How to Achieve the Dairy Calf and Heifer Association's Gold Standards for Calves - Your Guide For Success

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Abstract/Summary

Lifetime performance of heifer calves is greatly influenced by proper care and colostrum feeding within the first few hours after birth and growth rate over the first 6 to 8 weeks of life. Specific written goals and mindful efforts among all stakeholders can result in systematic improvements in calf performance. The Dairy Calf and Heifer Association (**DCHA**) has developed Gold Standards which are achievable benchmarks for heifer production. Dairymen are encouraged to obtain these standards from and participate with DCHA.To maximize calf performance, feeding high quality milk replacer at a level to achieve high growth rate is essential. Protein deposition during growth requires high protein (≥28%) and medium levels of fat (10 to 15%) fed to minimize body fat deposition. Increased energy demands of cold weather should be met by feeding 1 to 2 bottles of additional milk replacer per day, depending on ambient temperature. To minimize death losses due to dehydration, a systematic effort must be made as early as possible to maintain hydration, especially in calves with scours. Fluid should be provided in levels commensurate with level of dehydration to keep calves alive.

Introduction

More than 20 years ago, Israeli researchers (Bar-Peled et al., 1997) showed that Holstein heifer calves responded to a higher plane of nutrition with more rapid growth rate in the first 42 days and subsequently had an earlier age at calving (669 vs 700 days, respectively, $P = 0.05$) and greater milk production (21,217 vs 20,218 lb, respectively, $P = 0.08$) in their first lactation (300 days) than their traditionally fed, slower-growing counterparts. This remarkable discovery has led to subsequent research which has confirmed that growth rate of heifer calves during the first 6 weeks of life has a profound influence on promoting early fertility and lifetime milk production. Further, it has been shown that the total cost of producing a heifer from birth to freshening is essentially the same for calves managed with a traditional program or with an intensified program, but the return-on-investment is higher for the intensified program due to the increased lifetime milk production (Overton et al., 2014). The past 20 years have witnessed a revolution in calf nutrition and management based on an understanding of the impact of neonatal growth on lifetime milk production.

DCHA recently revised their Gold Standards (2016) benchmarks of performance standards for dairy heifers. The new standards clearly define objectives with regards to health status, survival rate, growth rate, reproduction, and production standards. While it is not the intent of this paper to discuss the Gold Standards in detail, it is my intention to present nutritional

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needs and management practices to achieve or exceed the Gold Standards.

DCHA Gold Standards

The DCHA Gold Standards are available from its website: www.Calfandheifer.org. More than being a list of goals, the Standards are an opportunity to create open interaction with dairy farmers, calf care givers, veterinary support, milk replacer and starter feed suppliers, and other stakeholders who then set measurable, meaningful, and objective guidance for their own calf performance. This paper will focus on technical and practical guides to meet or exceed the DCHA Gold Standards with a strong recommendation to become involved with DCHA and implement the recommendations herein to improve your calf growing operation.

Define the Destination and Get Started

To paraphrase Lewis Carroll: "If you don't know where you are going, any road will take you there." The Gold Standards represent a clear destination, so it is then possible to map the best route to reach the destination. The starting point for making improvements must be an honest evaluation of the current status of the operation, defining goals for various production variables, and time frames for milestones that indicate progress. An operation with 14% death loss in calves younger than 60 days cannot realistically set a goal of <2% death loss within 4 months, but it is realistic to reduce death loss to 2% within 24 months. By reducing death loss by 1% within each 60 day period, we could reach the goal of 2% within 2 years. Having specific targets also means that changes or adjustments must be made in many different areas of the operation: dry cow management, neonatal calf management, milk replacer and starter feed formulation and management, and upgrading the scours management program.

Calf Nutrition: What the Calf Needs and How to Meet Those Needs

The Latin phrase finis origine pendet means "the end depends upon the beginning." While it usually is used in reference to having good early education as a basis for lifetime achievement, it clearly applies to heifer (and also bull) calves. Bar-Peled et al. (1997) showed that faster growth rate in heifer calves during the first six weeks of life resulted in greater milk production when those calves joined the milk string later in life. The faster-growing calves in the Bar-Peled et al. (1997) study weighed 195% of birth weight at six weeks of age compared with 162% of birth weight for the control calves fed a traditional milk replacer program. Van Amburgh et al. (2014) summarized milk production differences from 12 published studies in which calves were fed approximately 50% more nutrients prior to weaning. The increase in milk yield ranged from 0 (no difference in calf growth) to 3,092 lb per lactation, but all other values were in the range of 1000 to 2200 lb (Table 1). Drackley (2005) showed that higher milk replacer protein level (22 vs 18%) resulted in increased milk yield [26,096 vs 24,979, not significant (**NS**)] but higher starter protein level had a negative impact (22 vs 18%, 24,944 vs 26,132, NS) so decisions must be science-based.

