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Pasteurization of Non-Saleable Milk

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Topics include:

Quality of waste milk
Precautions for feeding raw milk
Pasteurization
Considerations for using commercial on-farm systems

INTRODUCTION

All dairy operations have a supply of milk that is not saleable, commonly called waste or discard milk. For the purpose of this paper, non-saleable milk or waste milk is composed of excess colostrum, transition milk, mastitic milk or non-saleable milk containing antibiotics. According to Blosser (1979), discard milk ranges from 48 to 137 lb (22 to 62 kg) per cow per year, representing a huge economic loss, disposal problems, and environmental issues. For many years waste milk has been fed to calves, but concerns with microbial contamination, such as *E. coli*, bovine viral diarrhea virus, *Streptococcus* spp., *Salmonella* spp., *Mycoplasma* spp., *Listeria monocytogenes*, *Camphylobacter* spp. and *Staphylococcus* spp., among others (Selim and Cullor, 1997; Stewart et al., 2005), as well as possible transmission of diseases such as Johne's, through feeding waste milk have discouraged many producers from feeding calves this milk. However, pasteurization of waste milk is one option to reduce management risk while utilizing a valuable, low-cost liquid feed source for calves. Companies are starting to produce a variety of small and large, self-contained, on-farm pasteurizers specifically for the utilization of waste milk for calf feeding. These pasteurizers are being marketed at affordable prices for an individual dairy operation. The objective of this paper is to review some important considerations of implementing an on-farm pasteurization system and discuss available research findings related to feeding pasteurized non-saleable milk to calves.

QUALITY OF WASTE MILK

Dairy producers feed a variety of liquid feeds to young calves after the initial colostrum, including whole milk, surplus colostrum, transition milk, mastitic milk or non-saleable, antibiotic-containing milk, and milk replacer. Waste or discard milk cannot be sold for human consumption, thus it is often used as an economical alternative to milk replacer in many dairy farms. The nutrient profile of colostrum, transition milk, and whole milk is listed in Table 1.

Feeding this milk to calves offers a series of advantages besides economics. The solids content of mixed colostrum and transition milk ranges between 16% and 18% and so produces good gains by calves (Foley and Otterby, 1978; Davis and Drackley, 1998; Kehoe et al., 2007). Despite its tremendous economic advantages, many dairy producers avoid feeding waste milk to calves for fear of increasing the incidence of heifers calving with mastitis or blind quarters, which was commonly seen in early studies where calves generally were housed in pens that enabled them to suckle teats of other calves. This led to an increase in the incidence of mastitis in developing heifers. There are also other concerns with feeding discard milk to calves. One is related to the possible development of antibiotic resistance of intestinal bacteria in calves. However, Kesler (1981) concluded that milk from cows treated with antibiotics for mastitis and other disorders can be fed safely to calves. Calf growth will be at least equal to that obtained by feeding fermented colostrum or other liquid feed. The most important concern has to do with the risk for transmission of infectious pathogens. Pathogens that may be transmitted in colostrum and milk include: *Mycobacterium avium* subsp. *paratuberculosis*, *Salmonella* spp., *Mycoplasma* spp., *Listeria monocytogenes, Camphylobacter* spp., *Mycobacterium bovis, Enterobacter* spp., *Staphylococcus* spp., and *E. coli*, among others (Lovett et al., 1983; Streeter et al., 1995; Selim and Cullor, 1997; Stewart et al., 2005). When studying 12 dairies in California, Selim and Cullor (1997) demonstrated that raw, non-saleable milk contained significantly higher concentrations of bacteria than other types of milk or milkbased products (Figure 1). *Streptococcus* species and *Enterobacter* were the predominant bacteria identified, followed by *Staphylococcus*. *E. coli* was the most common gram-negative bacteria. For this reason, the former authors concluded that producers should be cautious of feeding raw waste milk to calves as it may contain a high number of bacteria that may be pathogenic to both cattle and humans.

Table 1. Characteristics and composition of Holstein colostrum, transition milk, and milk.

