This presentation will focus on on-farm pasteurization which has been adopted by some calf raisers as a method for reducing the risk of transmitting infectious pathogens when feeding non-saleable milk to calves. However, quality control including careful handling of the milk, both pre- and post-pasteurization, monitoring times/temperatures of the pasteurizer, and cleanliness of the pasteurizer are all keys to the success of this management practice in raising healthy calves.

Pasteurization

2007 USDA APHIS Study

- 70% of U.S. dairy farms fed milk replacer.
- 2.8% of U.S. dairy farms fed pasteurized milk
  - 28.7% of large operations (500+ cows)
  - 3.0% medium operations (100-499 cows)
  - 1.0% of small operations (<100 cows)

Bovine Alliance on Management and Nutrition (BAMN)

Survey results of dairies conducted in 2007 by the Animal and Plant Health Inspection Service of USDA. Only 2.8% of the farms were feeding pasteurized milk at that time. Just 1% of herds under 100 cows were feeding pasteurized milk. Will a pasteurization system be of benefit on your farm?

Pasteurization

- Feeding raw non-saleable milk represents one way to gain important economic and nutritional efficiencies thru growth and health advantages.
- However, using this milk can introduce the risk of infectious diseases to dairy calves.
- **Pasteurization** is an option to consider to reduce that risk, but producers must be committed to properly manage and monitor a pasteurized non-saleable milk feeding program.
- Pasteurized milk still may contain bacterial pathogens, some of which may be shed directly from an infected mammary gland, from post-harvest contamination with manure or proliferation in milk that is not stored or chilled properly.

Pasteurization is not sterilization. It's to *reduce* the pathogens.

(Godden, U of MN)

Feeding raw non-saleable milk has some advantages to the calf raiser, but pasteurization of that milk can reduce the risk of introducing infectious diseases to calves. Pasteurized milk still may contain bacterial pathogens. **Remember** -- Pasteurization is not sterilization. It's to *reduce* the pathogens.

Pasteurization

If considering using a commercial on-farm pasteurization system, consider these 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.

Godden and Chester-Jones, U of MN

Even if a pasteurization system could be beneficial in raising calves, in order for it to work properly and deliver the results expected, there are some installation requirements that need to be considered.

Pasteurization

Other considerations in determining whether or not to install a pasteurization system on the farm:

1. How will the raw non-saleable milk be handled?
2. How will the pasteurized milk be handled?

- The milk must be stored in closed, clean containers to prevent pre- and post-pasteurization contamination.
- If milk cannot be pasteurized within a few hours of collection, it must be chilled to prevent bacterial growth and fermentation prior to being pasteurized.
- Pasteurizers must be equipped to rapidly cool the milk to feeding temperature immediately after pasteurization is completed.
- If there is to be a significant delay to feeding time, then the milk needs to be chilled in a clean container until it can later be reheated and fed.
- The milk must be fed to calves in clean buckets or bottles to avoid post-pasteurization contamination of milk.

Godden and Chester-Jones, U of MN

How will the raw non-saleable milk as well as the pasteurized milk be handled? Here are additional considerations when determining whether or not to install a pasteurization system on the farm:

Pasteurization

Two acceptable methods as defined by the Pasteurized Milk Ordinance:

- **Batch**
- **Short time flash (Continuous flow)**

- What you choose depends on number of calves and how fast you want it done.
- Both methods will reduce viable bacteria concentrations; effectiveness depends on contamination of raw waste milk
- Inconsistent inactivation of antibiotic residues

There are two acceptable methods of pasteurization: **1) Batch; 2) Short time flash (Continuous flow).** Studies on pasteurizing milk containing antibiotic residues has shown inconsistent inactivation.

Pasteurization

Batch

- 145º F for 30 minutes = Low-Temperature-Long-Time (LTLT)
- Then automatically/rapidly cooled to 100-110º F prior to feeding
- Must be constantly agitated for even heating/cooling of the milk
- Might take several hours to heat (and later to cool) large volumes
- $5,000 or more depending on capacity

The **Batch Pasteurization** process is conducted at 145º F for 30 minutes. This is called Low-Temperature-Long-Time (LTLT).

This is a photo of one model of a Low-Temperature-Long-Time (LTLT) batch pasteurizer with a 100 gallon capacity.

17 gallon Lab LTLT model

This is a 17 gallon capacity model batch pasteurizer used in a research laboratory.