Maintenance energy: live weight and metabolic weight

Requirements for energy and protein depend on the calf's metabolic body weight (**BW**), ambient temperature, and rate of gain. Metabolic BW is the live weight (kg) to the 0.75 power and compensates for the fact that smaller animals have a greater surface area relative to BW than larger animals. Therefore, smaller animals have greater heat loss and higher energy requirements per unit of live BW. A 60 lb calf needs 1192 kCal Metabolizable Energy

(**ME**) for maintenance which is 19.87 kCal/lb of BW, while a 90 lb calf needs 1748 kCal ME for maintenance which is 17.48 kCal ME/lb of BW. Jersey calves have a relatively higher energy need than Holstein primarily because Jersey calves weigh less, not because of some inherent metabolic differences between the 2 breeds. The maintenance energy requirement of a 75 lb calf is approximately 1400 kCal/day, regardless of whether the calf is a large Jersey or a small Holstein (Van Amburgh and Drackley, 2005).

Beyond maintenance…growth!

Additional energy can be used for growth after maintenance energy requirements have been met. For growth, the need for additional protein increases more rapidly than the need for additional energy. At maintenance, in which a calf is gaining 0 lb/day, milk replacer would only need to contain about 9.3% crude protein to meet the maintenance requirement for protein. The amount of protein required in milk replacer increases rapidly as feed intake is increased because the ME intake above maintenance enables growth. Protein requirement in milk replacer plateaus around 28%. If adequate protein is available, the calf grows muscle and bone, but if protein is inadequate, the rate of gain decreases and composition of gain is higher in fat and lower in muscle and bone (Donnelly and Hutton, 1976 ab; Bartlett et al., 2006).

Milk replacer composition and body composition

Daily intake of total calories (determined by DM intake) as well as protein and fat intakes will determine both the rate of gain and the composition of gain. Dairy farmers claim that they do not want fat heifers, but feeding a low protein (20%), high fat (20%) milk replacer, which is still a common practice throughout the United States, is a sure way to have a slow rate of gain and a high amount of fat deposited on the body of heifer calves. On a dry basis, cow's milk contains approximately 28% protein, and this is a protein level that satisfies the protein requirement for most calves within a wide range of BW and intake levels. From a philosophical standpoint, we can choose to accommodate calves with the highest nutrient requirements and "overfeed" calves with lower requirements, or we can choose to accommodate calves with the lowest nutrient requirements and "underfeed" calves with higher requirements. My personal philosophy is to meet the needs of the calves with the highest needs. Feeding milk replacer with 28% protein satisfies this condition most of the time. In special cases where calves are uniform in weight and fed a lower total daily milk replacer intake, such as a dairy beef operation, 26% protein is generally adequate. But, in a large calf ranch or any dairy operation where calves arrive weighing from 45 to 105 lb, the small calf with high intake requires higher protein to meet its needs and 28% protein is recommended.

Calves do not utilize fat very well, and as fat level of milk replacer increases, daily starter feed intake generally decreases. Digestibility of DM, organic matter, fat, nonfiber carbohydrates, and Ca and P may also be reduced. Fat is preferentially used by the body to deposit body fat, so calves are fatter when fed higher amounts of fat in milk replacer (Tikofsky et al. 2001). In most milk replacer applications, a protein:fat ratio of 2:1 is preferred, such as milk replacers with 28% protein and 14 to 15% fat. Hill et al. (2006 ab, 2009) conducted several studies examining daily feeding rates as well as protein and fat levels in milk replacers and the reader is directed to these studies for additional information.

