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Milk Replacer Feeds and Feeding Systems for Sustainable Calf Rearing: A Comprehensive Review and Analysis

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Abstract

This comprehensive review examines milk replacer feed and feeding systems for sustainable calf rearing. Milk, a nutrient-rich liquid produced by female mammals, is vital for the nutrition of offspring. However, the high cost and disease risks associated with feeding whole milk to calves have led to the development of milk replacement feeds. This study emphasizes the importance of rearing practices, including weaning age, post-weaning management, and factors such as breed, starter ration, and rearing environment in influencing dairy cow performance. Milk replacers offer a cost-effective alternative, allowing farmers to sell milk at market prices, while using affordable substitutes for calf growth. This approach conserves milk for human consumption, provides high-quality proteins and energy, and evaluates milk replacement quality based on animal performance. In developing nations, the adoption of milk replacers can be facilitated by utilizing locally available ingredients to improve calf growth, while preserving milk resources. Proper nutrition in young calves is essential for their health and dairy profitability. This review highlights the risks of feeding raw milk to calves and suggests alternative options such as milk replacers, surplus colostrum, transition milk, and waste milk. This review provides a comprehensive overview of milk replacer feeds and feeding systems, emphasizing nutrition, quality evaluation, alternative approaches, and sustainable practices in calf rearing for long-term success in the dairy industry.

Keywords: milk replacer, calf rearing sustainable feeding systems, dairy cow performance

1. Introduction

Milk is a whitish liquid containing milk proteins, fats, lactose, and various vitamins and minerals, produced by the mammary glands of all adult female mammals after birth and serves as food for their young. Labor for care and individual feeding of calves before weaning is the major cost of calf production, but nutritional inputs are also more costly during this period. Therefore, nutrition of young calves remains of paramount importance for calf health and profitability of dairy operations. The milk produced by the glands is contained in the udder. Milk secreted in the first days after parturition is called colostrum. The quality of milk is paramount; therefore, it must be properly stored and transported in optimal conditions. Milk contains several groups of nutrients. Organic substances are present in about equal quantity and are divided into elements builders, proteins, and energy components, carbohydrates and lipids. It also comprises functional elements, such as traces of vitamins, enzymes and dissolved gases, and contains dissolved salts, especially in the form of phosphates, nitrates and chlorides of calcium, magnesium, potassium and sodium. It also contains dissolved gases (5% by volume), mainly carbon dioxide (CO_2), nitrogen (N) and oxygen (O_2) (Jasper & Weary, 2002).

Whole milk was the primary liquid feed for calves before the mid-1950s and still is fed on about one-third of U.S. dairy operations. While milk obviously is a high-quality feed on which calves grow well, its primary disadvantage is that it is the most expensive liquid feed. For maximum profit, producers should use lower-cost options to feed calves, such as milk replacer, surplus colostrum, transition milk, and waste milk. Furthermore, milk has been implicated in transfer of diseases such as Johne's (paratuberculosis), bovine viral diarrhea (BVD), and enzootic bovine leukosis. Producers with eradication or prevention programs in place for those diseases should consider milk replacer as an alternative (Otterby & Linn, 1981).

Common liquid feeding programs include, milk replacer, saleable whole milk and non-saleable (waste) milk. Non-saleable milk typically includes transition milk from the first six milking, abnormal milk and milk from treated cows. Factors to consider when selecting a liquid feeding program include: targets for nutrient intake in relation to goals, ease of managing the program, economics and potential disease risks. An important risk associated with feeding raw milk is the potential exposure to pathogenic bacteria such as *M par tuberculosis*, *Salmonella* spp., *Mycoplasma* spp and *Escherichia coli*. Some pathogens may be introduced directly from an infected udder, while others are introduced through manure contamination or bacterial growth in milk improperly collected, stored or handled. Because of these concerns, it is often recommended that producers avoid feeding raw (saleable or non-saleable) milk to calves (Stabel, 2001).

The various management approaches involve differences to best manage and deliver nutrition and nutrient intake for the pre-weaned calf within the specific farm management capability. There are teleological arguments for providing a greater supply of nutrients from milk or milk replacer. Calf rearing is important for cattle breeding and production and sustainability of any cattle enterprise depends upon the successful raising of calves for replacement stock. Several studies indicated that milk replacer had several benefits to the calf raiser and dairy producer, including consistency of product from day to day, ease and flexibility of storage, disease control, good calf performance and economics (Paula *et al*., 2008).

