PENNSTATE

College of Agricultural Sciences • Cooperative Extension

Using the Calf Milk Pasteurization Evaluator Spreadsheet and Considerations for Using a Pasteurizer

Coleen Jones and Jud Heinrichs, Penn State
Bob James and Chase Scott, Virginia Tech

Development of this spreadsheet was a collaboration of
Penn State and Virginia Tech extension educators.

Department of Dairy and Animal Science
The Pennsylvania State University
324 Henning Building
University Park, PA 16802
(814) 865-5491 FAX (814) 865-7442
www.das.psu.edu/dairy/

Department of Dairy Science
Virginia Tech
2440 Litton Reaves Hall
Blacksburg, VA 24061
(540) 231-4770 FAX (540) 231-5014
http://www.vtdairy.dasc.vt.edu/

Topics include:

Instructions for using the spreadsheet
Interpreting the spreadsheet output
Estimating waste milk supply and demand
Considerations of waste milk supply

Reviewed By: Hugh Chester Jones, University of Minnesota;
Rob Costello, Merrick's; Mark Hill, Akey; Dave Kuehnel, Milk Products

INTRODUCTION

Commercial systems for pasteurizing milk fed to calves have become available in recent years. Prior to the introduction of such systems, feeding waste milk was considered risky, primarily due to the potential for spreading disease. While it is now possible to recover the feed value of waste milk with much lower disease risk, it is important to carefully evaluate your situation before the decision to install a pasteurizer is made. Some potential considerations are an economic analysis, estimation of daily waste milk supply, and provision for feeding calves when the waste milk supply is not adequate. In addition, pasteurization does not reduce the amount of antibiotic residues or bacterial toxins that may be present in waste milk.

This spreadsheet calculates the cost of owning and operating a calf milk pasteurizer as well as costs to feed milk replacer or whole, saleable milk. The spreadsheet also provides a comparison of the nutrients provided by milk replacer, waste milk, and whole milk. All nutrient values can be edited to compare a variety of feeding programs. The spreadsheet calculates costs and nutrients fed, but does not evaluate calf health or growth for each option. We chose not to do this because many variables other than nutrient intake affect the actual growth and health performance of calves. Of course, adequate nutrient intake is very important, and the amount of fat and protein provided to calves is presented for each feed option for this reason. Additionally, the cost of each feed is expressed on a crude protein basis for comparison of cost-to-value. Additionally, the spreadsheet offers tables that compare the costs of alternatives to feeding pasteurized milk when the supply of waste milk is not adequate to feed all calves.

The final components of the spreadsheet are two simple calculators that estimate the supply of and demand for waste milk and calculate the amount of powder to add to waste milk to increase solids or volume.

INSTRUCTIONS FOR INPUT

All information to drive the economic calculations of the spreadsheet is entered on the “Input” worksheet. In the first section, capital investment, the purchase price and years of life for each component of the pasteurizer system are entered. If any of the components is not needed for your installation, enter a zero for the purchase price and leave the years of life blank. The interest rate is entered as a whole number.

The next section requires information about the operation of the pasteurizer. The first part of this section applies to both batch and continuous flow high-temperature, short-time (HTST) equipment. For the additional labor line, be sure to include only the *extra* time needed to operate the pasteurizer compared to feeding milk replacer, not the entire time required to feed. In addition to this first section, be sure to enter information under the appropriate heading for the pasteurizer you want to evaluate. It is not necessary to delete the information under the other type of pasteurizer. If you are evaluating a batch pasteurizer, the time required to process a batch should include the process from start to finish, both heating milk and cooling to feeding temperature.

Section three collects information about milk replacer mixing. This spreadsheet accounts for the costs of heating hot water (in an electric water heater), electricity used in running a mixer, and soap used to clean the mixer. Hot water used in cleaning the mixer is not counted. The annual cost of the mixer is not included because the purchase price is typically a minimal expense. If you do not use a mixer for milk replacer, leave these items blank or enter zeroes.

In the fourth section, enter your costs for various types of energy and for labor. Labor costs may include an adjustment for benefits in addition to wages.