Cold weather dramatically increases maintenance energy requirement and slows growth

In simplest terms, the potential to gain weight depends upon the amount of energy available after maintenance needs have been met. Think of it like our ability to go shopping at the end of the month depending on having money left over for shopping after paying the mortgage, utility bills and food bills (maintenance). Cold ambient temperatures increase the calf's need for energy to stay warm, so there is less energy available for growth. To maintain rate of gain, calves must consume more feed to provide more energy during cold weather.

The lower limit of the thermoneutral zone for young calves is 68^{o}F which means that young calves begin to feel cold stress on a cool night, even in the summertime. We generally do not think in terms of cold stress until winter is approaching, but maintenance energy requirement increases by approximately 50% at freezing and by 100% at 0^{o}F. Feeding an extra bottle of milk replacer per day to calves when temperatures drop to 32^{o}F and 2 extra bottles when temperatures drop to 0^{o}F will provide additional energy to keep calves gaining weight even when cold.

There is an often repeated myth that to compensate for cold weather, increase fat content in milk replacer. The fact is the only way to compensate for increased maintenance energy due to cold weather is to increase the daily amount of milk replacer ounces fed to calves. In round numbers, a medium fat milk replacer contains approximately 2000 kCal ME/lb and a 95 lb calf needs about 1700 kCal ME/day for maintenance at 68^{o}F and about 1350 kCal ME/lb gain. A calf gaining 1 lb per day needs about 1.5 lb milk replacer per day ((1700+1350)/2000=1.525 lb). When the temperature falls to 0^{o}F, maintenance energy increases by an additional 1700 kCal to a total of 2900 kCal/day. To meet additional maintenance requirements and maintain average daily gain (**ADG**), milk replacer would have to contain 70% fat if feeding rate remains at 1.5 lb/day. Obviously, nobody is neither going to feed 70% fat nor should feed that high amount of fat to a calf. Figure 1 shows the change in ME intake with increasing fat content in milk replacer at a feeding rate of 2 bottles (24 oz) per day. Additionally, it shows ME intake in calves fed 3 bottles (36 oz, 32^{o}F) and 4 bottles (48 oz, 0^{o}F). It is obvious that increasing daily intake of milk replacer is the best way to compensate for cold weather increases in maintenance requirements.

Ash content of milk replacers

Ask a dairy nutritionist what the effect would be on cows with an addition of 5% salt to the TMR and the nutritionist immediately reacts with concern about toxic salt levels. Yet, many milk replacers have extremely high levels of Na, K, and Cl due to the use of delactosed whey and/or whey permeate as milk replacer ingredients. Ash content in whey and whey protein concentrate are primarily composed of Na, K, and Cl, whereas non-fat dried milk is primarily composed of Ca and P. While veal milk replacers are normally 6.0 to 7.5% ash, poor quality herd milk replacers can have ash content ≥10% with the additional ash being Na, K, and Cl. Strayer et al. (2014) showed analysis of 2 herd milk replacers with ash contents of 11.72%. Since ash and lactose are not listed in the guaranteed analysis, the only indication of high ash content is the listing of "dried whey product" as an ingredient. Use of dried whey product replaces lactose in milk replacer with Na, K, and Cl, which lowers ME and increases risks for Na toxicity when feeding milk replacers ≥150 g/L and/or using water with high Na levels. Quality herd and veal milk replacers usually have ash contents <7.5% and do not include whey permeate or delactosed whey as ingredients, so "dried whey product" is not listed as an ingredient.

Water

Research shows that calves given free access to water consume more starter feed and gain more weight than calves without access to water (Kertz et al., 1984). My experience is that most calf water buckets have 3 to 4 inches of water remaining and if we add water, calves will drink. Calves don't like to put their head into buckets past their eyes. They don't drink water from the bottom inches of the bucket unless they are forced to drink it and reduce starter feed consumption and rate of gain without adequate water, especially in hot weather.

Calf starter feed and weaning

Heinrichs and Lesmeister (2005) have a very good review of rumen development in calves and the reader is directed to this review for more detailed information and references to appropriate literature. In brief, calves are born with a prototypic reticulo-rumen which grows rapidly due to the volatile fatty acids which result from fermentation of starch. Logically, one might believe that since calves are cattle, and cattle are ruminants, and ruminants have a bacterial population capable of digesting fiber, that feeding fiber to calves would be an appropriate practice. But, the reality is that calves are pre-ruminants and as such are incapable of digesting fiber. In fact, feeding fiber to milk-fed calves is detrimental, causing abomassal ulcers among other problems. Mattiello et al. (2002) tested different solid feeds in milk-fed veal calves and examined abomasa for ulcerative damage and concluded, "a solid feed able to satisfy calves' behavioral needs and improve digestive processes without damaging the digestive apparatus still has to be identified." Feeding roughage to older calves, post-weaning, may have some beneficial effect, depending on the buffer capacity of the starter feed and form of grain in the feed because it affects rate of fermentation, but in young milk fed calves, high levels of fermentable starch are required for the rumen to develop, but roughage should not be fed.