Lab model LTLT

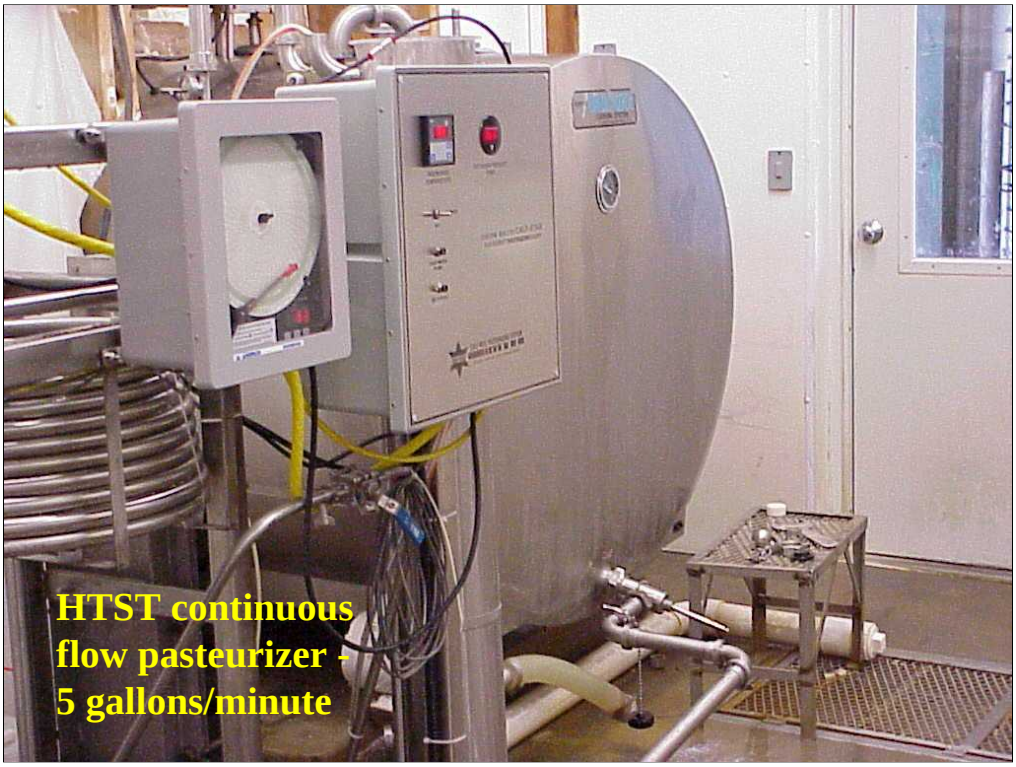
Agitation is critical

Whatever pasteurizer model is used it should be equipped with an agitator to get even heating for the entire batch of milk at the required **145º F for 30 minutes.**