After milking the calf is allowed to suckle the dam for a limited period. Restricted suckling has been regarded as labour intensive and has subsequently been replaced by artificial rearing, especially where milk is an expensive part of the diet and cheap substitutes are available (Galina *et al*., 2001). On the other hand, it has been found that the additional time needed to milk with the calf next to the dam was similar to the time spent on feeding calves (Junqueira *et al*., 2005).

There are several beneficial effects if restricted suckling is applied instead of artificial non-suckling systems (Mejia *et al*., 1998).

The health and metabolic status of the dam, along with the composition of colostrum, play a vital role in determining the growth and lifelong productivity of newborn calves. Maximizing the growth of young dairy calves is crucial for the profitability of dairy operations. However, when increasing the intake of liquid milk or milk replacer, it is important to consider the potential impact on starter feed and forage consumption (Brown, 2005; Jasper, 2002).

Therefore, the objectives of this seminar paper is: To review milk replacers with whole milk for calf growth and performance and assess the economic and sustainable aspects of milk replacer feeding systems in dairy operations.

2. General Overview on Milk and Its Components

Milk contains many biologically active substances, with protein and fat fractions being the richest sources. The content of total protein in milk equals on average 32%, including about 20% of whey proteins. Mainly of these are albumins (about 75%), *i.e.*, β-lacto globulin (β-LG), α-lactalbumin (α-LA), and bovine serum albumin (BSA) and bacteriostatic substances, i.e., immunoglobulin, lactoferrin, lactoperoxidase, and lysozyme. These substances affect the digestive, immune, circulatory, and nervous systems and reduce the risk of many human diseases (Chatterton, 2006).

In beef production systems, the survival and development of calves are determining factors for productivity that greatly depend on maternal ability and the genetic potential of the animal. Milk is the primary food consumed by calves from birth to weaning. Therefore, milk production is considered a key component of maternal ability. In beef cattle; milk production is a main factor influencing pre-weaning growth (Meyer *et al.*, 1994). Consequently, the contents of milk components and their variations have been proposed as significant factors influencing the development of calves during the pre-weaning period (Brown & Lalman, 2010; Martínez *et al.*, 2010).

During the last several decade several scientist studied the common practice of providing limited amount of milk to get better performance of calves (Godden *et al.*, 2005; Khan *et al.*, 2007). Study showed that restricted milk decreased the weight gain, increased the risk of disease and abnormal behavior in calves. Greater quantity of milk improves growth rate, feed efficiency and enhanced nutrition of calves (Drackley, 2008). Poor growth was due to insufficient supply of nutrients from milk and sudden change can cause scour and reduces the growth rate and ultimately increased the weaning time (Davis & Drackley, 1998).

2.1 Importance of Colostrums for Calf Rearing

Colostrum is a mixture of lacteal secretions and constituents of blood serum, such as immunoglobulin's (Ig) and other serum proteins that accumulate in the mammary gland during the pre-partum dry period and are collected via milking at parturition. Newborn calves must adapt to a new environment that include nutrition, and on top of that enter the world without disease resistance. Calves don’t receive placental transfer of immunoglobulin’s from the dam. The calf is totally dependent on the Ig in maternal colostrum for disease protection (Merrick, 2004).

The new born calf’s intestines are highly efficient at absorbing Ig. Immunoglobulins are divided into five classes namely IgG, IgM, IgA, IgD and IgE, where IgG, IgM and IgA are the three main classes. Calves start producing their own Ig at approximately10 days of age and reach normal levels by 8 weeks of age. During this time, the calf’s essential dependence on maternal colostrums reinforces the need for the calf to consume colostrums as soon as possible after birth (Corbett, 1991). Colostrums fed early postnatal affects the metabolic profile, endocrine status and intestinal absorptive capacity of calves and these effects, compared with those of milk replacer, are associated with better growth performance immediately after birth. Thus, colostrums are essential for sufficient passive immunity and for enhancing developmental changes and improving postnatal metabolism in calves (Kuhne *et al.,* 2000).

