Utilizing Milk Replacer to Maximize Early Growth Rates

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Milk replacers come in a wide variety of protein and fat concentrations. The type and quality of the ingredients also vary greatly. In order to determine the quality of a milk replacer, the dairy owner must become familiar with the ingredients and guaranteed analysis listed on the milk replacer.

Traditional Milk Replacers

The most expensive portion of a milk replacer is protein. Both the percent of protein in the milk replacer and its source must be evaluated before one can determine its quality. Most high quality milk replacers contain 20 to 22% protein with the major portion of the protein being derived from milk products or by-products of the milk processing industry. These would include dried skim milk, sodium caseinate, whey protein concentrate, dried whole whey, delactosed whey, dried buttermilk, and milk albumin. In the past, dried skim milk has been used as the major source of protein in calf milk replacers. In recent years, the demand for skim milk for human consumption has increased significantly, so whey protein concentrate is replacing a major portion of the protein previously supplied by skim milk. Milk proteins contain the highest quality protein and are more easily digested than other protein sources.

Soy proteins are the next most commonly used proteins in calf milk replacers. Unprocessed soy proteins contain numerous anti-nutritional factors (**ANF**). These ANF interfere with normal enzyme function and can bind to specific sugars or glycoproteins, which results in decreased absorption of nutrients and damage to the gut wall. Soy proteins have also been shown to produce a marked allergic reaction in the gut, which may result in damage to the microvilli that line the small intestine.

The soy proteins used in milk replacers most commonly are soy flour, soy protein concentrate, and soy protein isolate. All three products are obtained from defatted soy flakes through different processes. Soy flour is obtained simply by grinding the soy flakes. The protein in soy flour is the least utilizable of the three products, but utilization may be improved slightly through a heat treatment process. Soy protein concentrate and soy protein isolate are obtained through different chemical processes and are more available to the animal than is soy flour.

The calf cannot utilize soy proteins very well during the first 2 to 3 weeks of life. Therefore, milk replacers that contain soy protein should not be fed to calves younger than 3 weeks of age. Some of the manufacturers have tried to disguise soy protein on their label by calling it *Glycine max*, which is the scientific name for the soybean. Other companies have tried to use fiber levels to prove the quality of their product. A fiber level of 0.15% has been used to implicate a high quality milk replacer with all of the protein being derived from milk products. However, soy protein isolate carries no fiber with it and thus invalidates the assumption that a milk replacer with a 0.15% fiber level contains all milk protein. Other protein sources such as blood, plasma, and albumin are less available than milk protein and contain no fiber. Also the method of analyzing the fiber content of a milk replacer is not extremely accurate, and therefore should not be accepted totally at its face value.

The fat level in milk replacers generally varies from 10 to 20%. The source of fat is usually tallow or lard. In order for these fats to be easily mixed in water, and be more easily digested, they are homogenized and emulsified during the manufacturing process. Emulsifiers such as mono- and diglycerides and lecithin are often added to aid in this process.

Lactose is the main carbohydrate added to milk replacers since it is about the only one that is efficiently digested, especially by younger calves less than 3 weeks of age. Milk replacers should never contain sugars other than lactose.

Many of the milk replacers today are medicated, which means that low levels of antibiotics have been added. These antibiotics

are supposed to aid in the prevention of bacterial diarrhea or scours. An example would be the addition of oxytetracycline to a milk replacer at the rate of 50 grams per ton. This should result in the average calf receiving approximately 12.5 mg of oxytetracycline per feeding. The normal therapeutic dose for this antibiotic is 5 mg/lb of bodyweight, so this would be enough to treat a 2-½ pound calf. The *E. coli* bacteria that cause diarrhea in young calves is very resistant to antibiotic therapy and even high doses of oxytetracycline are usually ineffective. However, other bacteria that normally inhabit the intestinal tract may be more susceptible to the antibiotic than the one that causes the disease. This may result in an abnormal balance of normal bacteria resulting in poor digestion and/or disease. It has not been proven if these low levels of antibiotics are indeed detrimental to the calf; however, to my knowledge, there is no recent research that would indicate that there are beneficial effects. I usually recommend that my clients avoid the use of milk replacers containing low levels of antibiotics, especially when the consumer is becoming more concerned about possible antibiotic resistance and drug residues in milk and meat. When using a medicated milk replacer, it is important to observe the proper withholding time if the calves are sold to slaughter.

