

## Current Issues with Feeding Preweaned Heifers

**Robert E. James<sup>1</sup>**

*Department of Dairy Science*

*Virginia Tech*

### Summary

Sometimes it seems as if we lose sight of the forest for the trees. We slip into habits or traditions with little consideration to what our original goals were for the subject at hand. It's important to remember some facts about the neonatal calf. This is a newborn animal that is immunoincompetent and dependent upon timely absorption of colostrum. It requires a nutrient dense diet and is highly susceptible to heat loss from cold environments. This animal requires highly digestible nutrients that are frequently expensive. Consequences of mismanagement include diarrhea, respiratory disease, and death. Less research is available to suggest the impact of poor nutrition and management during the preweaning period on later productivity and longevity.

The accepted paradigm for preweaned calf management during the previous 30 years has centered on limit feeding milk or milk replacer to encourage early weaning, accelerated rumen development, and consumption of less expensive dry feeds. Programs which reduced feed costs and encouraged labor efficiency were encouraged. These management strategies encouraged limited gains during the first month of life.

More recently academics and industry workers have questioned this strategy, especially when one considers that no other species limit feeds their newborns to encourage early weaning. Rather

a new paradigm is being suggested which recognizes that this is a newborn calf with nutrient requirements for growth that are not satisfied by limit feeding programs. Logic argues that some deposition of fat may be desirable in the neonate as body reserves for suboptimal environmental temperatures or as energy stores when intake is depressed and energy requirements increase during illness. New goals for growth are suggested which encourage the doubling of a calf's birth weight by 56 days. Calf management practices should be adopted which first address the biological needs of the calf and then seek to achieve reasonable feed cost and labor efficiency.

This presentation will highlight current issues associated with feeding preweaned heifers that are receiving noteworthy attention from both academia and industry.

### **Pasteurizing Colostrum to Improve Biosecurity and Reduce Early Microbial Loads on the Gut of the Calf**

Consumption of adequate quantities of colostrum immunoglobins (**Ig**) early in life is imperative to acquisition of immunity by the dairy calf. However, failure of passive transfer annually continues to be a problem with nearly 30% of the dairy calves in the U.S. Research in the late 70's demonstrated that early microbial contamination of the intestine could impair absorption of colostrum antibodies. James et al. (1981) found that intestinal

---

<sup>1</sup>Contract at: 2420 Litton-Reaves Hall, Blacksburg, VA 24061-0315, (540) 231-4770, FAX: (540) 231-5014, Email: jamesre@vt.edu

uptake of gamma globulin by the neonatal calf was inversely related to the number of bacteria present in the lumen. Corley et al. (1977) observed that the intestinal epithelial cell of the neonatal calf was capable of internalizing bacteria. It is logical to assume that the ability of intestinal epithelial cells to internalize the macromolecules of colostrum Ig might be impaired by excessive numbers of bacteria which would be introduced by feeding colostrum with heavy microbial contamination or by calving in an unsanitary environment. It also questions the practice of administering “probiotics” to calves during the first 12 hours of life when the intestine is most capable of macromolecular absorption. These observations stress the importance of handling colostrum in such a manner that microbial growth is minimized by immediate feeding of fresh colostrum or rapid cooling it to less than 40°F and freezing it if not fed within 24 hours.

Another potential concern with colostrum management is that it also represents the earliest potential exposure to infectious bacteria, such as *Mycoplasma*, *Mycobacterium*, *Salmonella*, and coliforms. Early research using pasteurizers yielded disappointing results as Ig concentration was reduced, or it caused an unacceptable thickening of the colostrum. Johnson et al. (2007) found that heat treating colostrum for 60 minutes at 140°F in a commercial batch pasteurizer resulted in destruction of known pathogens while minimizing destruction of colostrum Ig. A field study showed that calves fed colostrum treated using these protocols resulted in improved efficiency of colostrum Ig absorption and higher levels of serum Ig at 24 hours of age as compared to calves fed untreated colostrum (Godden, 2005).

The following protocols are recommended to assure success in pasteurizing colostrum.

