrient intake towards maintenance with little remaining to support growth during this critical time.

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■ Nutrient Requirements of the Growing Milk-Fed Calf

Traditional calf management programs have stressed the utilization of milk replacer powder containing 20% protein and 20% fat fed at rates of approximately 400 to 500 g/calf/day. As a comparison, whole milk testing 3.5% fat and 3.0% protein would contain 27% fat and 24% protein on an equivalent basis. In many instances, particularly in Canada, this level of nutrition may not provide sufficient nutrients to meet the requirements for maintenance during cold weather. Unlike dairy cattle which can tolerate cold weather relatively well, the lower critical temperature (LCT) for the calf less than 21 days of age is 10 to 20^{o}C. The smaller the calf the higher the LCT. Temperatures below this level require more energy intake to enable the calf to maintain body temperature.

Table 1. Amount of milk replacer or milk dry matter required to meet maintenance requirements. (Kg/day)

Temperature ^{o}C						
	20	10	0	-10	-15	-20
Body weight - kg						
27	0.27	0.36	0.41	0.45	0.50	0.54
36	0.36	0.41	0.50	0.59	0.64	0.68
45	0.45	0.50	0.59	0.73	0.77	0.82
55	0.50	0.59	0.68	0.77	0.86	0.91

This has tremendous negative implications for calf health for the calf less than two to three weeks of age for several reasons. First, the calf less than two weeks of age has very low levels of body fat (<3-4%). If the calf becomes ill, dietary intake declines and energy requirements increase as the calf mounts a reaction to the disease. With such low levels of body fat in limit-fed calves, mortality rates are likely to increase. In field studies in Virginia, Minnesota and California more liberally fed calves exhibited lower mortality and morbidity during the first two months of life. The relationship of nutrition of the young calf to health is best illustrated in a study conducted at the University of Minnesota (Godden, 2005) where dairy calves received either ~4 liters of pasteurized whole milk or 454 g of a 20:20 milk replacer powder in an equivalent volume of liquid. A summary of growth and health is shown in Table 2.

Table 2. Growth and morbidity and mortality of calves fed either whole milk or a 20%protein: 20%fat milk replacer (Godden et al., 2005)

Measure	Pasteurized Whole milk	20:20 milk replacer
Average daily gain	472g	340g
Treatment rate – all months	12%	32%
Treatment rate – winter	20%	52%
Mortality – all months	2.3%	11.6%
Mortality – winter	2.8%	21%

Improvement in gains per day and lower treatment and mortality rates were attributed to the higher nutrient intake by calves fed pasteurized whole milk as they received 140 g of fat and 120 g of protein while calves fed the milk replacer diets consumed 90 g of fat and 90 g of protein daily.

Virginia Tech research (Bascom et al, 2007) has shown that the 2001 NRC underestimates maintenance requirements for smaller calves by 15 to 25%. Due to smaller size of Jerseys, they have a great body surface area and lose heat more rapidly. For many years we have been concerned about overfeeding smaller calves for fear of overloading their smaller digestive systems. In fact, smaller calves would benefit from proportionately higher feeding rates due to their greater propensity for heat loss. As a result of this research milk replacers for small breeds, such as Jerseys, have been developed which contain 28% protein and 25% fat. These products are especially beneficial during stressful winter feeding periods.

Research over the past 10 years indicates that there may be additional benefits to a more biologically normal feeding rate which encourages growth rates of 500 to 700 g/day during the preweaning period. Several studies in Israel, Denmark, Illinois and New York have shown that more liberally fed calves produce more milk during their first lactation than those that were limit-fed during the preweaning period. The impact of a more biologically normal feeding rate during the preweaning period on mammary development in the calf is demonstrated in the table below which represents a trial in which calves were fed at a moderate or high level from 2 to 8 weeks of age followed by either a moderate of high level until 14 weeks of age. As shown in the following table rates of gain were considerably different for each feeding level.

Table 3. The effect of early nutrition on mammary development.

