Pasteurized Milk and Colostrum for Calves: An Option or Necessity?

Sandra Godden and Hugh Chester-Jones

Infectious Disease Control Considerations when Feeding Non-saleable Milk

While the feeding of non-saleable milk to dairy calves would seem to offer tremendous economic efficiencies, one major concern with this practice is the increased risk for transmission of infectious pathogens that may be shed directly from the mammary gland, while others may result from post-harvest contamination (e.g. with manure) or proliferation in milk that is not stored/chilled properly.

Pasteurizing Non-saleable Milk

Pasteurization is the process of heating milk to a target time and temperature for a target microbe. The pasteurized milk ordinance (PMO) defines two different methods for pasteurization: 1) batch pasteurization at 145°F for 30 minutes (low-temperature, long-time or LTLT), or 2) high-temperature, short-time pasteurization (HTST) at 161°F for 15 seconds (usually using a continuous flow method). Heating results in a log reduction in concentration of viable bacteria. However, some heat-tolerant (usually non-pathogenic) bacteria will survive the process. Additionally, if a poor quality milk is pasteurized that already has a very high concentration of bacteria, some viable pathogenic bacteria may survive the pasteurization process.

Commercial batch pasteurizers heat milk to the target temperature (145°F), hold it there for 30 minutes, then automatically and rapidly cool the milk to feeding or storage temperature. They should be equipped with an agitator to allow for even heating.

Commercial HTST–continuous flow pasteurizers. Milk is usually circulated through a network of heated coils, rapidly heated to target temperature (161°F) and holding it there for 15 seconds.

Considerations for Using Commercial On-farm Pasteurization Systems

There are several important requirements and issues that producers should educate themselves about, and plan for, before purchasing and implementing this technology:

Installation requirements

- Hot water heater. Is a new one needed or is a heater self-contained in the unit? Does the existing hot water heater work? (i.e. Is the water hot enough?)
- Water supply.
- Are there special electrical requirements?
- Space/location.
- Drainage requirements.
- Purchase and installation costs.

Considerations for day-to-day use

- Training farm staff to properly use and clean the equipment.
- Time/labor to use and clean equipment.
- Cleaning requirements.
- Variable costs.

- Service. Is the equipment reliable? How quickly can service be provided?
- Moving and storing non-saleable milk before and after pasteurization.
- Monitoring performance. Is it working?
- Is a consistent supply of non-saleable milk available?

Handling of raw non-saleable milk

- Collect and store in closed, clean containers to prevent pre-pasteurization contamination.
- If milk is not to be pasteurized within a few hours of collection, chill it to prevent bacterial growth and fermentation prior to being pasteurized (e.g. use a small functional bulk tank).
- Chill stored raw milk to avoid fermentation, which results in acid production and lowers milk pH (~4.5). Acidic milk may result in protein coagulation and curd formation when the milk is pasteurized, resulting in a curdled end-product that is unsatisfactory to feed to calves.

Handling of pasteurized non-saleable milk. Any bacteria surviving the pasteurization process will begin to replicate again in the warm medium if the cooling process is delayed.

- Equip pasteurizers to rapidly cool the milk to feeding temperature immediately after pasteurization is completed.
- Feed the product soon after pasteurization is complete.
- If there is to be a significant delay between pasteurization and feeding, chill the milk in a clean container until it can later be reheated and fed.
- Store in clean, closed receptacles and feed to calves in clean buckets or bottles to avoid post-pasteurization contamination of milk.

Cleaning/sanitizing pasteurizers. Contact the manufacturers or distributors of commercial on-farm pasteurizers for cleaning instructions that best fit the equipment. Evaluating cleaning can include visual assessment for build-up of residual films plus cultures of pasteurized milk.

Monitoring pasteurizer equipment function

- Equip pasteurizers with a time-temperature control chart to assure target temperatures are being reached for the appropriate duration.
- Minimally, equip pasteurizer with a thermometer so that times and temperatures can be periodically checked and monitored.
- Monitor adequacy of cleaning by measuring bacteria counts and/or alkaline phosphatase in post-pasteurized milk.
- Culture of pre-pasteurized milk may be done to investigate if inadequate pasteurizer function (should it occur) is due to excessive bacteria counts in the raw product.

Effectiveness of On-farm Pasteurization in Destroying Infectious Pathogens

Studies have shown that pasteurization, both batch and HTST, is effective in destroying viable bacteria for most of the pathogenic species threatening calves. The efficacy of pasteurization in destroying Mycobacterium avium subsp. Paratuberculosis (Map), the organism causing Johne's disease, remains controversial. A number of researchers have reported that laboratory studies simulating batch or HTST pasteurization was completely effective in destroying this pathogen. Others have reported that small numbers of the organism may remain viable if inoculated into milk samples at high concentrations. Two studies to-date have used commercial on-farm pasteurization units; one a batch unit, the other HTST–both demonstrated that the pasteurization unit effectively destroyed the Johne's organism.