The next section of input gathers nutrient and cost information about the feeds you offer to calves. Milk replacer nutrient information can be found on the tag. Dry matter content will likely not be listed, but it typically ranges from 96 to 98%. Be sure to enter the amount of powder fed to each calf each day and the amount of water mixed with that powder. The amount of water is needed to calculate the cost of hot water used in mixing milk replacer. The cost and nutrient value of whole milk can be taken from your milk check. Protein values reported on milk checks reflect true protein, not crude protein. Enter the true protein value; the spreadsheet will adjust it to crude protein by adding 0.19. The cost and nutrient value of waste milk may be more difficult to estimate. Research shows that the composition of this milk can vary tremendously. If milk composition is analyzed, use those values. If milk composition is not analyzed, consider the source of milk when estimating nutrient content. If the milk is primarily from treated cows, then composition is likely to be similar to marketable whole milk. If a majority of the milk is transition milk (that is, milk collected in the first 2 to 3 days after calving), then the nutrient content will likely be greater than whole milk.

The final pieces of information needed are the number of calves fed each day and the number of calves fed pasteurized milk each day. The spreadsheet uses the number of calves fed pasteurized milk to calculate all costs for pasteurized milk. The total number of calves is used in various calculations to account for the remaining calves that must be fed another feed source.

INTERPRETING THE SPREADSHEET OUTPUT

This spreadsheet has two main types of output. The first is found on the “Output” worksheet, and the second appears on the “Compare to MR” and “Compare to Whole Milk” sheets.

Output Worksheet

At the top of the output worksheet, the three *feed options* are compared. The spreadsheet determines the protein and fat composition of each feed on a dry matter basis and the cost per pound of dry matter. The cost per pound of crude protein is calculated to provide an indication of the cost-to-value for each feed. The amount of dry matter, protein, and fat fed in each feed is also presented; this is based on the amounts fed that you entered on the Input worksheet. Of course, there are many other nutrients provided by both milk and milk replacer; this evaluation focuses on protein and fat because they contribute the majority of the cost of most milk replacers. Then the daily cost to feed each calf is calculated (a combination of the pounds fed and the cost per pound).

Feed preparation costs for each option are also determined. For milk replacer, this is the cost of heating water, running a mixer, and cleaning a mixer. For waste and whole milk, this is the cost of owning and operating the pasteurizer. The total daily cost for these preparations is outlined in the middle of the page. To determine the cost per calf, the daily total is divided by the number of calves. For milk replacer, the number of calves is calculated by subtracting the number fed pasteurized milk from the total number of calves. For pasteurized milk, the number of calves is equal to the number of calves fed pasteurized milk entered on the Input worksheet. For whole milk, the number of calves is the total number, because it is assumed that all milk is pasteurized.

The total daily cost per calf for each of the feed options is presented in the top section in bold print.

The bottom section of this worksheet compares *feeding systems*. First, the number of calves fed each option (based on your input) is outlined, and then the costs for various feeding scenarios are presented. The second column calculates the difference between feeding according to the scenario described and feeding all calves milk replacer. Positive values indicate a savings by not feeding all calves milk replacer, and negative values indicate that it would be less expensive to feed all calves milk replacer. The second type of output is an extension of this section.

Compare To Worksheets

The comparison worksheets are presented because it is unlikely that enough waste milk will be available every day to meet the needs of calves. These worksheets consider two alternative strategies, using milk replacer or whole milk, to feed calves that cannot be fed waste milk.

The "Compare to MR" worksheet provides a table that calculates the difference between feeding milk replacer to all calves or feeding pasteurized milk to some and milk replacer to the remaining calves for a range of 5 to 400 calves and over the range of 10 to 100% use of waste milk. Negative values indicate that feeding all calves milk replacer would be less expensive. Positive values indicate that using the pasteurizer is less expensive.

The "Compare to Whole Milk" worksheet provides a table that calculates the difference between feeding milk replacer to all calves or feeding pasteurized milk to some and whole milk to the remaining calves for a range of 5 to 400 calves and over the range of 10 to 100% use of waste milk. This comparison assumes that both waste and whole milk are pasteurized. Negative values indicate that feeding all calves milk replacer would be less expensive. Positive values indicate that using the pasteurizer is less expensive.

SUPPLY AND DEMAND WORKSHEET

The supply of waste milk is an important consideration in planning your pasteurization system. It will be helpful to determine how much milk will be available on an average day and how much the supply will vary from one day to the next. The spreadsheet includes a simple estimation of the average supply of and demand for waste milk based on herd size, weaning age, milk feeding rate, and clinical mastitis infection rate.