Does an increase in feed intake cause an increase in rumen development or does increased rumen development result in an increase in feed intake? Hodgson (1971) concluded that both conditions are true. Calves that consume more starter feed have greater rumen development due to increased fermentation of starch and calves with greater rumen development consume more starter feed as a result of greater rumen capacity. A key finding from Hodgson's research is that starter feed intake is an excellent indicator of rumen development, so weaning should be dependent on amount of daily dry starter feed intake.

Greenwood et al. (1997) compared 3 levels of feed intake as a percentage of initial BW as the initiation point for weaning and concluded that daily feed intake equal to 1.0% of initial BW is adequate to begin the weaning process. To complete the weaning process, calves should be at least 21 days old, have a daily starter intake of at least 1% of initial BW, have a cumulative total starter intake of at least 9% of calf's initial BW, and have gained at least 12% of its initial BW. This weaning strategy means that calves can be weaned earlier than most dairy farms currently wean calves, but is similar to most dairy beef operations where the objective is to minimize the cost of production from day 1 to 300 to 400 lb live weight. For heifer calves, where the objective is to maximize lifetime milk production, longer milk feeding period and higher amounts of daily milk replacer is recommended. Table 2 shows recommended milk replacer feeding schedules for bull and heifer calves to achieve their respective objectives. The schedule assumes 12 ounces of milk replacer powder (28% CP/14% fat) in 2 quart bottles. Ziegler et al. (2005) fed heifer calves 12 ounces of milk replacer (28% protein/16% fat) in either 2 quarts or 3 quarts of total solution. Even though both groups of calves were given the same amount of milk replacer per day, calves given 2 quarts weighed more on day 56 (180.09 vs 169.42 lb ($P < 0.05$), respectively), than calves given 3 quarts.

The Practical Side of Caring for Calves

The key to success with calves is doing many little things consistently well every day, with achieving your benchmarks in mind. Milk replacer should be mixed the same way, at the same temperature, for the same amount of time, the same quantity of powder, and delivered at the same time and at the same temperature every feeding and every day. I call this the “precise, boring, sameness that leads to success.”

To ensure consistency, develop written protocols for on-farm procedures and review with people caring for calves and cows. Develop a simple system to indicate status of animals that does not require looking in a book or checking a computer. Colored clothes pins, golf tees, or chalk marks on the outside of the pen, or position of pails or bottles can readily indicate calves that have been treated or need treatment that every worker can quickly and easily recognize without “checking the book.” As soon as possible might not be for 12 hours, so written procedures should be specific such as “feed colostrum within 2 hours of birth” rather than ambiguous such as “feed colostrum as soon as possible.”

Navel dipping

Infection of the navel, called “navel ill,” leads to infection of joints, called “joint ill,” and/or infection in other parts of the body and septicemia. Even in ancient times, the connection between navel infection and joint infection was recognized. Proverbs 3:8 states “it shall be health to thy navel and marrow to thy bones,” according to the King James Version Bible. Preventing navel infections and associated joint and systemic problems is perhaps the most cost-effective practice on the dairy, costing less than 40 cents per calf.

Within 30 minutes of birth, dip the navel using 7% tincture of iodine solution or another product specifically designed for dipping navels. Do not use teat dips and do not spray the navel but dip the entire navel using about 1 fluid ounce of solution per calf using a disposable paper Dixie cup and pressing the cup against the body wall to ensure complete immersion of the navel in disinfectant solution. Throw away the cup and disinfectant solution after each use and use a fresh dose of iodine for each calf. Check the navel of each calf on day 2, 4, and 6 after birth. Navel should be the size of a pencil or smaller. Mark calves with navel the size of your thumb as “suspect” and re-check the next day. If the navel is the size of a walnut or larger, treat navel using penicillin injected into navel, under veterinary supervision.