	Colostrum (milking post-partum)			
Variable	1	2	3	Milk
Specific gravity	1.056	1.045	1.035	1.032
pH	6.32	6.32	6.33	6.5
Total solids, %	23.9	17.9	14.1	12.5
Fat, %	6.7	5.4	3.9	3.6
Solids non-fat, %	16.7	12.2	9.8	8.6
Total protein, %	14.0	8.4	5.1	3.2
Casein, %	4.8	4.3	3.8	2.5
Albumin, %	0.9	1.1	0.9	0.5
Immunoglobulins, %	6.0	4.2	2.4	0.09
IgG, g/dL	3.2	2.5	1.5	0.06
Non-protein N, %	8.0	7.0	8.3	4.9
Lactose, %	2.7	3.9	4.4	4.9
Calcium, %	0.26	0.15	0.15	0.13
Potassium, %	0.14	0.13	0.14	0.15
Sodium, %	0.14	0.13	0.14	0.15
Vit A, µg/dL	295	190	113	34
Vit E, µg/g of fat	84	76	56	15
Riboflavin, µg/mL	4.83	2.71	1.85	1.47
Choline, mg/mL	0.70	0.34	0.23	0.13

Source: Davis and Drackley, 1998.

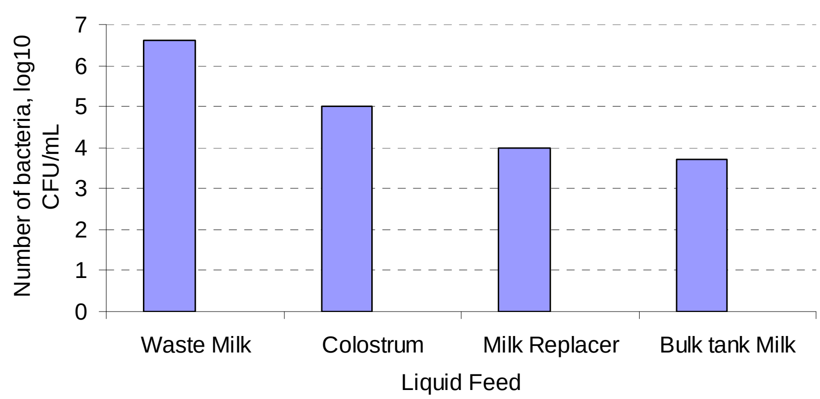

Figure 1. Bacterial count in some common calf liquid feeds (Selim and Cullor, 1997).

Microbial load in waste milk is a function of several factors, including:

- microbial content of milk produced by the cow
- cleanliness of the equipment used to collect the milk
- cleanliness of the equipment used to store the milk prior to feeding
- storage time (time from collection to feeding)
- temperature of milk during storage
- exposure to microbial sources (feces, flies, etc.) from the environment
- pasteurization or other processing to reduce microbial load

The microbial content of waste milk will increase dramatically if the milk is left at room temperature or above. Unfortunately, some milk collected during the morning milking may not be fed until the afternoon. Consequently, the microbial load may increase dramatically. Even though this may not cause problems in some cases, the microbial load may become a source of disease in others.

PRECAUTIONS FOR FEEDING RAW WASTE MILK

- Determine the health status of the cows in your herd. Do not feed raw waste milk if the cows are shedding organisms that cause disease, such as Johne's and bovine viral diarrhea. If you are aware of the disease status of your herd and you and your veterinarian agree, it may be acceptable to feed raw milk and limit risk by feeding only milk from test-negative cows. However, the risk remains that you may spread diseases that exist in the herd but are not identified.
- Do not feed waste milk to newborn calves on the first day of life. The intestinal wall is permeable to bacteria that could cause illness.
- House calves fed waste milk individually to prevent them from suckling one another. This should reduce the transmission of infectious micro-organisms that cause mastitis.
- Do not feed milk that is excessively bloody or has an unusual appearance since it can contain active pathogens and white blood cells, which are difficult for a calf to digest.
- Feed waste milk to herd replacements or to calves being kept at least eight to twelve weeks after the last feeding of waste milk.
- Use caution when feeding waste milk from antibiotic-treated cows to calves intended for meat production. Antibiotic residues from the milk could be deposited in the calves' tissues.