It is generally considered that the newborn calf should receive 4 L of colostrums in the first 12h, although up to 6 L is often recommended for the first day. Requirements will depend on the quality of colostrum usually determined by assessing its density associated with immunoglobulin (Ig) content and the presence of enzymes to form curd in the abomasums is also a rate limiting factor for Ig absorption (Mastelloni *et al.,* 2005). Adequate colostrum intake is the most important management factor affecting morbidity and mortality in pre weaned calves. Absorption of intact immunoglobulin begins and after birth and ends completely by about 24h. Inadequate absorption of colostral immunoglobulins, or failure of passive transfer (FPT), is common and increases morbidity and mortality risk. Many diseases, including Johne’s, can be passed to calves via maternal colostrums (MC) and producers are advised to discard or pasteurize MC from infected cows. This practice can reduce the supply of available MC and may force producers to use colostrums containing less IgG (Wells *et al*., 1996).

2.1.1 Nutrient Role of Colostrums

To maximize calf survival and growth, plasma immunoglobulin (Ig) status and the colostrums management is the most important. The primary reason colostrums has been of interest in neonatal ruminants is due to the importance of supplying Ig’s to calves born without any and lacking a mature immune system. Thus, without sufficient levels of Ig’s, morbidity and mortality rates are increased. While Ig’s are important, colostrums provides the newborn calf with much more than Ig’s (Weaver *et al*., 2000). The calves over time can produce their own Ig’s through exposure to bacteria and viruses, maternal antibodies from colostrums are transient and an argument could be made that they are not absolutely necessary. Data demonstrate that the presence of bacteria in the gut prior to colostrums ingestion or in the colostrums reduces the uptake of Ig, thus increasing the incidence of failure of passive transfer. Thus, excellent udder health and proper post-harvest colostrums handling is as important, or even more important than vaccination programs to minimize neonatal and post weaned calf diseases and death loss (Godden, 2008).

2.1.2 Lactocrine Role of Colostrums

Colostrums, in comparison with milk, is known to be rich in Ig, as well as hormones and growth factors such as, prolactin, insulin and leptin. For a long period of time, colostrums has been known to have a major effect on the development of the gastrointestinal tract, but the exact mechanisms are still not well understood (Bartol *et al*., 2008). During the first few days of life in neonatal a notable increase in the length, mass, DNA content, and enzymatic activities of certain enzymes (lactase) occurs in the small intestine for neonates fed colostrums. This was originally thought to be mediated by differences in nutrient intake between milk and water. However, other studies have demonstrated differences between animals fed colostrums that are rich in growth factors, versus milk with comparable energy values (Burrin *et al*., 1995).

2.2 Waste Milk

Waste milk is the milk that obtains from cow after treatment for mastitis or other bacterial disease. Milk from cows after antibiotic treatment for mastitis or other bacterial diseases cannot be sold and must be discarded. Waste milk represents an enormous economic loss to dairy producers, and its disposal also poses environmental problems. Such milk often is fed to dairy calves as a method to capture some economic value from an otherwise wasted resource and to more effectively recycle nutrients (Quigley, 1998).

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. 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. Fortunately, commercial pasteurizers have been developed which are well suited to on-farm use to render this milk “safe” for calf feeding programs. As with all equipment used on the farm, proper installation and maintenance of pasteurizers is imperative (James & Scott, 2007).

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. Measure standard plate counts on pre- and post-pasteurized milk samples to determine if milk handling before and after pasteurization is appropriate. In herds with excellent mastitis control and herd health programs, waste milk may be adequate for less than 50% of daily calf feeding needs (Burlington *et al*., 2006).

3. Calf Feeding Habits in Ethiopia

Information on calf rearing practices is limited in Ethiopia. Dairy cows are influenced by the rearing practices at their calf hood age at which they are weaned, post-weaning management practices, breed, and starter ration and rearing environments. Basically, two types of calf rearing practices are commonly known by a dairy farmer: partial suckling and artificial rearing systems. Partial suckling system is a practice in which calves are allowed to suckle their dams before and after milking while artificial rearing system is a practice in which calves are separated from their dam immediately after birth and bucket fed predetermined amount of milk until weaning. However, the choices of alternative rearing practices are determined by scale of the farm, rearing objectives (beef/dairy) and biological and economic considerations (Little *et al*., 1991).