- Routinely monitor times and temperature of heat treatment of colostrum to assure that temperature does not exceed 141°F for 60 minutes,

- Culture colostrum to assure that post pasteurized standard plate counts (SPC) are less than 20,000 cfu/ml,
- Develop cleaning and sanitizing protocols for collection of colostrum, pasteurization equipment, storage vessels, and feeding utensils, and
- Routinely monitor health records and passive transfer rates in calves. Use of a refractometer is advised to monitor serum proteins in calves from 24 hours to 7 days of age. The goal should be to have 90% of calves with a serum protein value of > 5.0 g/dL.

### Nutrient Requirements for Smaller Calves

A common misconception that we have had about feeding calves is that we must guard against overfeeding calves, lest they succumb to diarrhea. This has especially been true when one considers Jersey calves. Recently published research conducted at Virginia Tech by Bascom et al. (2007) compared growth and body composition of Jersey bull calves fed either a 20% protein:20% fat milk replacer 29% protein:16% fat milk replacer, 27% protein:33% fat milk replacer, or whole milk. The whole milk and higher protein milk replacer diets were fed to provide sufficient protein (180 g) for 650 g (1.43 lb) of average daily gain. At the end of 5 weeks, body composition of calves was measured. Growth, feed efficiency, and body composition are shown in Table 1. Calves did not differ in average weekly scour score or medication days. Feed efficiency and average daily gain was highest for calves fed whole milk and lowest for calves limit fed the 20:20 milk replacer diet. Calves fed the whole milk or 27:33 milk replacer diets had the highest body fat content and gained more grams of fat than calves fed the other diets. Calves fed the 29:16 and 20:20 milk replacer diets had similar body fat composition. It's interesting that although diets

were formulated for an average daily gain of 650 g, all calves gained less than predicted by the NRC (2001), in spite of the study being conducted during relatively thermoneutral environmental conditions. This study demonstrated that the practice of feeding limited quantities of a 20:20 milk replacer diet provides sufficient nutrients for very limited body weight gains. Nutrient requirements for maintenance are probably higher than originally proposed by the NRC (2001). Based upon estimated efficiencies of nutrient utilization for gain, Bascom (2002) proposed that nutrient requirements for maintenance are 21 to 39% higher than estimated by NRC (2001). This is logical when one considers that smaller animals possess more surface area relative to their body size and therefore would likely lose body heat more readily than larger calves. By extrapolation from these data, a milk replacer containing 28% protein and 25% fat has been developed for use in feeding Jersey calves, which would provide sufficient energy to account for increased needs due to disease and other environmental stresses.

### **Alternative Proteins in Milk Replacer Diets**

During the past year, ingredient costs for milk replacers have fluctuated widely. Increased use of whey proteins for human consumption in a variety of health foods resulted in rapid increases in whey protein concentrate prices to a high of \$1.65/lb in July of 2007. Similarly, dried whey prices increased to a high of \$0.725/lb. Although prices have moderated to \$1.22/lb for whey protein concentrate and \$0.245/lb for dried whey, calf feeders have sought more cost effective milk replacer formulations. This has been an active field of research by all the major milk replacer manufacturers. At the present time, soy, wheat, and egg proteins have been evaluated as possible substitutes for a portion of the milk protein. Currently, the most popular substitutes for milk proteins are those manufactured utilizing soy-based proteins.

In a study involving 120 bull calves, Terui et al. (1996) studied the replacement of up to 50% of milk proteins with wheat gluten in replacers containing either 18 or 20% CP. Feeding rate was 1.19 lb of replacer powder reconstituted with warm water to 12% DM. A commercial calf starter containing 16% CP was also provided. Within a given protein percentage, body weight gains were not affected by protein composition. It should be noted that these calves were limit fed. Results would likely be different at higher feeding rates.

The use of egg as a substitute for milk proteins shows less promise, in spite of the long held belief that a raw egg was the best thing for a sick calf. Quigley (2002) fed 120 bull calves diets in which spray-dried whole egg comprised 0, 10, or 20% of the milk replacer formulation. Calves were fed the diets for 42 days. Increasing spray-dried whole egg resulted in linear reductions in body weight gain at 28 and 56 days, calf starter intake, and feed efficiency. Touchette et al. (2003) found no difference in calf performance when liquid egg was limited to 10% of the diet as a substitute for milk protein.