PASTEURIZATION

One strategy to decrease pathogen load and still utilize waste milk is to pasteurize the milk. Pasteurization is a method of exposing milk to elevated temperatures for a period of time as a means of reducing the bacterial contamination. This process kills bacteria that can cause diseases in humans and animals. It is important to note that ***pasteurization is not sterilization***. Pasteurized milk still may contain measurable amounts of bacteria. Pasteurizing poor quality milk with a very high concentration of bacteria may allow some viable pathogenic bacteria to survive the pasteurization process.

Types of pasteurization

There are two common methods of pasteurizing milk: batch pasteurization and high-temperature, short-time (HTST), continuous flow pasteurization.

Standard batch pasteurization is accomplished when a batch (usually a vat or tank) of milk is heated to 63°C (145°F) for 30 minutes. Thereafter, the milk is cooled and can be fed to the calves. Batch pasteurizers should be equipped with an agitator to allow for even heating. There are concerns about the volume of milk to be heated and the time to do it. Very large batches take several hours to reach the desired temperature and there are concerns that some bacteria may become heat resistant, surviving the pasteurization process. The cleaning process of these units is most often done manually.

The process of HTST is different. Milk is circulated through a network of heated coils, rapidly heated to 72°C (161°F) and held there for 15 seconds. This type of system is also equipped to automatically cool the milk quickly to feeding or storage temperature. Continuous flow pasteurization is much more rapid than batch pasteurization and offers more opportunities for energy conservation. Continuous flow systems are generally more difficult to clean, requiring a cleaning procedure similar to that used in milking systems, but in many cases the cleaning process can be automated.

Effectiveness of pasteurization in destroying infectious pathogens

Pasteurization safely decreases pathogens in all types of milk fed to young calves. Stabel (2001) showed that holding milk at 65.5°C (175.5°F) for 30 min is more than adequate to achieve total destruction of *Mycobacterium paratuberculosis*, the bacteria responsible for Johne's disease. Butler et al. (2000) demonstrated that on-farm pasteurization of waste milk held at 65°C for 10 min also destroyed common mastitic mycoplasma such as *Mycoplasma bovis*, *M. californicum*, and *M. canadense*. In another study, Stabel et al. (2004) demonstrated that HTST pasteurization is effective in the destruction of *M. paratuberculosis* (Table 2), *Salmonella* spp. (Table 3), and *Mycoplasma* spp. (Table 4) in waste milk.

Table 2. Destruction of *Mycobacterium paratuberculosis* after HTST heat treatment at 71.7°C for 15 s.

	High level of inoculum		Low level of inoculum	
Strain	Prepasteurization	Postpasteurization	Prepasteurization	Postpasteurization
19698	8.2×10^4	ND[1]	6.0×10^1	ND
(lab)	7.8×10^4	ND	1.3×10^2	ND
	2.3×10^3	ND	2.3×10^2	ND
167	1.9×10^5	ND	6.3×10^2	ND
(wild)	2.1×10^5	ND	4.2×10^2	ND
	2.2×10^4	ND	8.2×10^2	ND
6112	1.9×10^6	ND	5.4×10^1	ND
(wild)	5.9×10^5	ND	4.3×10^2	ND
	6.8×10^5	ND	2.1×10^2	ND

[1]ND = Not detected. Source: Stabel et al. (2004).

Table 3. Destruction of *Salmonella* spp. during HTST heat treatment at 71.7°C for 15 s.

		High level of inoculum		Low level of inoculum	
Species	Strain	Prepasteur.	Postpasteur.	Prepasteur.	Postpasteur.
S. derby	NVSL	2.0×10^6	ND[1]	2.5×10^3	ND
	2681b	2.0×10^6	ND	1.5×10^3	ND
		2.0×10^6	ND	9.0×10^2	ND
S. dublin	NVSL	6.0×10^6	ND	NP[2]	ND
	3129	9.0×10^6	ND	NP	ND
		3.3×10^7	ND	NP	ND
S. typhimurium	NVSL	2.1×10^7	ND	NP	ND
	5372	2.1×10^7	ND	NP	ND
		2.0×10^7	ND	NP	ND

[1]ND = Not detected. [2]NP = Not performed. Source: Stabel et al. (2004).