Consequently, partial suckling is well known and has been a long-standing tradition under smallholder systems in Ethiopia. Therefore, it is not practically feasible and economically sound to recommend artificial calf rearing practices. In Ethiopia, dairy production is dominated by smallholder farm system. On the other hand, artificial calf rearing practice is the rule of thumb, and calf rearing practices are commonly known by a dairy farmer alternative option widely used in large-scale dairy farms. Both suckled and bucket fed calves were weaned at 94 days of age. But they didn’t attempt to reduce weaning age below 94 days (Azage *et al.*, 1994).

Nowadays, interplays of many factors are contributing towards the establishment of large-scale dairy farms in Ethiopia. Favorable economic policy reforms directed towards a liberalized and market-oriented economic system and drivers of change such as rapidly growing urbanization, high population growth rate, changing consumer taste preferences towards safe and quality products are attracting investors into dairy business. Due to their scale of production, commercial dairy producers are likely to practice artificial calf rearing systems. Therefore, improved and economically as well as biologically efficient calf rearing practices are needed (Azage *et al*., 1990).

4. Milk Replacer Feeds

Milk replacer feeds are feeds which substitute the milk that provide a convenient way to feed pre-ruminant stock. Milk replacers, which were less expensive than whole milk, allowed dairy farmers to sell whole milk that would otherwise have been fed to calves (Davis & Drackley, 1998). It was formulated in the 1950’s. The first MR was gruels that led to poor calf performance unless supplemented with milk. Milk replacer was fed on approximately 70% of U.S. dairy farms. There are many high quality milk replacers available in developed country dairy producers today. Newer technologies, using high quality proteins, provide a highly digestible source of protein and energy at a reasonable price. Determining milk replacer quality is best determined by animal performance. Also, the quality and price of milk replacer programs can vary significantly due to factors such as ingredient quality, manufacturing techniques and nutritional composition. Some factors that are related to milk replacer quality and calf performance include: a reputable manufacturer analysis of replacer, ingredients used, level of medication, mix ability, absence of off-colored materials and its ability to stay in solution (Quigley, 1998).

Milk replacers are usually made up of ingredients such as skim milk powder (60–75 percent), vegetable or animal fat (15–25 percent), butter milk powder, whey protein (5–10 percent), soy lecithin (1–2 percent) and vitamin-mineral premix. A small proportion of other ingredients like glucose, non-milk protein and cereal flour can also be used. They can be stored long term as powder and mixed with water just prior to feeding. Calves can then be milk reared anywhere and at any time without having to source liquid whole milk. Taking into consideration the basic composition of milk and its physical form, milk replacers should contain such ingredients to provide protein, fat, lactose, minerals and vitamins and dissolve readily in water to facilitate feeding in a physical form similar to milk. The chemical composition of ingredients most commonly used in milk replacer diets (Hill *et al.*, 2008).

Provided the calf milk replacer (CMR) is formulated correctly from good-quality ingredients and fed according to the instructions, which are usually on the CMR bag, calves can grow equally well when reared on Calf milk Replacer (CMR) and their rumens can develop just as well as they would on a diet of whole milk. Because manufacturing CMR directly from whole milk is an expensive process and because whole milk has a high market value, the bulk of the ingredients for commercial CMR are either by-products of dairy processing or non-dairy products (Moran, 2011). A milk replacer is a designed to substitute natural cow's milk by supplying the nutritional needs of the calf during the critical, early nursing stage of its life, typically 8 to 10% of body weight to encourage early intake of starter. Surplus colostrums and transition milk as well as waste or discard milk are also used sometimes to rear calves (Drackley, 2004).

Milk replacer can support equivalent or greater calf performance if milk replacer is supplemented with amino acid and fatty acid. Increased rate of milk replacer feeding to increase the rate of gain and conventional milk replacer contain 20-22% CP. Feeding too much milk replacer will result in post weaning reduction in growth that might be due to less intake of nutrient and delayed rumen development. Dairy calves have been fed milk replacer 10% of body weight of calves, the level allows only for maintenance requirement and minimal weight gain under thermo neutral condition. Accelerated growth programs have become a popular topic. These programs can include milk replacers with high protein content ranging from 26-28 percent or milk replacers fed at a larger amount than conventional calf programs (Morabito, 2013).