Results of calf performance utilizing alternative proteins are summarized in Figure 1 (data provided by T. J. Earleywine, Land O'Lakes Animal Milk, Shoreview, MN) Glymaxene represents a treated soy flour product that has been proven as an acceptable partial substitute for whey proteins in replacers fed for more limited gains. Note the reduced rate of daily gain in all cases where vegetable or egg proteins substituted for milk proteins. The data for relative producer price must be considered in light of current market prices for soy, wheat, egg, and whey proteins as they do not always move in synchrony.

The prices of milk replacer ingredients are very dynamic and must be considered in relation to milk price. During the latter half of 2007, when milk replacer prices surged, so did the price of whole

milk. More recently, the increased value of soybeans and wheat has likely altered the relative producer price of milk replacers containing alternative proteins.

### **Practical Considerations for Use of Pasteurized Waste Milk**

As the price of milk replacer ingredients increased, calf growers have looked towards utilization of unsalable milk from fresh cows and those treated with antibiotics as sources of economical nutrients. However, the practice of feeding raw milk to calves is not recommended due to the potential for disease transmission (Jalaluddin et al., 1996). Fortunately, pasteurizers have become commercially available that are well suited to treating waste milk and rendering it safe to use in preweaned calf diets. When installed, operated, and maintained as recommended, they are highly successful in reducing risks associated with disease transmission. Field studies in Wisconsin (Jorgensen et al., 2006), and North Carolina and California (Scott, 2006), revealed critical control points in successful management of systems using pasteurized waste milk as the source of nutrients for calf feeding programs:

- Quality of incoming raw milk,
- Rapid cooling of incoming raw waste milk and sanitation of receiving vessels,
- Proper operation and sanitation of the pasteurizer, and
- Nutrient content and variability of the supply of waste milk.

Table 2 represents the aerobic plate count of raw waste milk from several studies. Note the wide variation in microbial numbers in milk prior to pasteurization. When effectively operated and maintained, pasteurizers will effectively destroy 98 to 99% of the microorganisms present. They do

not sterilize the milk! Therefore to achieve a goal of less than 20,000 cfu/ml, raw waste milk should contain less than 2,000,000 organisms/ml. Successful reduction in prepasteurization counts is achieved by a high degree of sanitation of the receiving vessel and rapid cooling.

Table 2 also shows extensive variation in nutrient content of waste milk. Reductions in nutrient content appear to result from addition of excessive water when milk lines are flushed after milking the hospital pen. Proportion of fresh cow milk also appears to increase solids content. High nutrient levels may occur when the milk is poorly agitated prior to pasteurization. The studies by Jorgensen et al. (2006) revealed that pasteurizers were unsuccessful in achieving pasteurization goals of 20,000 cfu/ml in 10% of the 32 samples obtained from dairy farms and calf ranches in Wisconsin. Scott (2006) found varying degrees of success on North Carolina dairy farms, ranging from 100% to less than 50% achievement of post pasteurization goals. In California, only one of 9 dairy farms experienced pasteurization failure due to improper installation of equipment.

#### *Waste milk supply*

Many descriptions of waste milk feeding programs make the assumption that adequate supplies for waste milk are consistently available. Abundant supplies of waste milk could be indicative of a failure in mastitis and herd health control programs which allow such abundant supplies of treated milk. Blosser (1979) noted that the average herd produced between 48 and 136 lb/cow/year of waste milk. Scott (2006) found that between 5 and 22 lb/calf/day of non-saleable milk was produced on 3 North Carolina and 9 California dairy herds. Waste milk needs are dependent on calf feeding strategies of the farm, which include weaning age and feeding rate. These relationships are shown in Table 3.

Table 4 demonstrates how many cows with discard milk at 2 different levels of average production would be required to meet the waste milk needs for different numbers of calves.

An additional challenge in utilizing waste milk feeding programs concerns the stability of the daily supply of waste milk. Unfortunately, “averages” can be deceiving. It’s not uncommon to see large fluctuations in the quantity of waste milk available from day to day. This is best illustrated in Figure 2, which represents the recorded daily waste milk volume on one 1200 cow Holstein dairy farm in the eastern U.S. If the daily required volume of milk was 700 lb/day, there would be frequent, significant shortfalls of supply.