Preventing scours: Cow vaccination and colostrum

Immunity to calfhood diseases in newborn calves is obtained through feeding colostrum within hours of birth. To assure that colostrum will provide protection against *Rotavirus*, *Coronavirus*, *Clostridium perfringens* Type C, and K99 *E. coli*, cows should be vaccinated 6 to 9 weeks and given a booster 3-6 weeks before calving. Giving cows vaccinations improves the quality of colostrum, but calves need to consume colostrum to receive the benefit. In addition to colostrum, dairy farmers should consider blood-derived IgG (non-specific), colostrum-derived antibodies (*Coronavirus* and K99+ *E. coli*), and/or egg-derived antibodies (*Rotavirus*, *Coronavirus*, *E. coli*, and *Salmonella*) which can be effective in reducing morbidity and mortality.

Colostrum harvest, storage, and feeding

The importance of colostrum for calves cannot be overstated. In addition to immunoglobulins, colostrum contains many bioactive substances which are critical for optimum growth and well-being. Not every dairy can successfully collect and feed colostrum. Those dairy farms should consider feeding a high-quality dried colostrum or high quality colostrum replacer to provide calves with >150 g IgG instead of feeding poor quality colostrum to newborn calves. Sick or dead calves have a higher cost than buying high quality dried colostrum or a high quality colostrum replacer. For dairy farms feeding colostrum, investing in an improved colostrum program yields immediate rewards.

Not every cow produces colostrum that should be fed to calves. Only feed colostrum from cows that have a "negative" *Johnes* ELISA test. Cows should be healthy, free of mastitis, and should not have leaked milk, and should not have blood in milk. Cows should have been dry at least 45 days prior to calving and in the transition group for a minimum of 14 days. The right cow will have had an appropriate vaccination program based on consultation with the herd veterinarian.

Colostrum should be harvested within 2 hours of calving. Fresh cows should be milked before sick or treated cows to avoid transferring disease organisms and cow preparation should be identical to routine parlor practices, including equipment service and sanitation between cows and between milking. Save a sample of colostrum for future reference.

After testing colostrum quality with a refractometer or colostrometer, colostrum should be fed or chilled and properly stored within 30 minutes of collection. What's proper storage? Pour colostrum into milk bottles, plastic food storage bags, or other clean containers with the cow ID and date of collection clearly marked. The container should be immediately placed into ice water. Do not put hot colostrum into a refrigerator because it takes >8 hours to cool in a refrigerator. During this time, bacteria are growing rapidly in the colostrum and any vaccines or medications stored in the refrigerator are being subjected to temperatures higher than their ideal storage temperatures. Freeze plastic storage containers of water in the freezer section of the refrigerator to keep an adequate supply of ice available to rapidly chill harvested colostrum. After colostrum has been cooled in ice water, put the chilled colostrum in the refrigerator. While potassium sorbate can be added to colostrum to extend shelf-life, colostrum should be fed or frozen within 7 days or the colostrum should be discarded.

Calves should be fed colostrum equal to 10% of their BW within the first 2 hours of life and an additional 5% of BW before 12 hours of life. For a 90 lb calf, this is equal to 4 quarts within the first 2 hours of life and an additional 2 quarts within the next 10 hours. Test serum using a refractometer. Well-managed farms may have >90% of calves with serum total protein ≥5.2 g/dL. Dairy farmers should set a goal of having >80% of calves with serum total protein of ≥5.0 g/dL and 50% of calves with ≥5.5 g/dL. Serum protein values should be interpreted to evaluate the overall colostrum program and not necessarily to evaluate the colostrum status of any individual calf because dehydration can increase the serum protein value. The best use of these data is to look at serum total protein values for calves on a monthly basis and determine the percent of calves above 5.0, 5.2, and 5.5 g/dL as an indication of whether or not the colostrum collection, storage, and feeding program is working well or if it is in need of improvement.

Bull calves need colostrum, too!