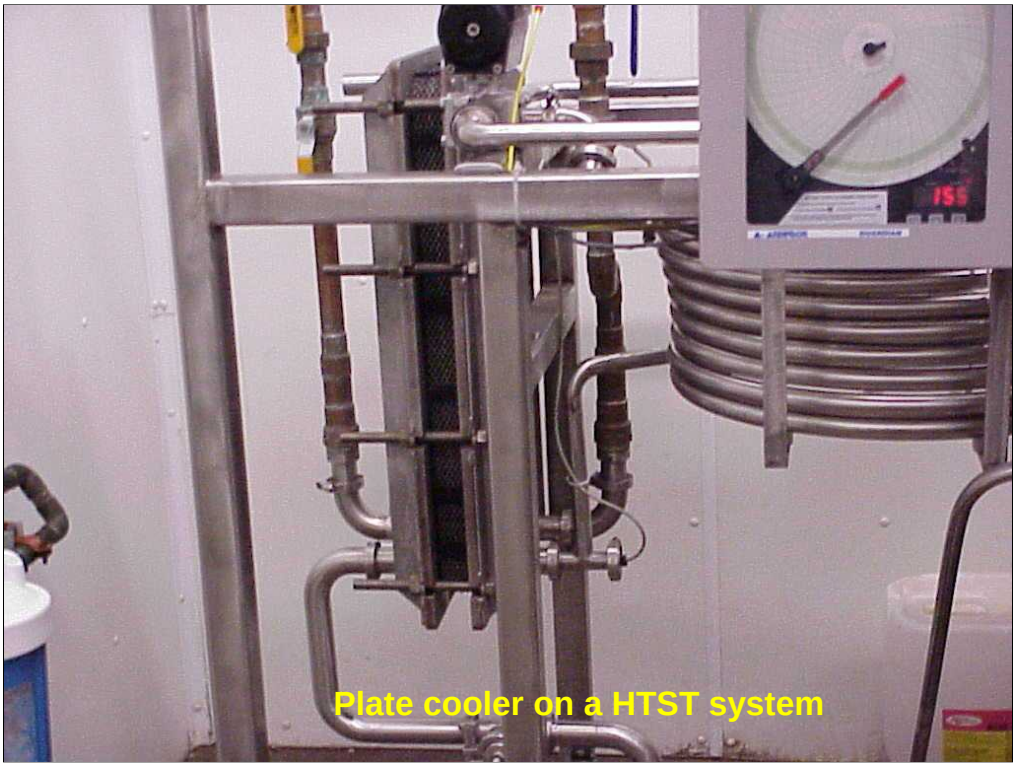
Pasteurization

- **Short time flash (Continuous flow)**
  - 161º F for 15 seconds = High-Temperature-Short-Time (HTST) continuous flow system
  - Then, rapidly cooled to 110º F prior to discharge and feeding.
  - $10,000 to > $50,000, depending on capacity

The other acceptable method of pasteurization is a **High-temperature-short-time (HTST) continuous flow system** where milk is heated at 161º F for 15 seconds, then rapidly cooled to 110º F prior to discharge and feeding.



This is a photo of a High-temperature-short-time (HTST) continuous flow system that can handle 5 gallons per minute of waste milk. To the left of the tank is a temperature monitoring system displaying the temperature of milk being pasteurized as well as for the pasteurized milk leaving the system. To its left is a graph printed by a needle to show the temperatures over a period of time for reference to determine if the system is functioning properly.



The HTST pasteurization system has a plate cooler to rapidly cool the pasteurized milk to 110º F prior to discharge.

In order to get the waste milk heated at 161º F for 15 seconds an adequate sized furnace is needed.

Milk receiving and storage tanks are needed for the High-temperature-short-time (HTST) continuous flow system.

Pasteurization

Examples of Commercial Sources:

- **Calf Star - www.calfstar.com**
- **Bettermilk Products - www.bettermilk.com**
- **Goodnature Products - www.goodnature.com**

- **Home-made systems another option**

Here are web site addresses for some sources of commercial pasteurizers. Of course, those who are good at building home made equipment, that is another option.

Table. Comparative nutrient analyses of pre- and post-pasteurized waste milk

Nutrient	Raw	Pasteurized	Pr > F
Fat, % of DM	35.4	31.2	$P < 0.01$
Fat, %	4.42	3.90	$P < 0.01$
Protein, % of DM	28.3	28.1	NS
Protein, %	3.54	3.51	NS
Lactose, % of DM	34.0	35.3	$P < 0.05$
Lactose, %	4.25	4.42	$P < 0.05$
Energy[1]			
GE[2], Mcal/kg	6.22	5.86	$P < 0.05$
ME[3], Mcal/kg	5.79	5.45	$P < 0.05$
NEm[4], Mcal/kg	4.97	4.69	$P < 0.05$
NEg[5], Mcal/kg	3.99	3.76	$P < 0.05$

[1] Calculated (NRC, 2001)
[2] Gross Energy
[3] Metabolizable Energy
[4] Net Energy for Maintenance
[5] Net Energy for Gain

Does pasteurizing raw non-saleable milk affect the nutrient content of the milk? This table shows the results of a study looking at the nutrient analysis of waste milk before and after that same milk was pasteurized. In general, there were no real differences in fat%, protein% or lactose% or energy levels.

Pasteurization

On-farm evaluation of milk pasteurizers on Wisconsin dairy and custom calf -raising operations

Key observations:

- Overall results indicated pasteurizers did a good job
- 12.9% of operations with pasteurizers did not inactivate alkaline phosphatase in pasteurized milk samples = inadequate temperature to meet PMO Standard (2001, Pasteurized Milk Ordnance)
- 50% incidence of antibiotic residues in pasteurized waste milk (residues for pre-and post pasteurization were similar)

In a Wisconsin study evaluating pasteurizers on dairies and custom calf-raising operations, overall results indicated pasteurizers did a good job.

Economics of Pasteurization

- On farm pasteurization systems can be a viable economic strategy for feeding dairy calves.
- Determining true cost of pasteurizing systems is difficult due to fluctuations in supply of NSM, # of calves, relative costs of feeding either MR or NSM.
- Capital and operating costs for the system.
- Cost of labor, equipment, installation, energy.
- Facilities for housing a pasteurizer, storage tanks, hot water heaters.

On farm pasteurization systems can be a viable economic strategy for feeding dairy calves. However, how to determine the true cost of a pasteurizing system can be a challenge.

Equipment will be needed for sanitizing, cleaning and for disposal of waste water.

An adequate flow rate for the pasteurized milk of between 1 to 15 gallons per minute will be necessary to meet the needs of the operation.