	MM	MH	HM	HH
ADG, 2-8 wks	0.40[a]	0.40[a]	0.67[b]	0.67[b]
ADG, 8-14 wks	0.47a	1.06b	0.40a	1.13b
Final BW, kg	80[a]	106[b]	89.5[a]	121[b]
Total Mammary wt, g/100 kg BW	252	390	274	511
Parenchyma wt., g/100 kg BW	16[a]	15[a]	24[b]	23[b]
Parenchyma DNA mg/100 kg BW	44[a]	42[a]	85[b]	86[b]
Parenchyma RNA mg/100 kg BW	63[b]	63[b]	103[b]	108[b]

MM = Medium rate of gain for weeks 2 -14.
MH = medium rate of gain for weeks 2 – 8 followed by high rate of gain for weeks 8 – 14.
HM = High rate of gain for weeks 2 – 8 followed by medium rate of gain for weeks 8 – 14.
HH = High rate of gain for weeks 2 – 14.
[ab]$P<.05$, Brown et al, 2005.

During the first 8 weeks, higher feeding rates resulted in increased average daily gain, mammary weight and mammary parenchyma weight. Parenchyma DNA indicates greater cell numbers and the RNA indicates greater cell activity of calves on the higher plane of nutrition. This trial demonstrated that, during the first 8 weeks of life, the mammary gland appears to be very responsive to higher nutrient intake. The biological mechanisms which seem to be responsible for accelerated mammary development in more liberally fed young calves have not been fully determined and are an active field of research.

Waste Milk Feeding

In late 2007, prices for whey products and animal-based fats used in milk replacers increased greatly. As a result of these high ingredient prices, dairy producers in the U.S. increased use of unsalable waste milk for calf feeding to reduce calf rearing costs. In Canada, over-quota milk may represent a more economical source of feed for calves. Although the immediate benefits of “cheaper” calf feeding programs are readily evident, the risks of feeding raw milk must be considered.

A growing concern of the dairy industry concerns the control of Johne’s disease. It has been estimated that 49% of Canadian dairy herds may have at least one cow infected with the Johne’s organism. Johne’s control programs in the U.S. recommend that raw milk not be fed to calves to decrease the risk of transmission to calves. Raw milk destined for human consumption should also be recognized as a source of other potential pathogens for the neonatal calf. Fortunately commercial pasteurizers have been developed that are well suited to on-farm use to render this milk "safe" for calf feeding programs. Successful pasteurization is indicated when the bacterial counts (SPC) are reduced to less than 20,000 colony forming units (CFU) per ml. Pasteurization does not sterilize milk. Pasteurizers are designed to kill 98% of the bacteria which means that milk should contain less than 1 – 2,000,000 cfu/ml to achieve these goals. As with all equipment used on the farm, proper installation and maintenance of pasteurizers is imperative. Studies in Wisconsin (Jorgensen et al, 2006), North Carolina and California(James and Scott, 2006, 2007) noted that approximately 10% of post pasteurization milk samples tested indicated that the pasteurizer was not functioning properly or had not been sanitized correctly. In order to assure that waste milk is suitable for calves, the following protocols should be established:

- Treat milk for calves as one would for saleable milk. Rapid cooling and sanitation of all milk contact surfaces are important for milk destined for calf feed. Bacterial growth in unrefrigerated milk can exceed the 6,000,000 cfu/ml within 6 hours.
- Measure standard plate counts on pre- and post-pasteurized milk samples to determine if milk handling before and after pasteurization is appropriate.
- Determine a strategy to use when supply of waste or over-quota milk is insufficient to meet the calf operations needs. Our field studies have shown wide daily and weekly variation in supply. Supply can vary by 5% to 10% of total milk shipped which creates challenges for delivery of sufficient milk to the calf enterprise. In herds with excellent mastitis control and herd health programs, waste milk may be adequate for less than 50% of daily calf feeding needs. When waste milk is not sufficient, supplemental nutrients can be provided by saleable milk, or addition of milk replacer or whey protein concentrate and water to the mixture. Alternately calves can be switched to milk replacer, but this should occur after 3 weeks of age to minimize digestive upsets.

A New Paradigm for Growing Calves?

The calf rearing enterprise should be viewed as an investment center rather than a center where costs are minimized. Calves are not rugged individuals, at birth; they are sterile with low reserves of body fat and proportionately higher nutrient requirements for growth and maintenance due to their smaller body size. The comparatively high level of mortality during the preweaning period and high treatment rate suggests there be a re-examination of our traditional calf rearing practices.