Besides antibiotics, some milk replacers are medicated with products to prevent or control coccidiosis. These products, such as Deccox® and Bovatec®, are becoming more popular and seem to be quite effective in the prevention of coccidiosis. It is advisable to use the same product in the milk replacer that you will be using in the calf starter if possible.

Newborn calves have little to no reserves of vitamins A, D, and E. Good quality colostrum has high levels of these vitamins and can provide adequate levels to the calf provided it has received sufficient colostrum. Good quality milk replacers should also contain vitamins A, D, and E in the appropriate levels; which range from 10,000 to 30,000 USP units of vitamin A per pound of milk replacer, 2,000 to 6,000 international units of vitamin D_3 per pound, and 25 to 125 international units of vitamin E per pound. Some replacers also contain vitamin C, since it seems to boost the immune response along with vitamin E. Even though cow's milk contains a fairly high level of calcium, milk replacer should be supplemented with a calcium source since the fat interferes with calcium digestibility. Iron should also be supplemented since the iron content of whole milk is low.

Only first milking colostrum should be fed to the calf during the first 24 hours. It is recommended that 1 gallon of first milking colostrum be administered as soon as possible after birth and a second gallon be given within 6 to 8 hours. It is advantageous to feed transition milk (2^{nd} and 3^{rd} milkings) to the calf for the first 3 days of life before switching to milk replacer. If this much colostrum has not been fed in the past, the person caring for the calves will notice that the stool will be looser than before. One of the purposes of colostrum is to loosen the stool and the meconium (fecal material present in the large intestine at birth) to prevent constipation. Even though the stool is looser, it is not detrimental to the calf. There will also be a larger volume of fecal material the first several days since a larger volume of colostrum was given to the calf.

It is important to know the differences between whole milk and milk replacer so one can better understand the mixing instructions and the importance of accurately measuring the amounts of milk replacer and water. Whole milk has a dry matter content of approximately 12.7% solids. On a dry matter basis it contains approximately 27% protein and 30% fat. It has been previously mentioned that most commercial milk replacers contain 20-22% protein and 10-20% fat. Therefore, a 20% protein-20% fat milk replacer contains 26% less protein and 33% less fat than whole milk.

There is a wide range of recommendations from milk replacer manufacturers when it comes to mixing and feeding instructions. The percent solids of the mixed product varies from 10 to 12.5% for a traditional milk replacer. The percent of the calf's body weight to be fed per day varies from 8 to 12%. The standard in the industry is to assume that a newborn calf averages 80 lbs, and that it should be fed 10% of its body weight per day (8 lbs of mixed milk replacer or 1 gallon per day). Most milk replacer manufacturers recommend that 1 lb of milk replacer powder be mixed with 1 gallon of water, which is supposed to yield a final concentration of 12.5% solids. However, if you consider that the actual weight of a gallon of water is 8.32 lbs and that milk replacer powder is 95% dry matter, a mixture of 1 lb of powder in 1 gallon of water

yields a final concentration of 11.4% solids. Not only does the milk replacer contain significantly less protein and fat than whole milk, it is usually mixed at a solids content lower than whole milk.

First of all, the days of the average Holstein calf weighing 80 lbs is long gone. There might be a significant percentage of heifer calves that weigh in this range, but the majority of bull calves will weigh 90 lbs and above. One of my clients recently weighed 375 bull calves and only had one that weighed 80 lbs or less. Most dairy owners have been assuming that they are feeding milk replacer at a rate of 10% of the body weight of their calves, when in reality, only a small percentage of their calves are actually receiving milk replacer at the 10% body weight rate.