Economics of Pasteurization

Winter Feeding Study --

- A nutrition study, not a pasteurization vs no study
- 10 month study, 438 dairy calves, MN heifer growing operation (Godden, U of MN, 2005)
- Conventional 20:20 MR vs batch pasteurized non-saleable milk
- Volume adjusted equally in both groups according to temp
  - 4 qt/day if temperature was > 24 F
  - 5 qt/day if temperature was 5 to 24 F
  - 6 qt/day if temperature was < 5 F

In a 10 month nutrition study on 438 calves at a Minnesota heifer growing operation, a conventional 20:20 milk replacer was compared to batch pasteurized non-saleable milk.

Economics of Pasteurization

- ADG was significantly greater in calves on the pasteurized milk vs calves fed conventional MR
- Significantly fewer calves were treated or died on the pasteurized milk program
  - Treated – 12.1% vs 32.1%
  - Mortality – 2.3% vs 21%
  - Shows that improved nutrient intake improves ROG and health fed pasteurized milk.
  - Calves needs extra energy reserves in early life to prepare for a sickness event.
  - Less disease and death in calves from pasteurized raw milk, especially in winter
  - In winter the immune system can crash if not fed extra energy. Possibly one of the arguments for raw milk which supply more nutrients.
- Partial budget model estimated a $34/calf advantage at weaning on the pasteurized milk program

Note: Spreadsheet – www.cvm.umn.edu/dairy/software/listing

Godden, U of MN, 2005

Results of this study were as follows:

- ADG was significantly greater in calves on the pasteurized milk.
- Significantly fewer calves were treated or died on the pasteurized milk program.
- Using a partial budget model, it was estimated to be a $34/calf advantage at weaning on the pasteurized milk program. **Note:** There is a spreadsheet that can be used to develop your own partial budget.

Pasteurizing Colostrum

- Early research using conventional methods and temperatures showed less than acceptable results:
  - Mild to severe thickening or congealing of colostrum
  - Reduction of up to 32% of immunoglobulin (IgG) concentration
  - Lower serum IgG concentrations in calves
- The problem may be solved by using a lower-temperature, longer-time approach to heat-treat colostrum.
  - Research showing that heat-treating colostrum at **140º F for 60 minutes** is beneficial to calves, perhaps due to fewer bacteria present to interfere with antibody absorption across the gut.

More research needs to be completed before this practice can be widely recommended to the industry.

Godden, U of MN

Can pasteurized colostrum be used in getting calves off to a successful start? According to Dr. Sandra Godden, research showing that heat-treating colostrum at **140º F for 60 minutes** is beneficial to calves. However, more research needs to be completed before this practice can be widely recommended to the industry.

Pasteurizing Colostrum

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

- Handle colostrum so microbial growth is minimized by immediate feeding of fresh colostrum or rapid cooling it to less than 40F and freezing it if not fed within 24 hrs.
- Culture colostrum to assure that post pasteurized standard plate counts are less than 20,000 cfu/ml (colony forming units per milliliter).
- Routinely monitor health records and passive transfer rates in calves.
- Use a refractometer to monitor serum proteins from 24 hrs to 7 days of age. Goal is to have 90% of calves with a value of >5.0g/dL (grams per deciliter).
- Routinely monitor times and temperatures of heat treatment of colostrum to assure that temperature *does not exceed 141º F for 60 minutes.*
- Develop cleaning and sanitizing protocols for collection, pasteurization equipment, storage vessels, and feeding utensils.

James, Virginia Tech, 2008

To assure success in pasteurizing colostrum to feed to calves, Dr. Bob James of Virginia Tech, recommends the listed protocols.

On-farm challenges for optimum use of pasteurization systems

(Adapted from Godden)

- It may improve ROG, health, and economic efficiencies. However, a system must be properly managed and maintained.
- Non-saleable milk is not allowed in the milk house, so a separate location is necessary.
- Equipment supplier should provide a proper protocol for use. Employees using equipment need to be trained and protocol maintained.
- Quality of raw waste milk (RWM) - *high bacterial contamination*

Having a pasteurization system on the farm is not without its challenges. One key factor is that a highly bacterial contaminated milk can make it difficult to reduce the bacteria significantly enough thru pasteurization to feed a quality product to the calf.

On-farm challenges for optimum use of pasteurization systems

- Inadequate temperature during the process (161° F for HTST; 145 ^{0}F for Batch) - *check water heater; inadequate plate cooler; inaccurate calibration; inadequate cleaning build-up of material to interfere with heat transfer*
- Milk not kept at target temperature for correct time - operator error
- Post-pasteurized milk should be cooled very quickly (mostly automatic process) to prevent incubation.
- Prevent post-pasteurization milk contamination - *Store in closed clean/sanitized tank, then* reheat to feeding temperature (100-105º F) and feed. Thoroughly mix.