Table 4. Destruction of *Mycoplasma* spp. during HTST heat treatment at 71.7°C for 15 s.

		High level of inoculum		Low level of inoculum	
Species	Strain	Prepasteur.	Postpasteur.	Prepasteur.	Postpasteur.
M. bovis	1135-6	1.0×10^6	ND[1]	1.0×10^2	ND
	UCD9	1.0×10^6	ND	1.0×10^2	ND
	Jasper	1.0×10^6	ND	1.0×10^2	ND
M. californicum	Cs657	1.0×10^6	ND	1.0×10^2	ND
	ST6	1.0×10^6	ND	1.0×10^2	ND
M. canadense	275C	1.0×10^6	ND	1.0×10^2	ND
M. serogroup 7	CS826	1.0×10^6	ND	1.0×10^2	ND
	PG50	2.0×10^4	ND	1.0×10^2	ND

[1]ND = Not detected. Source: Stabel et al. (2004).

In another study, Butler et al. (2000) reported that at 60°C, *M. bovis* and *M. californicum* did not grow after 5 and 10 min of heat, respectively, while *M. canadense* remained viable even after 30 min of heat. *M. bovis* and *M. californicum* were both negative by culture after 2 min at 65°C, but *M. canadense* produced colonies when processed for up to 10 min. When the temperature increased to 67.5°C, 1 min inactivated *M. bovis*, 2 min inactivated *M. californicum*, and 5 min inactivated *M. canadense. M. bovis* and *M. californicum* failed to produce viable cultures after 1 min at 70°C, but *M. canadense* remained viable after up to 3 minutes of exposure.

Jamaluddin et al. (1996) reported that calves fed pasteurized milk had fewer days with diarrhea and pneumonia than calves fed non-pasteurized milk. Also, calves fed pasteurized milk had greater average weight gain than calves fed non-pasteurized milk. Calves fed pasteurized milk grossed an extra $8.13 per head, attributed to reduced health complications and treatment costs, when compared with calves fed non-pasteurized milk. They also indicated that calves fed pasteurized waste milk continued to perform better after weaning than those fed raw waste milk.

In a more recent study, Godden et al. (2005) indicated that calves fed conventional milk replacer had significantly lower rates of gain, lower weaning weights; higher risk for treatment during the summer and winter months, and higher risk of death during the winter months than did calves fed pasteurized, non-saleable milk. The estimated savings of feeding pasteurized non-saleable milk compared with milk replacer was $0.69/calf per day, and the estimated number of calves needed to economically justify the non-saleable milk pasteurization system was 23 calves/day.

The results of these and other studies suggest that on-farm pasteurization of waste milk is effective in generating a safer product to feed to young calves.

CONSIDERATIONS FOR USING COMMERCIAL ON-FARM PASTEURIZATION SYSTEMS

A benefit to on-farm commercial waste milk pasteurizers is that they are becoming relatively easy for users to operate, clean, and maintain. Control systems are simple, easy to understand and installation is not complex. On-farm pasteurizers are relatively small, taking up the space of a small bulk tank. In spite of those advantages, there are several important requirements and issues that producers should evaluate before purchasing, installing and using this technology. Godden et al. (2004) suggests the following installation requirements and considerations for day-to-day use.

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 waste milk before and after pasteurization
- Monitoring performance. Is it working?

Handling of pre-pasteurized milk and equipment requirements

When handling large quantities of waste milk, dairy operators need to have the proper equipment. It is recommended to have an adequate container, preferably an used bulk tank to store the waste milk produced daily. This allows pooling of all waste milk sources (mastitis and/or transition milk, excess colostrum, etc.) and reduces the chance of feeding excessive amounts of antibiotic milk in one feeding (Davis and Drackley, 1998). Pooling waste milk in larger quantities also minimizes daily variation in nutrient content of the milk. The bulk tank or container has to be clean and closed to prevent contamination of the pre-pasteurized milk. If the milk is not to be pasteurized within a few hours of collection, it should be chilled to prevent fermentation and bacterial growth. This is very important since a heavy bacterial load in waste milk will not be eliminated completely by pasteurization.