Soy milk is being used as a milk replacer in calf raising facilities. The primary objective was to determine the effects of partial replacement of whole milk with soymilk on pre weaning calf performance and weaning costs (Ghorbani *et al*., 2007). Feeding soymilk at up to 50% of the milk diet maintained health during the first 2 to 4wk of age when the neonate calf is highly sensitive to non milk proteins and plant anti nutrients. Results introduce soymilk as an economic partial substitute for whole milk in calf-raising facilities. Any strategy that can stimulate early starter intake in dairy facilities without compromising calf health will reduce weaning age and costs. Neonate calves possess little activity of starch and non-starch carbohydrates and proteinases. An adequate and early supply of moderately fermentable dry feed is necessary for the timely establishment of amylolytic, fibrolytic and proteolytic capacities in the reticulorumen (Maiga *et al.,* 1994).

Early reticulorumen development will subsequently lower weaning age, save milk, and reduce feed and labor costs. Soy protein sources such as soy protein concentrate and soy protein isolate have partly been used in milk replacers (Drackley *et al*., 2006). Soy protein preparations, however, contain antigenic and phenolic compounds which adversely affect intestinal integrity and calf growth during the first 2 to 4wk of life (Gardner *et al*., 1990).

The dairy industry, particularly in regions where weaning occurs late, is in much need of economical milk replacers that can maintain normal calf health during the first 2 to 4 wk of age and make calf raising more profitable. Soymilk is cheaper and contains less protein and fat compared with milk. Due to the lower nutrient content of soy-milk than whole milk, its partial substitution for whole milk will drive calf appetite toward dry starter, will stimulate butyrate and propionate production (Baldwin *et al.*, 2004).

4.1 Milk versus Milk Replacer

On a dry matter basis, whole milk has higher concentrations of protein and fat (25.4 and 30.8%, respectively) compared to milk replacers in which protein concentrations range from 18 to 20% and fat concentrations range from 15 to 20%. The impact on calf growth of this nutrient intake difference was demonstrated in a dairy calves in which calves were fed on an equal volume milk-protein based milk replacer (Godden *et al.,* 2005).

Milk replacers containing higher levels of nutrients more similar to milk have become available. Improved health in milk- fed calves was primarily attributed to higher levels of nutrient intake. Additionally, immunoglobulins and non-specific immune factors found in milk (e.g., interferon's, cytokines, growth factors, hormones, lactoferrin and lysozyme) also promote calf health (Scott *et al*., 2006). When properly mixed, handled and delivered, milk replacers provide several benefits including consistency of product, ease and flexibility of storage and management, infectious disease control and good calf performance. However, milk replacers are not sterile and can become contaminated and support bacterial growth. Calf milk replacer is delivered as milk powder and therefore the storage time can last up to six months. There is no real reason to store fresh milk because it is produced at least twice a day. Besides that, it takes a lot of cooling capacity to keep the milk fresh and it is more expensive to first cool it and later heat it up again (Nonnecke *et al*., 2003).

4.2 Development of Milk Replacer Feeds and Its Ingredient

The preparation and use of milk replacer feeds are generally accepted practices in developed countries but not in many of the developing countries. Therefore, promoting preparation and feeding of milk replacers using locally available ingredients can be useful in improving the survivability and growth of young ones while diverting milk for human consumption. Conventional MR feeding programs limit-feed calves at 8-10% birth body weight (BW). Conventional MR typically contains 20 to 22% CP and 20% fat to maximize lean tissue growth at that in take (Bartlett *et al*., 2006).