The temperature needs to be constantly monitored during the pasteurization process. Post-pasteurized milk should be cooled very quickly, and then stored in a closed, clean, sanitized tank. When ready to feed, it needs to be reheated to a feeding temperature of 100-105º F and thoroughly mixed.

On-farm challenges for optimum use of pasteurization systems

- Use of on-farm pasteurization of waste milk requires comparative economic assessments of existing calf raising systems
- Practical advantages and disadvantages in relationship to size of operation, resources and current feeding management should be clearly understood.
- Because the amount of non-salable milk can fluctuate from day-to-day, the farm needs to have a plan or strategy in case an adequate supply is not available such as:
  - Add high SCC milk to the inventory
  - Extend the supply by adding MR
  - Feed the pasteurized milk to younger calves that need higher nutrients and feed older calves MR program

A comparative economic assessment of using on-farm pasteurization needs to be conducted.

On-farm challenges for optimum use of pasteurization systems

- Culture milk once/month
- pH
  - Normal is 6.7
  - Trouble if < 5.
- Monitor total solids.
  - Milk ranges from 5 to 15%
  - Most is from 10 to 12%

The goal is to feed a high quality product to the calf.

On-farm challenges for optimum use of pasteurization systems

Remember:

- Feeding pasteurized non-saleable milk needs intensive management.
- Avoid inconsistent nutrient composition. Agitate well.
- Avoid pasteurization failure. ***From the cow thru the pasteurizer to the calf (the whole system)***
  - One cause of failure is starting with too many bugs!
  - Don't pasteurize spoiled milk
  - Don't re-contaminate

➢ Pasteurization is not sterilization. It's to *reduce* the pathogens.

University of Minnesota EXTENSION

Some final thoughts to optimize the use of a pasteurization system. One big cause of failure is that pasteurization is not the cure all to using contaminated milk to feed calves. Using a pasteurization system can be beneficial to reduce pathogens in non-saleable milk, but the process does not sterilize the milk.

Calf Milk Pasteurization Calculator

Nutrient and Cost Comparison of Liquid Feeds

	MILK REPLACER	WASTE MILK	WHOLE MILK
Crude protein, % dry matter	20.6	26.1	25.5
Fat, % dry matter	20.6	30.0	28.0
Cost per lb of dry matter	$1.55	$0.23	$1.55
Cost per lb of CP (DM basis)	$7.50	$0.88	$6.08
Dry matter fed, lb/day	1.21	1.12	1.08
Crude protein fed, lb/d (DM)	0.25	0.29	0.27
Fat fed, lb/d (DM)	0.25	0.34	0.30
Daily feed cost, $/calf (DM)	$1.88	$0.26	$1.67
Feed prep cost, $/calf per day	$0.18	$0.99	$0.93
Total cost per calf, $/day	**$2.06**	**$1.25**	**$2.60**
Breakdown of feed prep costs*	HOT WATER & MIXING	PASTEURIZATION	PASTEURIZATION
Ownership, $/d		$11.51	$11.51
Energy, $/d	$0.10	$21.04	$23.90
Cleaning, $/d	$1.00	$3.00	$3.00
Labor, $/d		$8.00	$8.00
Total feed prep cost, $/d	$1.10	$43.55	$46.42

*Hot water/mixing cost calculated for calves not fed pasteurized milk; waste milk pasteurization cost based on number of calves fed pasteurized milk; whole milk pasteurization cost based on all calves

Comparison of Various Feeding Systems

Total number of calves to feed	50	
Number of calves to feed pasteurized waste milk	44	
Number of calves to feed another source	6	
Total daily cost of feeding…	$/day	Compared to all MR**
All milk replacer	$95.42	
All pasteurized waste milk	$59.32	$36.10
Feed pasteurized waste milk and some milk replacer	$67.25	$28.16
Feed pasteurized waste milk and some whole milk	$67.78	$27.64

**Savings or (loss) compared to feeding all milk replacer

Penn St and VA Tech

http://www.das.psu.edu/research-extension/dairy/nutrition/xls/pasteurizer.xls

A Calf Milk Pasteurization Calculator can be found at the web address shown on the bottom of the slide. This interactive spreadsheet calculates the cost of owning and operating a calf milk pasteurizer and provides a comparison of the nutrients provided by milk replacer, waste milk, and whole milk, and determines which system would be the most economical way to feed pre-weaned calves.