Colostrum management is the first requisite for a successful calf rearing program. The standby recommendations of 4 liters of high quality colostrum containing at least 50 g IgG/L fed with 6 hours of birth continues to be our best recommendation for successful transfer of passive immunity to the calf. However, it appears that we are not making much progress in this area as approximately 30% of all calves experience failure of passive transfer, which is similar to failure rates 20 years ago. Undoubtedly, many factors influence the success of colostrum absorption. However, James et al (1981) found a strong negative correlation between microbial growth in the intestine of the newborn calf and IgG absorption. Further evidence for microbial interference with IgG absorption was demonstrated by Oklahoma researchers who revealed, under microscopic evaluation of the intestine, that dosing calves with an E. coli inoculum prior to colostrum resulted in apparent internalization of the bacteria and impairment of IgG absorption by interference with absorptive sites on the intestinal wall. In a practical sense what does this mean? Cleanliness of the calving environment is very important as these bacteria have the greatest opportunity to colonize the intestine of the calf. Colostrum needs to be collected and stored in a sanitary manner. Frequently, fresh cows are milked first and their colostrum may not be fed to the calf for several hours or it may be several hours before it is stored in the refrigerator or freezer. Field studies by Stewart et al (2005) observed rapid bacterial growth in colostrum stored at room temperature. However, Minnesota studies have shown that batch pasteurization for 60 minutes at 60°C resulted in little destruction of colostral IgG, a significant reduction in bacterial standard plate counts and improved IgG absorption over similar unpasteurized colostrum. These findings also suggest that use of probiotic preparations in neonatal calves should be delayed at least until several hours after the first colostrum feeding.

Liquid Feeding Programs

The goal of the liquid feeding program should be to enable the calf to double birth weight by 8 weeks of age. This can be achieved through:

- Use of highly digestible dietary sources of protein, energy, minerals and vitamins.
- Feeding sufficient quantities of nutrients to encourage frame growth, reasonable feed efficiency and development of sufficient body reserves of fat in the young calf (less than 6 weeks of age) to accommodate environmental and disease challenges.

Limit feeding programs based on feeding less than 500 g of milk (4 liters) or milk replacer DM /day puts the calf at serious risk for limited or no growth during the first two to three weeks of life unless environmental conditions of temperature and moisture are optimal. The importance of more liberal feeding of calves is demonstrated in Table 3. At 32°C, 454 g of a 20:20 milk replacer provides sufficient energy for 45 g gain, yet when temperature drops to zero calves will lose weight. Similarly approximately 4 liters of whole milk does not provide enough nutrients for gain at 0°C. Many producers have observed the benefits of higher feeding rates on calf health and body weight gain, especially during cold weather. Twenty-eight percent protein in the milk replacer powder has been associated with optimal lean tissue gain.

Table 3. Energy and protein allowable gain for 57 kg calf fed whole milk or two different milk replacers at different feeding rates.

		32°C		0°C	
Liquid	Kg/day	Energy allowable gain	Protein allowable gain	Energy allowable gain	Protein allowable gain
Whole milk	3.9 kg	213 g	345 g	Weight loss	Weight loss
	9.1 kg	1.18 kg	0.99 kg	0.85 kg	0.99 kg
20%protein: 20%fat milk replacer	3.9 kg @ 12.5% DM	45 g	218 g	Weight loss	Weight loss
28%protein: 20%fat milk replacer	6.68 kg @ 17% DM	1.014 kg	1.154 kg	740 g	1.154 kg

The growth rates shown in Table 3 do not consider quality of protein provided in the diet. It is assumed that casein and other milk proteins such as whey proteins used in milk replacer represent the "gold" standard. In an effort to reduce costs milk replacer manufacturers have sought less expensive proteins of plant or animal origin. Numerous studies have shown acceptable growth of calves fed these alternative proteins. However, research evaluation of alternative protein sources is frequently conducted with male calves that were more than 2 – 3 weeks of age at the beginning of the feeding trials. It is known that the digestive system of the calf less than 3 weeks of age is not well equipped to digest vegetable proteins such as soy or wheat gluten. Utilization of soy and wheat proteins improves considerably in older calves. Of the alternative animal sources, serum derived proteins are very digestible with possible added benefit of local protective action in the small intestine. On the other hand, spray dried whole egg products and other animal source are not well digested and should be avoided in milk replacers for the calf less than 3 weeks of age.