When milk by-products are available, it may be economical to prepare milk replacers for calves. Add dried skim milk to the mixer followed by addition of dried whey; Mix thoroughly for 10 minutes (Mix 1), Mix soy protein concentrate, fish protein concentrate, starch, dicalcium phosphate and Min-vit (Mix 2); Add Mix-2 to Mix 1 and continue to mix for 10 minutes (Mix 3); Mix dried fat with lecithin (Mix 4); Add Mix 4 to Mix 3 and mix for another 10 minutes; and Keep the mixture in an air tight container for one week. If fat is not in a dried powder form: Heat the fat in a pot just enough to melt. Add soy lecithin and mix well (Mix 1); Make a mixture of dry ingredients separately (Mix 2); and Add Mix 1 to Mix 2 and mix thoroughly. Mixers of different capacity can be used depending on the quantity to be mixed. One or two kg of milk replacers can be prepared using domestic food mixers (Gillespie, 2002).

Traditionally MR have been formulated using milk protein sources (now principally whey proteins) because of their high digestibility, desirable amino acid profile, and lack of anti-nutritional factors for pre weaned calves (Davis & Drackley, 1998). It is well-known that calf performance prior to weaning will be influenced greatly by the composition of milk replacers. The important factors that must be taken into account include source and amount of protein and energy, vitamin and mineral supplementation, and inclusion of critical nutritional additives such as emulsifiers. Unfortunately, methods traditionally used to determine milk replacer quality may not be useful with modern replacers used by calf raisers today (Quigley, 1998). The digestive enzymes in the pre ruminant are designed to digest milk based proteins in the first few weeks of life and their capability to digest more complex non-milk proteins and carbohydrates increases in the first month of life (Tanan, 2005).

In formulation of MR, protein ingredients are a major portion of the cost and with increasing demand from the human market, milk derived proteins have become more expensive to include in MR formulations. (Guilloteau *et a*l., 1992) With the increased milk protein ingredient cost, milk replacers frequently include alternative protein sources in formulations. Protein sources milk by-products originating from milk processing industries, and protein sources other than milk by-products are used in milk replacers. Based on the protein source used in formulations, milk replacers are generally classified as ‘all-milk protein milk replacers’ or ‘alternative-protein milk replacers’. All-milk protein milk replacers contain skim milk, whey protein concentrate, dried whey, and delactosed whey as protein sources. Alternative-protein formulations are those in which portions of milk proteins (typically 50 percent) are replaced with low cost ingredients such as fish protein concentrates, soy protein concentrate, soy protein isolates, and modified wheat gluten. Most MR formulations with alternative protein sources do not replace all of the milk proteins. Instead, they typically replace less than 50% of the milk proteins, although as much as 60 to 70% has been replaced (Tomkins & Jaster, 1991).

Non-milk proteins generally have lower digestibility than the typical milk-based proteins included in MR with inclusion of alternative protein sources there are several different alternative protein sources that have been researched including wheat, soy, egg, hydrolyzed red blood cells, and spray dried plasma protein. Wheat proteins have been fed in several forms. Wheat gluten was shown to have a lower protein solubility and digestibility and has antigenic effects that skim milk does not (Branco *et al*., 1995).

Wheat proteins become more soluble when treated with acid to hydrolyze the proteins. This also results in improved digestibility and decreased antigenicity, making hydrolyzed wheat protein more favorable to include in MR because of the improved physical properties, including solubility (Laporte & Demeersman, 1991). Soy proteins have also been incorporated in MR and are very popular as an alternative protein; however, there are still some limitations to their use (Drackley, 2008).

Soy proteins are less digestible than milk proteins, especially in the first three weeks of life because of the immature digestive tract. Additionally, due to the anti-nutritional factors, including trypsin inhibitor, present in soybeans, if not processed, soy proteins result in inferior calf performance. Soy products include soy flour, soy protein concentrates, and soy protein isolates. Steam-heating raw soybeans results in soybean meal and soybean flour, which do not contain less of the anti-nutritional factors compared with unprocessed soy products. However, when soybean flour is fed to pre ruminants there are often poorer growth results and digestive disruptions because of sensitivity of young calves to protein quality. Further processing of soy with a solvent extraction results in soy protein concentrate and soy protein isolate. These products are more refined and improve performance slightly over soybean meal products; however, with more extensive processing the antigenic properties can be reduced but at a greater cost (Lallès, 2000).