Problems That May Occur With On-farm Pasteurization Systems

Producers should be aware that problems can arise that may interfere with pasteurizer function or cleaning:

- Start with poor quality milk with a high degree of bacterial contamination:
  - Stored raw non-saleable milk should be chilled to reduce incubation.
- Milk not heated to the correct target temperature (HTST-161°F; Batch-145°F):
  - Water heater does not get water hot enough or not enough hot water available.
  - Inadequate plate cooler function.
  - Pasteurizer malfunctioning or not calibrated properly.
  - Cleaning failure–build-up of fat, protein or inorganic films interfere with heat transfer.
- Milk is not maintained at the target temperature for a long enough duration:
  - HTST: Milk not circulated for full 15 seconds.
  - Batch: Milk not kept at target temperature for a full 30 minutes.
  - Operator error–people rushing to complete chores may stop the pasteurization process before either target time or temperature is met.
- Curdling of milk if fermented (acidic pH):
  - Chill raw pre-pasteurized milk to prevent fermentation.
- Post-pasteurized milk should be cooled rapidly (should be automatic in commercial machines, more difficult to achieve in 'home-made' machines) to prevent incubation.
- Post-pasteurization contamination of the milk:
  - Store in closed, clean container. Chill if delay before feeding.
- Inconsistent supply of waste milk:
  - May need to periodically extend milk by blending in milk replacer.

Field Studies Feeding Pasteurized Non-saleable Milk

Raw vs pasteurized non-saleable milk–health, performance, and economics for California dairy calves. Calves fed pasteurized colostrum and milk had fewer sick days, lower mortality rates, lower costs for health expenditures, higher weights at weaning, and a higher gross margin ($8.41/calf) per calf, as compared to calves fed nonpasteurized non-saleable milk

Milk replacer vs pasteurized non-saleable milk–health, performance, and economics for Minnesota dairy calves. A recent 10-month field study of 438 dairy calves showed that average daily gain (ADG) was significantly greater in calves fed pasteurized non-saleable milk (0.47 kg/day) vs calves fed milk replacer (0.35 kg/day); significantly fewer calves were treated on the pasteurized milk diet (overall treatment rate = 12.1%) compared to calves fed the milk replacer diet (overall treatment rate = 32.1%) ($P<0.05$); preweaning mortality rates were significantly lower for calves fed pasteurized non-saleable milk (overall mortality rate = 2.3%) than for calves fed milk replacer (overall mortality rate = 11.6%); calves fed pasteurized whole milk grew faster and were healthier because of the higher level of nutrient intake in the whole milk diet (vs 20:20 milk replacer) and possibly because the non-saleable milk will most likely contain significantly higher concentrations of protective antibodies and other non-specific immune factors than would powdered milk replacer.

A partial budget model of the economics of pasteurizing non-saleable milk was developed to account for major areas of difference between a feeding system depending on pasteurized non-saleable milk and one using milk replacer (EXCEL spreadsheet model; Microsoft Office, 2000). This model estimated that feeding pasteurized milk resulted in a $34 per calf advantage over the calf's life up to weaning, and that a minimum of 23 calves would be necessary to make

feeding pasteurized non-saleable milk economically feasible (or 41 calves if only feeding costs and labor were considered, but growth and health benefits were not considered). This model is available on the website of the Center of Dairy Health, Management, and Food Quality: http://www.ahc.umn.edu/ahc_content/colleges/vetmed/Depts_and_Centers?CVM_Dairy_Center /index.cfm (U of MN, College of Veterinary Medicine). Users are free to examine the model and to alter the assumptions to best fit their own farm's situation.

Pasteurizing Colostrum

In contrast to milk, pasteurizing colostrum presents some special challenges such as congealing of colostrum and loss of important immunoglobulins (e.g. IgG). Researchers used two commercial pasteurizers, one HTST design and one batch design, to pasteurize five 1-gal (HTST) and ten 8-gal (batch) batches of colostrum. The mean IgG loss for both units ranged between 25 and 30%. Similar results (mean 25% IgG loss) were attained when pasteurizing almost 40 separate 1-gal batches of colostrum using a lab-scale batch pasteurizer. In recent field study of newborn calves on a large dairy in Colorado, 123 newborn calves were systematically allocated to be fed either fresh or batch pasteurized colostrum at both the first and second colostrum feedings. Calf serum IgG concentrations were significantly higher for 40 calves fed un-pasteurized (LSmean = 19.1 mg/ml) vs 55 calves fed pasteurized colostrum (LSmean = 9.7 mg/ml) for calves fed only 2 qts of colostrum at first feeding. By contrast, there was no statistically significant and a numerically smaller difference in serum IgG concentrations between eight calves fed unpasteurized (LSmean = 16.1 mg/ml) vs 20 calves fed pasteurized colostrum (LSmean = 13.5 mg/ml) for calves fed 4 qts of colostrum at first feeding. While this study suggests that pasteurizing colostrum may be made to work for producers with excellent colostrum management, these results are preliminary and should be interpreted with caution. Further research is needed to describe the effect of batch size, time and temperature on percent reduction in IgG concentrations.