If we look at both ends of the spectrum for mixing and feeding instructions, an 80 lb calf fed at 8% of its body weight and 10% solids would receive about 0.64 lbs of milk replacer powder per day. The same calf fed at 12% of its body weight and 12.5% solids would receive about 1.2 lbs of milk replacer powder per day. This is an 87.5% increase in the amount of milk replacer powder received on a daily basis! Now let's look at what a calf would normally receive if it was left on its mother. Most calves will nurse from 6 to 10 times per day and consume between 16 and 24% of its body weight per day as milk. If we assumed the calf weighed 100 lbs, it would consume 16 to 24 lbs of milk per day or approximately 1.9 to 2.8 gallons. Since whole milk is about 12.5% solids, this calf would consume between 2 and 3 pounds of dry milk solids per day. The average calf on milk replacer is lucky if it receives 1 lb of dry milk solids per day of a product that is lower in both protein and fat than whole milk. Is it any wonder that many dairy operations struggle to maintain a 5% death loss when dairy calves are limit fed to a level of 30 to 50% of what they would normally consume if left on their mothers?

Environmental temperature has a major effect on the nutritional requirements of calves. The published nutritional requirements, that are considered to be the standard for the calf, are usually calculated assuming that the calf is in a thermoneutral environment. The thermoneutral zone for the calf has been defined to be the environmental temperature range in which the amount of body heat produced is balanced with the amount of heat lost from the body through condition, convection, radiant, and evaporative heat loss. The thermoneutral range for the calf has been determined to be 50° to 68° F. Temperatures above and below this range will affect the calf's efforts to maintain a constant level of body heat.

Higher environmental temperatures result in an increased water intake and a decreased appetite. Calves have the ability to regulate their body temperature at a fairly constant level until the environmental temperature reaches 80° F. At that point the core body temperature starts to increase and more energy is required to dissipate body heat by panting. Heat loss is achieved by sweating and by evaporation of water from the lung tissue while panting. Increasing the humidity results in a decreased respiratory evaporation rate and in turn causes a more rapid rise in body core temperature. Therefore, high temperatures, especially with high humidity, will increase the required energy level but at the same time will decrease the calf's appetite. Calves may have a decreased growth rate or may even lose weight if severely stressed by high environmental temperatures. Therefore, since the calf's energy requirement may increase because of high environmental temperatures, it may be necessary to increase the amount of energy fed by increasing the solids content of the milk replacer and/or increasing the volume of milk replacer fed. All calves should have fresh, cool water free choice at all times in order to assist the calf in losing body heat through evaporation.

When temperatures drop below 50° F, more energy is required for the increased heat production necessary to maintain body temperature. Cold temperatures also decrease the calf's ability to digest dry matter. The dairy calf has a much greater surface area per pound of weight than do larger animals. This results in a rapid increase in heat production when temperatures drop and in calves being more vulnerable to the stresses of low temperatures.

Even though individual outside calf hutches usually result in less disease, these calves are exposed to much lower environmental temperatures than are calves raised indoors. Steps must be taken immediately to increase the energy level in the calf's diet in order to compensate for the increased demands of heat production to maintain body core temperature.

Increasing the energy level of the calf's diet can be accomplished in the following ways:

1. Increasing the percent solids when mixing the milk replacer, adding whole milk to the milk replacer or switching to whole milk.
2. Adding additional fat to the milk replacer or whole milk.
3. Increasing the feeding frequency from 2 to 3 times per day.

During extreme weather conditions, the solids content of milk replacer can be increased to 15 to 18%. Concentrations above 18% may tend to cause an osmotic diarrhea. I have not had any problem with increasing the solids content up to the 18% level. Several supplements are available that contain 60% fat which can be added to whole milk or milk replacer to increase its energy density. A third feeding may be necessary in order to provide the energy level required by the calf to maintain its body temperature without losing weight. Calves raised at an environmental temperature of 39° F had a 32% increase in energy requirement compared to calves raised at 50° F. When temperatures drop below 0° F it is conceivable that the energy requirement may more than double. It is especially important to warm the milk replacer or whole milk to 105° F before feeding so the calf does not have to expend extra energy to bring the milk up to body temperature after ingestion.