Shields (1994, unpublished) showed that veal calves with adequate colostrum had 10% higher gain (349.6 vs 319.2 lb, respectively) and half as many calves treated in the first 28 days (25% vs 50%, respectively) versus calves which had not received adequate colostrum. My testing routinely shows that >70% of bull calves received in veal and dairy beef barns have not received any colostrum! Dairy farmers who would never think of withholding milk replacer routinely send bull calves to a sale barn without first giving them the superfood and immunity protection of colostrum and think nothing of it. Sending a calf to a sale barn without colostrum puts the calf at risk. Bull calves go from a sale barn to an order buyer's station and are then transported to a farm where a veal producer or dairy beef producer struggles to care for them and keep them alive. Such high numbers of calves sent to sales barns without colostrum is a shameful failure on the part of dairy farmers. Every calf, both bulls and heifers, need to be fed colostrum equal to 10% of their BW within the first 2 hours of life and an additional 5% of BW before 12 hours of life. Send your customer the best calf possible and give colostrum first!

Milk replacer mixing, temperature, and feeding

Buying a diesel pickup truck means using a different fuel than used in the gasoline pickup truck it replaced. So too, a different milk replacer might require a very different mixing procedure than the one it replaced. The method used by various milk replacer manufacturers to transform liquid fat into dry powders determines the optimum mixing temperature and conditions. So-called easy mix formulas usually have a dry fat ingredient in which the fat has been encapsulated in a protein matrix with heat. This type of fat can be mixed in water at 125 to 135° F with a wire whisk. Another process is just the opposite in which milk replacer powders are encapsulated in fat which is crystallized with extreme cold. For this type of milk replacer, water should be 155 to 165°F and mixed with a power mixer. There are other processes, but the important lesson is to always read and follow manufacturer's directions for mixing milk replacer.

A small farm mixing a small quantity of milk replacer might use a 5 gallon bucket with a wire whisk or a plastic drum and an electric drill with a mixer to make milk replacer. Large operations generally use stainless steel mixers designed to mix milk replacer. In both small and large operations, the preferred milk replacer mixing procedure is very simple and should be consistent every day. Remember "TWA" to mix correctly. TWA stands for Time, Water (temperature and quality), and Agitation. As an example, imagine that we need to mix milk replacer for 50 calves and we're feeding 12 ounces of milk replacer powder per calf in 2-quart bottles. We need (50 x 12 ounces ÷ 16 oz/lb = 37.5) lb of milk replacer powder and (50 x 2 quarts ÷ 4 qt/gallon = 25) gallons of total milk replacer solution. Step 1 is to add 50% of the total water needed into the mixer which is 12.5 gallons. The water should be at or slightly higher than the mixing temperature according to manufacturer's directions which we will assume is 135°F for our example. Next, we add all the milk replacer powder to the mixer and mix for the amount of time recommended by the manufacturer which we will assume is 3 minutes for this example. Use a thermometer to check the temperature of the mix after all the milk replacer powder is added to the mixer. Adding hot water and cold milk replacer powder to a cold mixer in January will result in colder milk replacer than the same mixer in July. Make sure that the water temperature is within the prescribed range. After mixing, add additional water to bring the volume to 25 gallons and bring the temperature down to approximately 118°F. Mix for 1 minute and then fill the bottles, put on nipples, and deliver bottles to feed the calves. Check the temperature of the milk in the last bottle fed. It should be minimum 113°F. If it is too cold, increase filling temperature for the next batch, and if it is too hot, decrease filling temperature for the next batch. Repeat this process for every feeding, every day. My recommended feeding temperature is higher than most recommendations and is based on the digestibility and melting temperatures of fats used to make milk replacers, ingredient composition of modern milk replacers, and medication cost and performance of thousands of calves. My preferred feeding temperature for milk replacer is 113°F for the last calf.