Handling of post-pasteurized milk

Any bacteria surviving the pasteurization process will begin to replicate in the warm medium if the cooling process is delayed. This can occur if the milk is allowed to cool slowly for several hours at ambient temperature or if milk is left to sit at warm ambient temperatures for long periods before being fed. For this reason, pasteurizers should be equipped to rapidly cool the milk to feeding temperature immediately after pasteurization is completed, and producers should try to feed the product soon after pasteurization is complete. If there is to be a delay between pasteurization and feeding, then the milk should be chilled.

Post-pasteurization contamination of milk is another important concern. Pasteurized milk should be stored in clean, closed containers and distributed to calves in clean buckets or bottles. Careful attention must be paid to cleaning and sanitizing buckets, bottles, nipples, etc.

Cleaning and sanitizing pasteurizers

With poor cleaning, fat, protein, and inorganic films (minerals) can build up in these systems, interfering with temperature transfer to the milk and serving as a source to inoculate milk with bacteria. Producers should clean this equipment as diligently as they would their own milking system, using procedures similar to common milking system sanitization procedures. One recommended cleaning process (Reynolds, 2002) is as follows:

a) Pre-rinse with cold water
b) Circulate alkaline detergent rinse to remove fat (1% wt/vol NaOH; 75°C, 30 min)
c) Rinse with hot water (75°C, 15 min)
d) Circulate nitric acid rinse to remove protein (0.7% wt/vol; 70 °C, 15 min)
e) Post-rinse with hot water (75°C, 15 min)

Producers should contact the manufacturers or distributors of commercial on-farm pasteurizers for cleaning instructions that best fit their equipment. Evaluating cleaning can include visual assessment for build-up of residual films plus cultures of pasteurized milk (e.g. standard plate count, total bacteria count, lab pasteurized count).

Potential problems

Dairy operations have to consider their supply of waste milk. To be practically effective a dairy operation must have a stable supply of waste milk. A stable supply of waste milk is critically important because the liquid feed fed to calves should not be changed frequently. For smaller herds this is sometimes difficult because days can go by where there is little or no waste milk. In these situation an alternative feed must be available, such as marketable milk from the bulk tank, milk from high somatic cell cows, milk replacer, or a milk extender.

Quality control is also an issue that demands constant attention. Milk pasteurizers need to be operated, evaluated, and maintained so a quality product is produced. Milk pasteurizers are also an investment requiring a return on investment.

Calves fed pasteurized waste milk may be contaminated with antibiotic residue and as result are un-saleable until after the appropriate withholding period.

The cost of equipment can be substantial, and the capital cost as well as the cost of managing the process should be carefully evaluated. If your operation does not have the management skill to properly purchase, install and utilize a pasteurizer, then it is important to make this determination prior to making the capital investment.

Maybe the greatest challenge with on-farm pasteurization is maintaining the equipment in proper repair and calibration so that the proper time and temperature is achieved consistently.

Tips for success

- Monitor pasteurizer function by routinely culturing samples of pasteurized milk.

- Train all employees that will be using the pasteurizer to be sure they understand how to operate the unit and what the concepts of pasteurization are.
- Conduct follow-up training and review for employees.
- Do not pasteurize extremely abnormal milk because nutritional characteristics may be altered.
- If calf death loss occurs, diagnose calf morbidities and mortalities.
- Know how to manually check the temperature of pasteurized milk to ensure proper temperatures are being met.
- Visit other operations successfully using on-farm waste milk pasteurization systems.

THE BOTTOM LINE

Pasteurizing waste milk can provide an opportunity to produce a low-cost, high-value liquid feed for calves, which if managed properly has the potential to substantially reduce the cost of rearing calves. Quality control, routine maintenance, and proper utilization of the waste milk are essential to ensuring the safety of milk for calves. As commercial units come down in price, more dairy operations may find it economical to install a pasteurizer on-farm. The decision process should weigh all of the advantages and disadvantages of milk pasteurization.

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