Several alternatives exist to accommodate these shortfalls in supply:

- Use additional saleable milk from the bulk tank. This is commonly used when deficiencies in waste milk supply are small. It can be an expensive option when quantities required are large.
- Supplement waste milk by adding additional solids from milk replacer, whey proteins, and/or fat supplements. In some cases, additional water is required as well. This option can be complicated as it requires knowledge of waste milk solids on a daily basis. Total solids can be estimated using digital refractometers which can provide the basis of recommendations of additional water and milk solids.
- If pasteurizer management is excellent, waste milk is fed to young calves, with older calves receiving milk replacer.
- If pasteurizer management is less than desired, milk replacer is fed to the youngest calves with sensitive digestive systems, and older calves are fed waste milk.

### *Successful management of waste milk feeding systems*

On farm pasteurizers can be a valuable tool for management of the feeding program. However, significant risks are taken if managers do not address critical control points involved.

1. Treat waste milk with as much care as is given to marketable milk.
  - a. Guard against addition of too much water when flushing lines at the end of each milking.
  - b. Refrigerate waste milk immediately or pasteurize milk within 2 hours of the end of each milking.
  - c. Clean tanks used for storage or transfer with the same procedures as used for herd milk.
2. Follow manufacturer’s recommendations for operation and cleaning of pasteurizing equipment.
  - a. Assure that there is an adequate source of hot water for operation of the pasteurizer and immediate cleaning when pasteurization is completed.
  - b. Flush equipment with clean water immediately after pasteurization, followed by a caustic detergent and sanitizer. Avoid excessive use of chlorinated sanitizers as they are detrimental to the life of gaskets.
  - c. Cleaning temperature should be 10°F hotter than pasteurization temperature.
3. Monitor operation of the pasteurizer at least monthly, and preferably weekly, by measuring standard plate counts and/or alkaline phosphatase activity. Alkaline phosphatase is an enzyme normally present in milk which is destroyed when the proper temperature and time relationships associated with successful pasteurization are achieved. Assure that all temperature gauges are accurate by checking



temperature of the milk with an accurate hand held thermometer.

4. Develop a strategy to use when the supply of waste milk is inadequate. If additional powder and water are added, provide clear mixing instructions to enable feeders to achieve desired levels of protein, fat, and total solids. Consider using pasteurized waste milk for one group of calves and feeding others milk replacer in accordance with mixing instructions provided by the replacer manufacturer.

### Robotic Calf Feeding Systems

Although automated calf feeding systems have been in existence for over 30 years, advances in computer hardware and software have made these systems more appealing to dairy managers. The main objective of such systems is to save labor and avoid digestive upsets by providing more frequent meals throughout the day. Quigley and Bearden (1996) assigned 40 calves at birth to either a computer feeder or bottle feeding system. Calves were placed in group pens at 7 days of age for a 52 day trial. Calves were fed 460 g (1.01 lb) of milk replacer in 4 L (1.05 gal) of water divided into 2 equal feedings per day. The system allowed one meal of 500 ml (0.13 gal) containing 57.5 g (0.13 lb) of milk replacer powder per feeding every 3 hours. Bottle fed calves received 2 liter (0.53 gal)/feeding twice daily. A commercial calf starter grain was offered separately for ad libitum consumption. Calves were also observed for cross nursing. Intake of milk replacer was slightly lower for computer fed calves. However, body weight gain at the end of the study was slightly higher for computer fed calves. Although it was not possible to analyze starter intake, average intakes were 2.35 and 2.26 lb/day for calves on the computer and bottle feeding regimes, respectively. Observation of calves by video camera found that interanimal contacts were much higher for group-housed bottle-fed calves within the first hour after feeding.

In another experiment, Kung et al. (1997) found no differences in average daily gains and final body weight at weaning between bottle-fed calves housed in hutches and group-housed calves fed both milk replacer and calf starter by computer. Calf starter intake did not differ. Calves managed in the group pens had fewer days of medication than those in hutches. Time needed to manage calves was 10 minutes/day versus < 1 minute/day for group-fed calves. Most recommendations for use of robotic feeding systems include individual housing and feeding of calves for the first 4 days of life. Calves appear to adapt to the computer feeding station quite readily at this age. Concerns about excessive sucking appear to be unfounded, as more frequent meals appear to satisfy the need to suck. Most systems will accommodate from 15 to 30 calves per nipple feeding station, with computers equipped to handle multiple nipples. Stocking rate depends upon amount of liquid feed allocated per calf per day. Most research conducted has involved limit feeding milk or milk replacer solids to 1 lb/calf/day.