Cleanliness is next to…

The old saying is "cleanliness is next to Godliness," but in many operations, cleanliness is next to impossible! Proper cleaning of equipment used to mix, deliver, and feed milk replacer to calves has many benefits to the calf and calf producer. Reducing the risk of sickness, use of antibiotics, and risk of respiratory and digestive problems are immediate benefits from proper cleaning procedures. For best results, rinse all equipment with warm (80 to 110°F) water to remove manure, dirt, and all milk residues. Rinsing with lukewarm water allows milk residues to rinse off without becoming permanently attached. Use a thermometer to adjust rinse temperature every time you rinse. Clean using a mixture of chlorinated alkaline soap and hot water (165°F) to wash the mixing and feeding equipment. Chlorine is a powerful disinfectant and alkaline soap dissolves fat. Wear gloves and scrub all surfaces to remove protein, fat, and foreign materials that adhere to surfaces. Special brushes may be needed to clean bottle nipples, bottles, esophageal feeders, floating nipples, feed buckets, etc. Use a thermometer to adjust wash temperature to 165°F every time you wash. Chlorine solutions must be at least 150 parts per million to effectively kill bacteria. Liquid chlorine products generally have shelf-lives in the range of a few weeks, and should be purchased in small quantities frequently rather than large quantities infrequently. Suspended milk solids can re-deposit on equipment if the temperature of the wash water falls below 120°F. For this reason, the temperature of the final wash water should be above 130°F. Use a thermometer to check final temperature. Finally, rinse with an acid-sanitizing solution in warm water (70°F) per manufacturer's directions and allow to completely dry. Acid final rinses reduce surface pH to <4 for up to 12 hours which reduces bacterial growth. This cleaning ritual should be performed every time calves are fed.

Electrolytes and scours

This is a topic area in which I am very passionate, and I have developed several electrolyte products over the past 30 years. Oral rehydration solutions were developed for humans in the 1960's by Drs. Norbert Hirschorn and William Greenough, working with the World Health Organization (**WHO**). The original formula used sodium bicarbonate, dextrose, sodium chloride and potassium chloride. In the 1970's, sodium citrate replaced sodium bicarbonate to reduce reinfection because bicarbonate neutralizes stomach acid while citrate has no effect on pH of the stomach.

Acid in the stomach provides natural protection against pathogens. In the 1990's, the WHO adopted a formulation in which dextrose had also been replaced with complex carbohydrates.

Regardless of the cause of scours, calves can suffer from Dr. Drew's Four D's: **D**iarrhea leads to **D**ehydration, **D**epression (outward signs of acidosis), and **D**eath occurs when dehydration reaches 12 to 14%. We cannot usually see changes, such as sunken eyes or droopy ears, until dehydration reaches 6%, meaning that the calf is "halfway dead" when we first see signs of dehydration! Reducing death losses due to scours requires changing the old way of how we treat calves with scours to a new and different way of doing things. The simplest change is to systematically feed electrolytes to calves based on their level of dehydration. I call it the 1-2-3 plan: feed **1** bottle of electrolyte to calves with scours (1 to 5% dehydrated). Feed **2** bottles to calves with signs of dehydration (6 to 8% dehydrated). Feed **3** bottles to calves with severe dehydration (9 to 12% dehydration). If your electrolyte contains dextrose, give 2 liters of Lactated Ringer's solution (intravenous) and give oral electrolyte when calves have recovered to moderate dehydration levels. Dextrose can be deadly to calves with severe dehydration because of the negative impact of high osmotic pressure. Continue to offer milk or milk replacer to calves with scours because they still need and benefit from the energy and nutrients in milk replacer, and use products that contain sodium citrate and not sodium bicarbonate because bicarbonate interferes with milk digestion because it neutralizes pH of the abomasum. Calves that show signs of dehydration, such as sunken eyes, droopy ears, or skin tenting >1 second, require immediate attention! Keep calves hydrated and you will keep calves alive, regardless of the cause of scours.

Conclusions

Successful calf raising is doing 100 little things right every day, over and over. We no longer have to live in a world of starving calves with 8 ounces of milk replacer containing 20% protein and 20% fat. Modern heifer raising involves proper pre- and post-natal care and feeding higher (intensified) daily amounts of milk replacers containing 26 to 28% protein and lower levels of fat. Calves raised under these conditions routinely double their birth weight in 50 to 60 days and produce 1000 to 2000 lb more milk than their slower growing counterparts raised on traditional diets of yesteryear. Establishing written protocols and clear production goals can help dairy farmers become more productive, gauge their progress as they achieve each benchmark, and become more profitable.

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Table 1. Milk production differences among treatments where calves were allowed to consume approximately 50% more nutrients than the standard feeding rate prior to weaning from liquid feed.

Study	Milk yield, lb
Foldager and Krohn, 1991	3,092
Bar-Peled et al., 1997	998
Foldager et al., 1997	1,143
Ballard et al., 2005 (@200 DIM)	1,543
Shamay et al., 2005 (post-weaning protein)	2,162
Rinker et al., 2006 (projected 305 @ 150 DIM)	1,100
Drackley et al., 2007	1,841
Raith-Knight et al., 2009	1,582
Terre et al., 2009	1,375
Morrison et al., 2009 (no difference in calf growth)	0
Moallem et al., 2010	1,600
Soberon et al., 2011	1,217

Source: Reprinted from Van Amburgh et al. (2014)

Table 2. Milk replacer feeding schedules for bull and heifer calves[1].