Users enter the requested information in the "Input" section. In the "Output" section, the spreadsheet calculates the amount of milk needed to feed all calves for a day, week, and the whole year. Estimations for the amount of transition and discard milk are made, then added together to determine the supply of milk available each day, week, and for the year. Finally, a balance is calculated by subtracting the demand from the supply. Negative values indicate that there will not be enough waste milk produced to feed all calves. Positive values indicate that there will be more than enough waste milk to feed all calves. This estimate assumes that calving and mastitis infection occur at the same rate throughout the year and does not account for milk discarded due to treatment for illnesses other than mastitis.

SOLIDS CALCULATOR WORKSHEET

When the waste milk supply is inadequate to meet the needs of calves, adding a milk replacer or milk extender product is one way to increase the volume of milk. Analyzing the fat and protein of waste milk takes time, but total solids can be estimated quickly using a refractometer. The solids available in waste milk can be calculated and an appropriate amount of powder added to make up the total solids needed to feed calves.

This spreadsheet contains a simple calculator that will determine the amount of milk, water, and powder that are needed. Users enter information in the "Input" section, and the "Output" section provides the results. The "Goal Seek" tool must be used to calculate the amount of powder needed. To access the goal seek tool in Excel 2003, users simply choose "goal seek" from the tools menu. In Excel 2007, the tool is located on the data menu, under data tools, and what if analysis. Goal seek is an Excel add-in that may not be present on menus, but it can be quickly installed as needed. In Excel 2003, go to the tools menu, choose add-ins, and then choose goal seek. In Excel 2007, go to the office button; choose Excel options, then add-ins, then goal seek.

When adding solids to waste milk in this manner, the fat and protein content are not considered. However, some contemplation of the typical fat and protein level of waste milk and of the levels in the chosen product is advised when determining what product will be used. A 20% protein, 20% fat milk replacer will change protein and fat in waste milk proportionally and the final mix will have the same relative amount of protein and fat as the original waste milk. However, other formulations can reduce fat more than protein or reduce both fat and protein to bring the composition of milk closer to the composition of a 20/20 milk replacer. Consider the impact of these options on milk composition before choosing a strategy for increasing the volume of milk.

WASTE MILK SUPPLY

Virginia Tech research recently documented extreme daily variation in waste milk supply (Figure 1). On average, the 11 herds studied produced enough waste milk to provide 12 lb/calf per day, but the range was 6 to 22 lb/calf (Scott, 2006). Research data on expected volumes of waste milk is limited. However, some estimates of the milk discarded during antibiotic treatment and subsequent withholding range from about 550 lb to about 700 lb per case of clinical mastitis (Bartlett et al., 1991; Shim et al., 2004, weighted average of 2 treatments). If discard milk were weighed, it would be fairly simple to determine an average for your farm (lb/d multiplied by number of days discarded). Combining this information with your average rate of clinical mastitis can provide a rough estimate of the expected volume of waste milk produced.

Of course, while a large volume of waste milk is helpful for feeding calves, an abundant supply of waste milk may indicate high treatment rates and a potential problem in the lactating herd. When evaluating mastitis infection rates, common benchmarks are that < 5% of cows develop new subclinical infections (SCC > 250,000 cells/mL) each month and 85% of cows have SCC < 250,000 cells/mL. A goal for the incidence of clinical mastitis is < 2% of cows developing new infections each month (Ruegg, 2001).