Feeding programs have been developed that are intermediate in nature to accelerated and conventional programs. These moderately aggressive programs call for liquid intakes between those in conventional and accelerated programs. These programs are reported to result in less slump in growth around weaning and fewer digestive upsets in calves than more aggressive liquid feeding programs, milk replacers designed for use in intermediate programs usually contain 24 to 26 % CP and are fed at 1.5 to 1.75 % of BW. While easier to implement, they do not fully capitalize on the early growth potential. These programs may be more easily implemented with transported or colostrum-deprived calves than are more aggressive accelerated programs (Hill *et al.*, 2006).

4.3 Feeding System of Milk and Milk Replacer for Calf

Conventional calf-rearing systems historically have restricted the amount of milk or milk replacer fed during the first few weeks of life in an effort to encourage solid feed intake and allow early weaning (Flower & Weary, 2001). Calf feeding helps to establish the potential advantages and limitations of group housing systems. It has become more popular to feed calves increased levels of liquid diets. When the basic principles of ration balancing are applied to dairy calf nutrition it is evident that feeding calves limited amounts of milk solids is barely sufficient to meet maintenance requirements with little remaining to support calf growth. Calf must consume 1.2gallons of whole milk to solely maintain body weight (Kmicikewycz *et al*., 2011). Low intake of milk or milk replacer solids is especially a problem for calves during the first 3 weeks of life when starter intake is limited. Higher feeding rates of milk or milk replacer solids results in higher daily feed costs but improved feed efficiency of body weight gain and lower cost per unit of weight gain. Additionally, higher intake of solids in the liquid diet by dairy calves is associated with significant reductions in morbidity and mortality (Van den *et al*., 2006).

More frequent feeding may be critically important in situations when milk solids are fed at rates less than 1.5 lb. / day. Under these conditions of limited intake and with long intervals between the evening and morning feeding, calves may be mobilizing body fat stores to maintain body temperature. If body fat is limited as occurs in limit-fed calves, it's not uncommon for body fat to drop to 2% of body composition in calves less than 2 weeks of age. Unfortunately, most individual housing calf management systems are not well suited to more frequent feeding of calves. Surveys of dairy farms and calf growers reveal that only 8 – 14% of farms fed calves three times daily. Group housing of calves has not been widely adopted on U.S. dairies (Sockett *et al.,* 2011).

There are several ways to deliver liquid diet to group housed calves. Mob feeding, milk replacer and Computer controlled automatic feeders. Mob feeding of calves is a common practice in grazing dairies practicing seasonal calving. This practice involves placing larger containers with multiple nipples in the calf pen until all the liquid is consumed liquid feeding systems. Computer controlled automatic calf feeding systems are gaining rapidly in popularity as a means of accurately delivering the liquid diet while controlling meal size and frequency. More sophisticated systems provide valuable management information to enable the calf manager to monitor diet consumption by individual calves and make timely intervention for calves becoming ill which is generally less than 30 minutes. Sufficient liquid is added to provide the average calf with the desired amount of liquid. Although, it encourages labor efficiency, there are some challenges with this system. The most common problem is cross sucking which is a greater problem if the feeder is removed from the pen shortly after calves have finished eating. More elaborate systems using milk replacer to preserve and limit liquid intake are gaining popularity on some dairies in more northern climates. These systems are very labor efficient but there is a lack of control of intake by individual calves and minimal sanitation of nipples and feeding equipment (Anderson, 2008).

In recent years, automatic calf feeding (ACF) machines have become popular on many large-scale calf-rearing operations. Calves can enter and leave the milk or concentrate feeding station at will, but their feeding regime is controlled by computer technology. They are promoted as labour-saving devices that can provide for a more carefully controlled milk feeding program. Each calf is individually identified to allow its milk feeding regime to be controlled by predetermined programs of daily milk allocations. Some Machines also allow for controlled concentrate feeding (Moran, 2006).

4.4 Significance of Milk Replacer

Calf milk replacers have two major goals: to reduce the cost of feeding calves and to find ingredients that contains available, digestible protein. Usage of milk replacer for feeding young dairy calves saving more milk for human consumption and sell to secure economic considerations. Because of high price of milk, calf rearing on whole milk is very costly; therefore, usually dairy farmers prefer to sell milk instead of feeding to the calves. Majority of male calves are slaughtered when these are 5-15 days old (Khan *et al*., 2002). Small number of calves is raised to 60-80 kg on extremely poor and unbalanced diets. If these calves are raised on balanced diet, they could double the quality beef production in the country. Dairy male calves are generally unwanted by dairy industry that can be used as alternative source for veal and beef production (Albright, 1983).