If the extra energy is not supplied, the calf must utilize its own fat stores for energy. Fat deposits in young calves are usually not very large and once they are used up the calf starts breaking down muscle protein for heat production and energy. Calves receiving insufficient energy in their diet start losing weight and become severely stressed. They then become more susceptible to disease and have much higher morbidity and mortality rates than do calves receiving the required energy and protein levels. If they survive, they are often stunted and require more feed and time before reaching their breeding size as replacement heifers.

When the amount of milk replacer or whole milk fed to the dairy calf is increased, a corresponding decrease may be noticed in the consumption of calf starter. However, the calf will still be much healthier and can still gain weight even in the presence of adverse weather conditions. Weaning should be based on the consumption of calf starter and not based on a specific age. A fairly common recommendation is to wean the calf after it is consuming 2 lbs of calf starter a day for three consecutive days. If the calf is not consuming much calf starter due to the increased rates of feeding milk replacer or whole milk, milk feeding can be reduced to once a day until sufficient calf starter is being consumed before weaning.

It is common to discontinue feeding free choice water to calves during winter months because of the problems caused with the water freezing in the buckets. Free choice water is still extremely important in order to maximize hydration and also consumption of calf starter. Research has shown that warming up water during cold weather may actually discourage or decrease water intake.

Milk replacer quality varies greatly depending upon the manufacturer and formula. The ingredients are listed on the tag in order of the largest amount used down to the smallest amount. If protein from a soy source is one of the first few ingredients listed, that product should probably be avoided. One must consider quality and percent of protein and fat, amount of solids in the final mixture, environmental temperature, and weight of the calf before the appropriate feeding program can be determined. One other consideration is the current price of milk. A rule of thumb often used to determine if it is economical to use a milk replacer is if 25 lbs of good quality milk replacer can be purchased and mixed for less cost than the value of 160 lbs of the whole milk it replaces.

As you can see, developing a good milk replacer feeding program requires knowledge of milk replacer ingredients, nutrition, and environmental conditions. If the time is taken to formulate a good program according to these guidelines discussed, the dairy owner will see an improvement in the overall health and growth rate of the calves along with decreased costs related to sickness, death, and costs of medicine and veterinary care. Heifers will also reach their breeding size at an earlier age resulting in decreased age at first calving.

Accelerated Growth Formulas

The recent increase in the cost of replacement heifers has renewed the interests of dairy owners and heifer raisers in accelerated heifer raising programs. Decreasing the age at first calving has a significant impact on the number of heifers required to maintain the herd size, as well as decreasing the total cost of raising replacement heifers. Until recently, the newborn calf has been somewhat ignored in accelerated heifer replacement programs. Recent research has brought to light some very important points about the growth and development of young calves and how they fit into the total equation of a good accelerated heifer growth program.

Research has shown that the ideal weight for heifers at first calving is between 1,350 lbs and 1,400 lbs with a minimum wither height of 54.9 inches for Holstein heifers. Baby calves that are fed on whole milk or traditional milk replacer (20% protein, 20% fat) at a rate of 8-10% of their body weight per day will only gain between 0.5 and 1.0 lb per day. Even if these calves had a pre-pubertal average daily gain of 1.3 lbs per day, they still would not be able to reach puberty until approximately 14 months of age and would not reach breeding size until approximately 18 months old. This would eliminate the possibility of achieving an age at first calving of 24 months. Heifers experience the most rapid growth rate from birth to 9 months of age. Anything that prevents them from maximizing their growth during this time period will have a very significant effect on their age at first calving as well as their wither height.

It was previously mentioned that if a calf is left on its mother, it will nurse between 6 and 10 times per day and consume somewhere between 16 and 24% of its body weight per day as milk. A 100 lb calf would then consume 16 to 24 lbs of whole milk per day (1.9 to 2.8 gallons). Whole milk is approximately 12.5% solids so this would translate to between 2 and 3 lbs of dry milk solids per day. Calves consuming this much dry milk solids can gain between 2 and 3 lbs per day. Most milk replacer companies recommend that 1 pound of dry powder be added to 1 gallon of water and that 1 gallon of mixed product be fed to each calf per day. This amount is only 1/3 to ½ the amount that a calf would normally consume if left on its mother. Whole milk is 26% protein and most milk replacers are 20-22% protein. Therefore, not only is the calf on a traditional milk replacer program receiving 1/3 to ½ as much dry milk solids, the dry milk solids contain much less protein than that found in the dry milk solids of whole milk. Perhaps the milk replacers labeled as “Accelerated Formulas” should be renamed “Normal Growth Formulas” since all we are trying to do is obtain the same growth rates as those calves that remain on their mothers.