It is recommended to producers considering pasteurizing colostrum only attempt to do so after ensuring that they can successfully implement the following steps and then carefully monitor the outcome on an ongoing basis:

- Use only high quality colostrum (goal >60 mg/ml with a colostrometer).
- Collect and store colostrum under sanitary conditions and keep pre- and post-pasteurized colostrum chilled if is any delay in pasteurization and/or feeding.
- Pasteurize only small-to-moderately sized batches (maximum 57 L or 15 gal).
- Monitor pasteurizer function by routinely culturing samples of pasteurized colostrum.
- Pay attention to equipment maintenance and day-to-day cleaning.
- Feed a full 4 qts of colostrum as soon as possible after birth.
- Offer a second feeding of 2 qts of colostrum within 6 hours of the first feeding.
- Monitor serum IgG concentrations as well as morbidity and mortality rates in calves.
- Pay strict attention to sanitation and hygiene in the maternity pen, during feeding, and in the environment so as to minimize calf challenge with infectious pathogens.
- Use a batch pasteurization method. Avoid HTST continuous flow methods.

Ongoing research–pasteurizing colostrum. We are currently in the process of investigating a lower-temperature/longer-time approach to heat-treat colostrum that would protect the important colostral antibodies. Results (to-date) will be presented at the meeting.

Summary

The recent introduction of on-farm commercial pasteurizers represents a method for reducing the risk of transmitting infectious pathogens when feeding non-saleable milk to calves. Early studies have shown health, performance and economic advantages to feeding pasteurized non-saleable milk. However, in order to be successful, producers must pay careful attention to quality control including careful handling of non-saleable milk, both pre- and post-pasteurization, pasteurizer performance (monitoring times/temperatures), and pasteurizer cleaning.

Table 1. Pasteurizer cost evaluation for 3 on-farm systems.[a]

Item	Farm A	Farm B	Farm C
Primary business	Dairy operation	Custom calf raiser	Custom calf raiser
Calves raised/year	1000	1500	3500
Calves fed/day	160	250	650
Weaning age, days	42	42	42
HTST pasteurizer, installation, accessories	$40,165	$35,000	$19,000
Pasteurizer flow rate	5 gpm	5 gpm	8 gpm
Milk fed/calf daily	1.1 gal	1 .5 gal	1.1 gal
Daily operating costs	$0.16/calf	$0.15/calf	$0.30/calf
Waste milk cows/day	20	44	75
Waste milk available/day	1.03 gal/calf	1.5 gal	1.1 gal
Saleable milk required	0.07 gal/calf	0.00	0.00
Value of saleable milk @ $19/cwt	$0.11/calf	0.00	0.00
Daily pasteurizer milk feeding costs	$0.41/calf	$0.23/calf	$0.60 purchase waste milk @ $3/cwt
Daily pasteurizer fixed costs	$0.14/calf	$0.08/calf	$0.02/calf
Comparative daily milk replacer feeding costs @ $1/lb	$1.20/calf	$1.20/calf	$1.20

[a] Assessment from pasteurizer evaluator program in Heifer Suite software (Profit Source LLC) described by Hoffman et al. (2004).

Table 2. Economics of feeding pasteurized waste milk vs milk replacer[a] – MN study.

Item	Pasteurized waste milk	Milk replacer
Capital costs for pasteurizer system	$12,250	------
Daily capital cost/calf at 1 gal	$0.25	------
Daily operating costs/calf	$0.29	
Total daily feed costs/calf	$0.54	$1.00
Health incidence and costs:		
Respiratory incidence	8%	20%
Respiratory cost/calf @ $6/incidence	$0.46	$1.17
Scour incidence	3%	17%
Scours cost/calf @ $5/incidence	$0.16	$0.86
Other infections	5%	9%
Other cost/calf @ $3/incidence	$0.15	$0.27
Mortality, %	2%	12%
Mortality @ $350 calf value	$0.91	$5.46
Total morbidity and mortality losses	$1.67	$7.76
Health incidence advantage/calf	+$6.09	------

[a] Adapted from a worksheet developed by Fetrow and Godden (2004).