Calves rearing on whole milk or MR alone are uneconomical because this system has narrow margin of profit. Therefore, it is the need to explore the optimum growth of calves consumed EWD or their combination with MR in early age. Calves can efficiently utilize processed grain in complete diet and the performance was comparable to that obtained from calves fed whole milk. It is necessary to determine cost effective feeding system that will ensure the profit margin of the farming community. Better weight gain and feed efficiency was observed in cow calves (Pommier *et al.,* 1995).

Benefits of improved nutritional status in the first 2-3 wk may include reaching breeding age (and thus calving age) sooner, an improved ability to withstand infectious challenges and increased subsequent milk production (Drackley, 2005). The increased early growth of heifers easily translates into 2 wk earlier calving age provided typical BW or height differences at weaning are maintained. If heifers continue to grow more rapidly the advantage may increased. Of course, to realize this decrease in calving age, heifers must be bred according to body size rather than age. It is important to note that calves must have adequate early colostrum intake to be able to efficiently utilize additional nutrients from milk intake. In addition, calves undergoing adaptation to stressors, such as transport, also may be less able to utilize high amounts of milk solids intake in early life (Quigley *et al*., 2006).

To get healthier calves, some additives are used by different manufacturers such as organic acids to lower the pH level. This is because healthy bacteria perform better at lower pH and harmful bacteria are suppressed in an acidic environment. Vitamins and minerals in the right proportions are also added to provide the calf with the building blocks to grow into a healthy calf. Some other ingredients, like Lecithin are added for better dissolving of the milk powder and soothing the intestine wall. This will help prevent calves getting diseases like scours. Considerable evidence points to inadequate nutrition during early life as a major factor in decreased resistance to disease and compromised health and wellbeing. Calves fed the higher amount of milk replacer with ad libitum access to starter had the greatest average daily gain (ADG) and least mortality (Khan *et al*., 2007). The available evidence suggests that improvements in health seen with calves fed greater amounts of milk replacer likely are due to improved overall nutritional status rather than to any specific alterations n immune system characteristics or function. Studies that have examined functional aspects of components of the immune system generally have found small differences between calves fed conventionally or on accelerated programs (Foote *et al*., 2007).

When feeding calves fresh milk, the fat and protein levels can vary. It just depends on from which cows they receive milk. Not to mention the quality of the milk, especially if you want to feed waste milk that contains antibiotics or has a high cell count. Calf milk replacer on the other hand is always constant in fat and protein levels. If prepared the right way (with the right temperature and mixing time), the quality is always the same. And if one thing is important for a young calf, it is constant quality (Pollard *et al*., 2003).

5. Conclusion and Recommendations

Milk replacer feeds are feeds which substitutes the milk that provide a convenient way to feed pre-ruminant stock. Milk replacers are usually made up of ingredients such as skim milk powder vegetable or animal fat, butter milk powder, whey protein, soy lecithin and vitamin-mineral premix. A small proportion of other ingredients like glucose, non-milk protein and cereal flour can also be used. When properly mixed, handled and delivered, high quality milk replacers provide several benefits including consistency of product, ease and flexibility of storage and management, infectious disease control and good calf performance. It is well-known that calf performance prior to weaning will be influenced greatly by the composition of milk replacers. Manufacturing CMR directly from whole milk is an expensive process because whole milk has a. high market value, the bulk of the ingredients for commercial CMR are either by-products of dairy processing or non-dairy products. Milk replacer can support equivalent or greater calf performance if milk replacer is supplemented with amino acid and fatty acid. The preparation and use of milk replacers feeds are generally accepted practices in developed countries but not in many of the developing countries. Therefore, promoting preparation and feeding of milk replacers using locally available ingredients can be useful in improving the survivability and growth of young ones while diverting milk for human consumption.

Based on above conclusion, the following points are recommended:

- ❖ Basic milk replacer ingredients and its preparation for sustainable calf rearing should be documented.
- ❖ Milk replacer feeds should be practiced in developing country to increase economy of countries.

Government should extend extension to society about milk replacer and its significance.

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