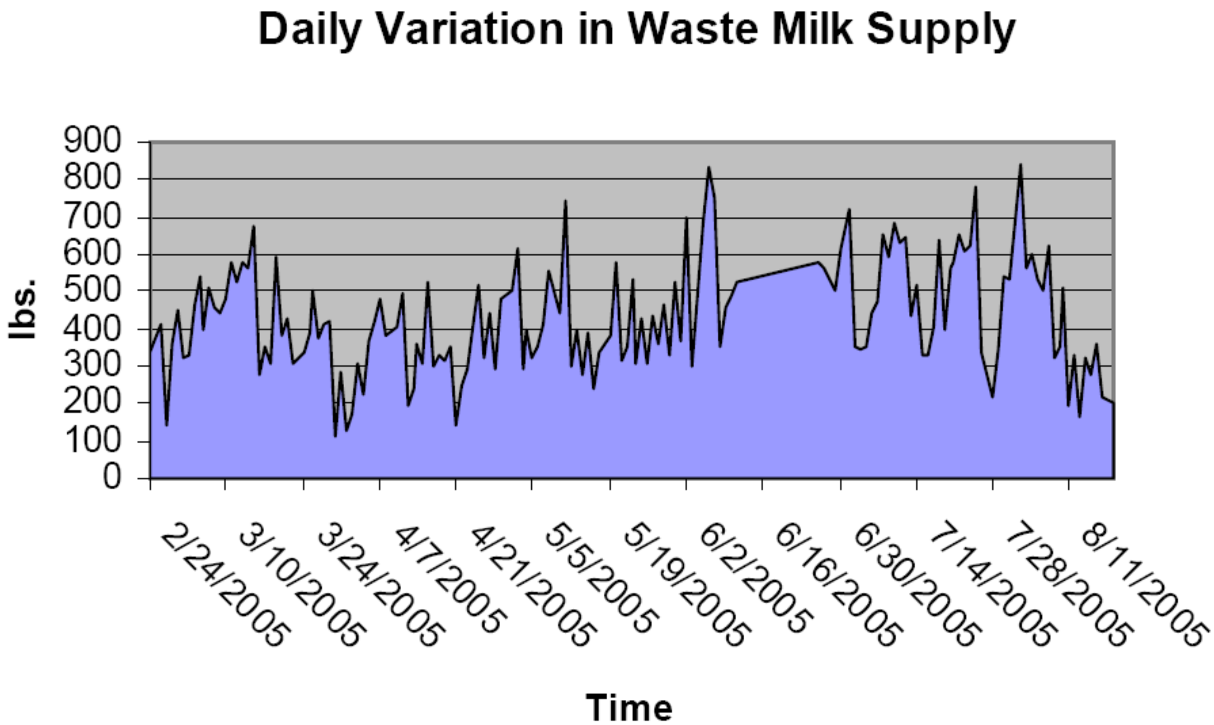

Figure 1. Daily variation in waste milk supply on a 1,200-cow operation in North Carolina over a 6-month period.

Several estimates of colostrum and transition milk production during the first 6 milkings after calving were published in the late 1970s and ranged from 18 to 24 lb/d for heifers and 31 to 40 lb/d for cows (Foley and Otterby, 1978). No recent studies have specifically investigated transition milk production. However, one study (de Passillé et al., 2008) measured early lactation milk production in cows nursing calves compared to cows milked by machine. Milk production was reported by week of lactation and was similar for the two groups of cows. In the first week, cows produced about 53 lb/d; keep in mind that milk production likely increased daily throughout this time. Thus, total production of colostrum and transition milk by modern Holsteins during the first 3 days postpartum (6 milkings) can be estimated in the range of 100 to 150 lb. If all of the first milking colostrum is saved (assume a range of 15 to 30 lb, which is either fed to calves or frozen for later use), approximately 85 to 120 lb of milk per cow will enter the waste milk supply.

The amount of milk available must then be compared to the amount of milk needed to feed calves. This amount will depend on the number of calves fed and the daily feeding rate. The total amount of milk needed for each calf will also be affected by the number of days calves are fed (weaning age). Once this supply and demand information is established, the next step is to develop a feeding strategy for times when the supply is inadequate to feed all calves.

First, it is necessary to determine what other liquid feed(s) will be used. Milk replacer has the advantage of being convenient, and can easily be stored until it is needed. Milk replacer can be fed directly to calves or mixed with water and waste milk to extend the supply. Whole, saleable milk pulled from the bulk tank is another option. It is readily available and could be mixed with waste milk and handled with minimal extra labor.

The primary disadvantage of using whole milk is typically the cost; milk replacer is often less expensive. Supplementing waste milk with a “milk extender” product is a third option. These products are similar to milk replacer, but are not intended to be fed directly to calves. They may contain higher levels of alternative proteins, which will be diluted to acceptable levels when mixed with milk and water.