Suggested feeding rates for more intensive feeding programs provide 680 g to as much as 1.14 kg of milk or milk replacer DM diluted to 12.5 to 17% DM. For systems where whole milk is fed with 12.5% DM for milk, the equivalent feeding rate would be about 9.1 kg or over 7.6 L/ day. It is common to begin with a slightly lower feeding rate and increase the amount to full feeding after the first week. Calf starter of 18 to 22% CP should be offered in limited quantities during the first week with weaning by 6-8 weeks of age. However, with the higher milk solids intake it is not unusual for calves to begin consuming calf starter until after the second week. Weaning is facilitated by offering one feeding per day or providing one-half the amount of powder in a similar quantity of liquid.

Acidified milk feeding programs are gaining favor in Canada according to workers from the University of Guelph. Systems have been developed utilizing dilute formic acid (1 part 85% formic acid: 9 parts water) added at a rate of 30 ml of dilute formic acid / liter of liquid. Consult publications by Dr. Neil Anderson, Lead Veterinarian, Ontario Ministry of Agriculture, Food and Rural Affairs. *(http://www.omafra.gov.on.ca/english/livestock/)* Extensive field trials on commercial dairies are underway to determine performance, health and economics of free choice acidified feeding programs. Consult Dr. Ken Leslie and associates at Ontario Veterinary College at Guelph when their data are summarized. It is interesting to note that acidified milk replacer feeding programs were studied at Pennsylvania State University in the 1980's with excellent growth observed at high intakes of milk replacer dry matter.

▪ The Little Things That Make a Difference

In spite of all of the research conducted, too often the "little things" don't receive enough attention in the calf management program. Here are several practices that can make a difference.

- Colostrum stored at room temperature may contain as much as 6,000,000 bacteria/ml. Develop systems to feed colostrum soon after collection or refrigerate within 1 – 2 hours. Rapidly cool by placing the container in cold water.
- Test colostrum at room temperature with a colostrometer, record results and discard or feed low quality colostrum (<50 g IgG/liter) to older calves.
- Do not pool colostrum as this increases the risk of feeding colostrum contaminated with infectious bacteria, particularly Johne's disease organisms to multiple calves.
- Make sure the holes in nipple bottles are not too large as to cause aspiration of liquid into the lungs of young calves.
- Reduce variation in liquid feeding by following one of the following practices.
  - Large calf ranches feed with nipple bottles because the amount of milk in full bottle is a known quantity and it's more labor efficient.

Bucket feeding is more labor intensive and is subject to greater daily variation in amounts of liquid diet fed to calves.

- Use scales to weigh milk and to mix milk replacer. The mixing cup found in most bags of milk replacer is rarely used as specified resulting in considerable variation in the amount of solids delivered to the calf. Research by a major nutrition company found poorer growth in calves receiving variable quantities of liquid of different DM% as compared to those receiving fixed amounts of liquids at constant DM %.

- Monitor the temperature of water used to mix the milk replacer. It should be about 43°C. Keep digital thermometers in the calf feeding room and use them.

How is Management of the Calf Program Measured?

Unfortunately most producers only know death loss. Isn't that unfortunate? Benchmarks to consider using for the calf enterprise are shown below.

- DOA'S (dead on arrival) - Calves from 1st calf heifers - <9%
  Calves from older cows - <5%
- Deaths from 24 h – weaning <3%
- Calves treated prior to weaning <25%
- Serum proteins @ 24 – 72 hr 85% of calves >5.5 g/dl
- Serum IgG @ 24 – 72 hr. 85% of calves >10mg/ml
- Colostrum quality # green, yellow, red on colostrometer
- Birth weight
- Weaning weight
- Average daily gain – birth to weaning 400 – 600g/day or double birth weight by 56 days of age. – 90% of calves.

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