Manufacturers have incorporated many very desirable features into new computer feeding systems (Siepelt et al., 2003), including:

- Provision for gradual increases in milk or milk replacer feeding, followed by a decrease in solids fed to encourage weaning.
- Use of a closing device which prevents other calves from disturbing the one at the feeder. However, it's been the author's experience that some animals can learn that they are "safe" in such stalls and are reluctant to leave.
- Provision for computerized feeding of calf starter grains. Calf starter grains are best incorporated at more than 3 weeks of age, as calves may balk at the slower response of delivery of calf starter grain feeding. In addition, molasses content of calf starter

grains should be limited (~2%) so that it flows more freely through the delivery system.

- Systems for disinfection of nipples between calves and sanitization of mixing and storage vessels.
- Use of either pasteurized milk or milk replacers.
- Addition of medication on an individually prescribed basis.

## Conclusions

Research by academia and industry will continually yield new methods of rearing dairy calves. The “acid test” in evaluating new technologies or practices for possible use must be linked to reducing risk of disease, enabling animals to reach their genetic potential, and cost effectiveness. Calves have long been viewed as a “cost center”, when in fact, they represent an investment in the future. Cost control has been one of the primary factors determining calf rearing practices. However, as values of calves have increased considerably over the past 5 years, the consideration needs to shift towards practices which reduce the risk of calf mortality and morbidity. More intensive management of colostrum harvest and feeding has been shown to improve passive immunity transfer and calf health. Feeding calves to enable them to achieve their growth potential and deposit moderate amounts of body fat may provide energy reserves for the calf to draw upon during illness or environmental stress. Similarly, improved neonatal nutrition may foster improved mammary development. Although the search will continue for more economical nutrient sources, the final evaluation must be based upon the ability of these alternative protein and energy sources to foster reasonable gains in lean tissue and provide for sound animal health. Finally, it’s obvious that robotic calf feeders will find usefulness in dairy operations where

management is more computer and technologically inclined and where labor is either too expensive or not of the caliber necessary to manage the enterprise. However, other calf rearing entities have developed rearing systems which are simpler and more economical given their resource availability.

## References

- Bascom, S.A. 2002. Jersey calf management, mortality, and body composition. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg.
- Bascom, S.A., R.E. James, M.L. McGilliard, and M. Van Amburgh. 2007. Influence of dietary fat and protein on body composition of Jersey bull calves. *J. Dairy Sci.* 90:5600-5609.
- Blosser, T.H. 1979. Economic losses from the national research program on mastitis in the United States. *J. Dairy Sci.* 62:119-127.
- Corley, L.D., T.E. Staley, L.J. Bush, and E.W. Jones. 1977. Influence of colostrum on transepithelial movement of *Escherichia coli* O55. *J. Dairy Sci.* 60:1416-1421.
- Godden, S. 2005. A review of issues surrounding the feeding of waste milk and pasteurization of waste milk and colostrum. In Proc. Seminar 10 B: The replacement heifer from birth to calving. Part 2. 38<sup>th</sup> Ann. Conf. Amer. Assoc. Bovine Pract. Salt Lake City, Utah.
- Jamaluddin, A.A., T.E. Carpenter, D.W. Hird, and M.C. Thurmond. 1996. Economics of feeding pasteurized colostrum and pasteurized waste milk to dairy calves. *J. Am. Vet. Med. Assoc.* 209(4):751-756.