Most of the accelerated formula milk replacers will contain between 26 and 30% protein and 15 to 20% fat. The protein level is very similar to that of whole milk solids, but the fat level is somewhat lower. The purpose of this protein to fat ratio is to promote lean tissue growth rates. Research at the University of Illinois showed that the ratio of lean tissue to body fat and the efficiency of gain was much greater in those calves fed the high protein milk replacer. These calves gained weight much faster but also required less dry matter per pound of weight gain. This fact needs to be considered when evaluating the economics of an accelerated calf growth program. This same study fed 3 groups of calves a 26% crude protein, 18% fat milk replacer at a rate of 10 %, 14%, or 18% of body weight per day. The corresponding growth rates were 0.79, 1.55, and 2.25 lbs per day, respectively. I would like to emphasize again that the calves with the greatest growth rates had the highest lean tissue to fat tissue ratio. The higher protein milk replacer promoted more lean tissue gain.

The feeding recommendations vary slightly according to the manufacturer. Most researchers agree that during the first week of life the calf should receive 1.5 to 2% of its body weight in dry milk replacer powder. A good example of this would be to mix 0.9 lbs (14.4 oz) of milk replacer powder in 2.5 quarts of warm water per feeding. This would give a 90 lb calf a total of 1.8 lbs of solids per day or 2% of its body weight. From week 2 to weaning the calf would receive a greater amount of solids per day. An example of this would be to mix 1.3 lbs of milk replacer powder in 3.5 quarts of warm water per feeding. This would result in 2.6 lbs of solids per day in a total volume of 7 quarts. A general recommendation would be to mix the milk replacer at a concentration of 15 to 18% solids. There are many dairies and calf ranches that currently use bottles for feeding milk and

milk replacer to their calves. Most of these bottles are two quart size. This makes it impossible to deliver the 3.5 quarts per feeding. However, if one decides to utilize an accelerated milk replacer formula at the recommended feeding rate, the bottle system can still be utilized by increasing the number of feedings per day to three. This increases the amount of labor required, but it is actually beneficial to the calf to receive its milk in three feedings instead of two. There are larger bottles now available that hold 3 quarts, and if filled up to the very top, will hold close to 3 ½ quarts. These bottles can be used successfully when feeding only two times per day.

One of the main concerns about accelerated milk replacer formulas is that they may cause a nutritional diarrhea. It should be noted that the stools of calves fed these formulas will more than likely be softer than those fed a traditional milk replacer, but nutritional diarrhea has not been observed on any of the many research trials that have been conducted. Obviously, these calves will consume less calf starter when fed larger volumes of high protein milk replacers. This tends to make the stool softer than when more calf starter is consumed. Calf starter should still be offered free choice starting at 3 to 7 days of age even though the amount consumed will be less with an accelerated growth program. Calf starter should be gradually increased as consumption increases with the leftovers being cleaned out on a daily basis.

Even though less starter is consumed, calves can still be weaned at 7 to 8 weeks of age. The recommendation is to discontinue one feeding per day when the calf reaches 6 to 7 weeks of age. The amount of calf starter consumed will rapidly increase. When the calf consumes 2 pounds of calf starter per day for 3 consecutive days, it is ready to be weaned. It is extremely important that the calf have access to free choice fresh water at all times, both while on the milk replacer and after weaning. If the calf raiser does not want to provide free choice water because of freezing problems in the winter or for any other reason, an accelerated growth program such as just described should not be undertaken.