Nutrient content of waste milk varies depending on the cows contributing milk. A survey of 31 Wisconsin farms showed ranges of 2.8 to 4.7% for fat and 2.9 to 5.1% for protein in waste milk (Jorgensen et al., 2006). Waste milk from 3 North Carolina herds contained 1.5 to 4.5% fat and 2.7 to 3.8% protein, and 10 California farms had 1.2 to 12.1% fat and 2.7 to 4.7% protein in calf milk (Scott, 2006). Milk contains casein, which curdles or forms a clot in the calf’s stomach. This allows the nutrients in milk to be digested slowly and may provide calves with some ability to adapt to variation in fat and protein content of milk. This may be one reason that calves seem to be less affected by slight variations in milk composition than they do by changes in milk replacer composition (most modern milk replacers are based on whey protein, which does not form a clot in the abomasum). This differential digestion issue is still being debated.

The addition of excess water from flushing milk lines is another potential source of variation in the nutrient composition of waste milk. Total solids content can be monitored to determine if too much water is getting into the waste milk supply. If solids are low, milk replacer or milk extender can be added to increase the solids content.

Keep in mind that when milk is stored without agitation, the fat begins to separate, which can contribute to variation in the nutrient content of milk between calves. For the best results, milk should be agitated before pasteurization and again before feeding, especially if there is a lag between the end of pasteurization and the beginning of feeding or when there is a long time between the start and end of feeding.

Another consideration is which calves will receive the alternative feed. If the waste milk supply is often short, calves could be fed milk replacer for 3 or 4 weeks and then switched to waste milk until weaning. It would also be possible to start calves on waste milk and switch to milk replacer, although it is likely that calves less than 3 weeks of age would benefit more from the consistency of milk replacer than older calves. Another option would be to designate some calves for milk replacer feeding from birth to weaning. Either of these options requires a system of identifying calves so that feeding protocols are consistently followed. If salable milk or a milk extender is fed, the milk supply is adjusted and all calves can receive the same feed. Regardless of your strategy, avoid repeated changes in a calf’s diet. These are not practical for you nor are they desirable for the calf.

Another option to reduce the total milk needs of individual calves is reducing the age at weaning. Calves can be weaned when they consume 1.5 to 2 lb of starter per day for 3 consecutive days. Most calves will achieve this intake by 5 or 6 weeks of age, which is at least 2 weeks sooner than the US average weaning age of 8 weeks.

CONCLUSIONS

Pasteurization is a viable option for reducing the disease-related risk of feeding waste milk to calves. The Calf Milk Pasteurization Evaluator spreadsheet can be useful in determining the costs associated with owning and operating the pasteurizer and may be used to estimate waste milk supply and demand. Some key elements of success with pasteurized milk include an adequate hot water supply, employee training, refrigerated milk storage, and regular monitoring of the pasteurization process. Before installing such a system, consideration also should be given to estimating the waste milk supply and demand as well as a strategy for feeding calves when the waste milk supply is not adequate.

REFERENCES

Bartlett, P. C., J. van Wijk, D. J. Wilson, C. D. Green, G. Y. Miller, G. A. Majewski, and L. E. Heider. 1991. Temporal patterns of lost milk production following clinical mastitis in a large Michigan Holstein herd. J. Dairy Sci. 74:1561-1572.

de Passillé, A. M., P.-G. Marnet, H. Lapierre, and J. Rushen. 2008. Effects of twice-daily nursing on milk ejection and milk yield during nursing and milking in dairy cows. J. Dairy Sci. 91:1416-1422.

Foley, J. A., and D. E. Otterby. 1978. Availability, storage, treatment, composition, and feeding value of surplus colostrum: a review. J. Dairy Sci. 61:1033-1060.

Jorgensen, M. A., P. C. Hoffman, and A. J. Nytes. 2006. Case study: a field survey of on-farm milk pasteurization efficacy. Prof. Anim. Scientist. 22:472-476.

Ruegg, P. L. 2001. Milk secretion and quality standards. http://www.uwex.edu/milkquality/PDF/milksecretionandqualitystandards.pdf. Accessed Mar. 26, 2008.

Scott, M. C. 2006. Viability of waste milk pasteurization systems for calf feeding systems. M.S. Thesis. Virginia Polytech. Inst. and State Univ., Blacksburg.

Shim, E. H., R. D. Shanks, and D. E. Morin. 2004. Milk loss and treatment costs associated with two treatment protocols for clinical mastitis in dairy cows. J. Dairy Sci. 87:2702-2708.

Penn State College of Agricultural Sciences research, extension, and resident education programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.