- James, R.E., C.E. Polan, and K.A. Cummins. 1981. Influence of administered indigenous microorganisms on uptake of [Iodine -125] ( -globulin in vivo by intestinal segments of neonatal calves. *J. Dairy Sci.* 64:52-61.
- Johnson, J.L., S.M. Godden, T. Molitor, T. Ames, and D. Hagman. 2007. Effects of feeding heat-treated colostrum on passive transfer of immune and nutritional parameters in neonatal dairy calves. *J. Dairy Sci.* 90:5189-5198.
- Jorgensen, M., P.C. Hoffman, and A. Nytes. 2006. Case study: A field survey of on-farm milk pasteurization efficacy. *Prof. Anim. Scientist* 6:472-476.
- Kung, L., S. Demarco, L.N. Siebenson, E. Joyner, G.F. W. Haenlein, and R.M. Morris. 1997. An evaluation of two management systems for rearing calves fed milk replacer. *J. Dairy Sci.* 80:2529-2533.
- NRC. 2001. Nutrient requirements of dairy cattle. 7th rev. ed. Washington, DC.
- Quigley, J.D., III. 2002. Effects of spray-dried whole egg and biotin in calf milk replacer. *J. Dairy Sci.* 85:198-203.
- Quigley, J.D., III., and B.J. Bearden. 1996. Growth and intake of calves fed milk replacer by nipple bottle or computer feeding system. *Prof. Anim. Scientist* 12:187-191.
- Scott, M.C. 2006. Viability of waste milk pasteurization systems for calf feeding systems. M. S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg.
- Siepelt, F., A. Bunger, R. Heeren, K. Kahler, M. Lullmann, and G. Pohl. 2003. Computer controlled calf rearing. Fifth Int. Dairy Housing Conference Proc. Amer. Soc. Agri. and Biol. Eng. Pgs. 356-360.
- Terui, H., J.L. Morrill, and J.J. Higgins. 1996. Evaluation of wheat gluten in milk replacers and calf starters. *J. Dairy Sci.* 79:1261-1266.
- Touchette, K.J., M.L. O'Brien, and J.A. Coalson. 2003. Liquid egg as an alternative protein source in calf-milk replacers. *J. Dairy Sci.* 86:2622-2628.



**Table 1.** Growth, feed efficiency, and body composition of Jersey bull calves fed different milk replacers or whole milk until 5 weeks of age (Bascom et al., 2007).<sup>1</sup>

Item	20/20	27/33	29/16	Whole Milk
Average daily gain (lb)	0.24 <sup>a</sup>	0.78 <sup>b</sup>	0.81 <sup>b</sup>	1.09 <sup>c</sup>
Weight gain (lb)	6.8 <sup>a</sup>	22 <sup>b</sup>	22.7 <sup>b</sup>	30.6 <sup>c</sup>
Fat gain (lb)	0.35 <sup>a</sup>	3.7 <sup>b</sup>	1.8 <sup>a</sup>	6.2 <sup>b</sup>
Body fat (%)	3.8	7.0	4.8	8.2
Efficiency (lb gain/lb DMI)	0.28 <sup>a</sup>	0.55 <sup>b</sup>	0.57 <sup>b</sup>	0.72 <sup>c</sup>
Apparent partial efficiency – Fat (%)	10.8 <sup>a</sup>	27.1 <sup>b</sup>	30.3 <sup>b</sup>	37.1 <sup>b</sup>

<sup>1</sup>20/20 – 20% protein: 20% fat milk replacer fed to provide 0.198 lb/day of CP; 27/33 – 27% protein: 33% fat milk replacer, formulated to mimic whole Jersey milk; 29/16 – 29% protein: 16% fat milk replacer; and whole milk – blended raw milk. Diets other than 20:20 were formulated to provide sufficient protein (0.396 lb) for 1.43 lb of average daily gain.

<sup>abc</sup>Values in a row with similar superscripts do not differ ( $P < 0.05$ ).

**Table 2.** Quality of raw milk on farms in North Carolina, California, and Wisconsin.<sup>1</sup>

Location	Standard Plate Count (cfu/ml)		Fat (%)		Protein (%)	
	Low	High	Low	High	Low	High
NC	300,000	1x10 <sup>8</sup>	1.5	4.5	2.7	3.8
CA	26,000	5.9x10 <sup>6</sup>	1.2	12.1	2.7	4.7
WI	6,000	7.2X10 <sup>7</sup>	2.8	4.7	2.9	5.1

<sup>1</sup>NC = survey of 3 dairy farms over a 7 month period (Scott, 2006), CA = survey of 9 dairy farms and one calf ranch (Scott, 2006), and WI = samples from 32 dairy farms and calf ranches (Jorgensen et al., 2006).

**Table 3.** Amount of milk required per calf as influenced by feeding rate and age at weaning.

Feeding Rate		Age at Weaning (weeks)			
Amount (quarts)	Amount (lb)	6	8	10	12
		Total milk required (lb)			
4	8.6	361	482	602	722
6	13	546	728	910	1092

**Table 4.** Number of cows with discard milk at 2 different levels of milk yield needed to meet the waste milk needs for different numbers of calves.