Days	Bull Calves, Bottles/day 2x4+1 Schedule	Cumulative milk replacer fed, lb	Heifer Calves, Bottles/Day 2-3-2-1 Schedule	Cumulative milk replacer fed, lb
1-7	2	10.50	2	10.50
8-14	2	21.00	2	21.00
15-21	2	31.50	3	36.75
22-28	2	42.00	3	52.50
29-35	1	47.25	3	68.25
36-42	0		2	78.75
43-49			2	89.25
50-56			1	94.50
57+			0	

[1]Assumes 12 oz milk replacer powder per bottle. Increase 1 to 2 bottles/day based on cold weather.

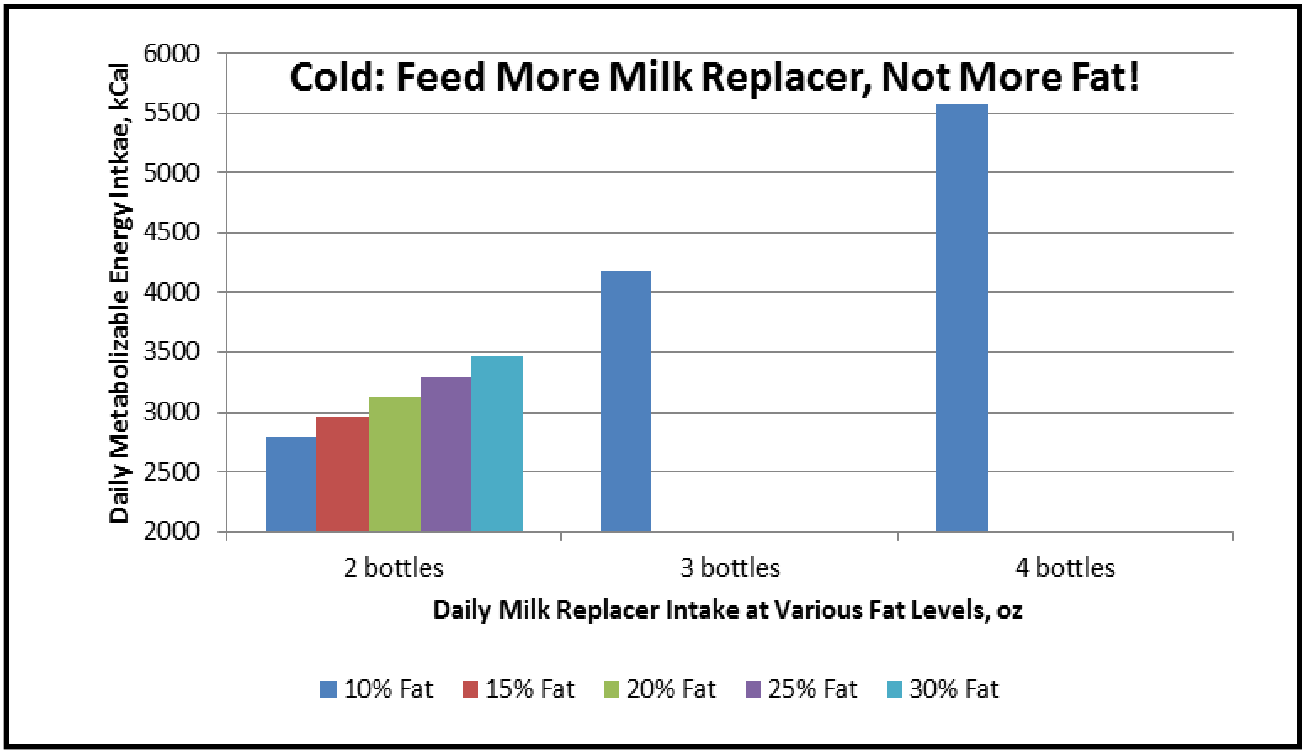

Figure 1. Daily metabolizable energy intake with increasing levels of intake versus percentage of fat.