The formulation of a calf starter to be used in an accelerated growth program is also higher in protein than traditional calf starters. Most calf starters on the market today are between 17 and 19 percent protein. It is recommended by most researchers in this area that accelerated calf starter formulas be between 22 and 26 percent protein. It only makes sense that if the calf is on a milk replacer that is 26 to 28 percent protein, the calf starter should also have a higher protein level in order to maintain the same growth rate around the time of weaning. Once weaning is accomplished, the calf should remain on this calf starter without hay for 2 to 4 more weeks. The volume of calf starter consumed can be monitored to make sure that consumption rapidly increases following weaning, to somewhere between 6 and 8 lbs per day. This insures that the calf will continue to maintain its rapid growth rate following weaning, by consuming an increased level of a calf starter with a similar protein level to that of the milk replacer. Once the calf has reached 10 to 12 weeks of age, it can then be introduced to a grower ration that contains 15 to 20 percent good quality alfalfa hay.

Calf starters should be formulated with ingredients that are easily fermented in the developing rumen and/or digested and absorbed in the intestine. Such products may include citrus pulp, beet pulp, small amounts of soyhulls, dried whey, animal protein blends (plasma), and added amino acids such as methionine, lysine, threonine, and histidine. It is extremely important that when calculating the amounts of an added medication such as Bovatec®, the nutritionist keeps in mind the fact that these calves are larger in body size than normal and will consume larger amounts of calf starter than what most nutrition programs assume. This could potentially result in the calves consuming toxic levels of specific medications. This should also be kept in mind if medications are added to the milk replacer itself.

The main advantages of an early accelerated growth program are as follows:

1. Increased growth rate from birth until weaning.
2. Increased lean tissue to fat tissue ratio.
3. Increased efficiency of gain.
4. Increased parenchymal tissue in the udder (more mammary tissue for potential future milk production).
5. Improved immune response resulting in decreased sickness and death.
6. Decreased costs due to extra labor and medicine required to treat sick calves.

7. Increased chances of heifers reaching puberty early, being bred, and calving at less than 24 months of age.
8. The program does not have to be altered because of environmental changes in order to fulfill nutritional requirements due to adverse environmental conditions.

In the herds I work with that have incorporated an early accelerated growth program for their calves, I have been impressed with the increase in growth rate and frame size of the calves. However, my biggest surprise was the astounding improvement in the overall health and vigor of the calves. Medicine costs for the treatment of sick calves have decreased by approximately 80 percent and death loss has decreased dramatically to around 1 to 2 percent. It must be emphasized that good management is just as important, if not more, when utilizing this type of program on the farm. Close attention still needs to be paid to good colostrum management and delivery, sanitation of the environment and feeding utensils, and feeding practices. The improved immune response of calves on an accelerated growth milk replacer formula will not compensate for poor management and unsanitary conditions in a calf operation.

Much of the benefit of this type of program will go unnoticed if the heifer does not continue on a well-formulated accelerated growth program as it matures. Continuing on a ration that has been formulated to maximize rumen microbial growth and providing adequate protein nutrition to maximize frame development without causing excessive fat deposition is necessary to accomplish the goal of ideal frame size at an earlier age of first calving. Approximately 63% of dairy operations in the U.S. have an average age at first calving of greater than 24 months. Research has shown that as long as the heifer reaches the desired frame size and weight at calving, there is no detriment to first lactation milk yield regardless of the age at first calving. Calving at an earlier age allows the dairy owner to maintain herd size with fewer replacements, decreases the amount of feed required before the animal enters the herd, and yields a faster return on investment.

Dr. Mike Van Amburgh of Cornell University has estimated that the traditional program of feeding a calf one pound of a standard formula milk replacer would cost approximately $67.00 per calf. The accelerated program would cost about $142.00. This would result in an increased cost of $75.00 per calf. My experience has proven that this increased cost is more than returned just in the decreased mortality rates. When considering the other advantages previously listed, this increased investment is returned several fold by the time the heifer enters the herd at first calving. I would like to reemphasize that in order to reap the maximum benefits of an accelerated calf growth program, excellent management needs to be in place. Changing to this type of program will not correct current disease problems or management deficiencies.