Feeding rate (quarts)	Waste milk (lb/cow/day)	Number of calves fed/day			
		25	50	75	100
4	40	6	11	16	22
4	60	4	7	11	14
6	40	8	16	24	32
6	60	6	11	16	22

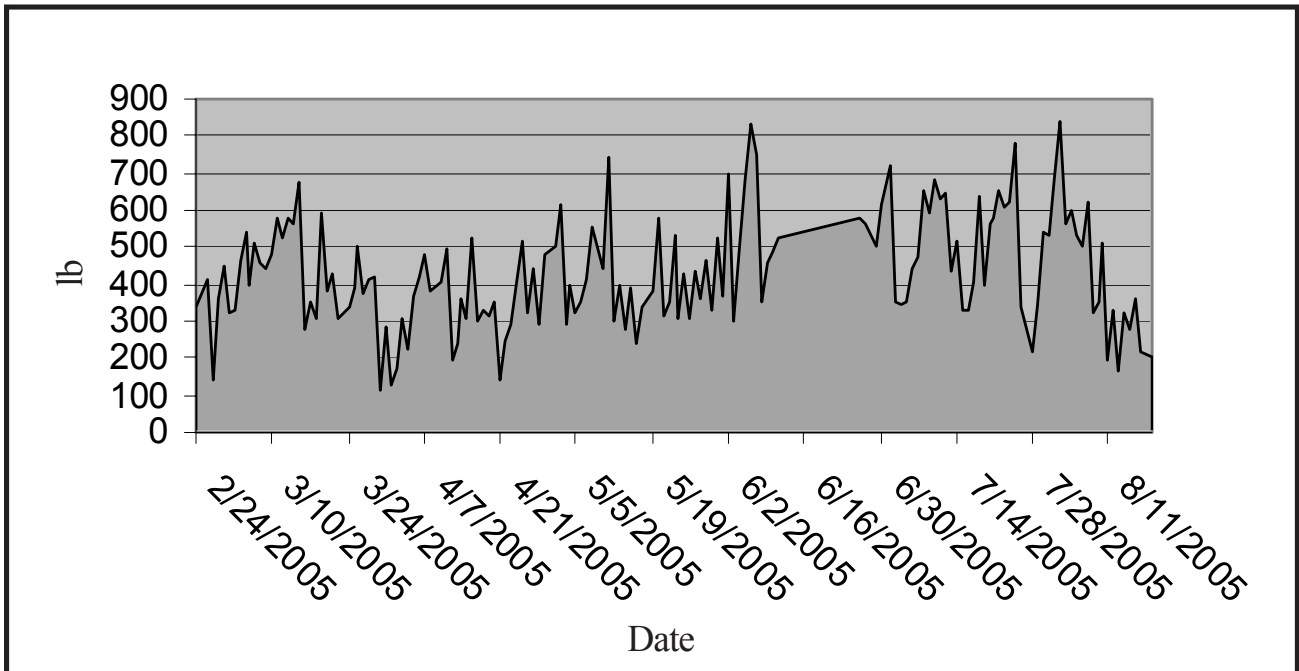
### Alternative Protein Options

Percent of Crude Protein -Expressed as percentage of All Milk

<i>Product (% of protein source)</i>	<i>Average Daily Gain</i>	<i>Scour Score</i>	<i>Relative Producer Price</i>
<b>All Milk (100%)</b>	<b>100%</b>	<b>100%</b>	<b>100%</b>
<b>Glymaxene (50%)</b>	<b>88%</b>	<b>85%</b>	<b>80%</b>
<b>Soy Protein Concentrate (50%)</b>	<b>87%</b>	<b>89%</b>	<b>83%</b>
<b>Soy Isolate (50%)</b>	<b>89%</b>	<b>91%</b>	<b>85%</b>
<b>Egg Albumin (25%)</b>	<b>67%</b>	<b>102%</b>	<b>85%</b>
<b>Wheat Gluten (25%)</b>	<b>87%</b>	<b>108%</b>	<b>91%</b>
<b>2% protein substitution with lysine</b>	<b>93%</b>	<b>100%</b>	<b>97%</b>

Data provided by LOL Lower Scour Score is desirable

**Figure 1.** Alternative protein options (percent of crude protein is expressed as percent of all milk; data provided by T.J. Earleywine, Land O'Lakes Animal Health, Shoreview, MN).



**Figure 2.** Daily variation in waste milk supply on a 1200 cow dairy farm in the eastern U.S.