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Bacteria in Milk Sources and Control

Bacterial contamination reduces the quality of milk and can cause serious health problems. This NebGuide discusses common causes of contamination as well as prevention.

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Bacteria are single-cell organisms that multiply by dividing to form two cells (a process known as mitosis). Under optimum conditions, many bacteria can double in number each 20 minutes. That means one bacterium can result in up to 16,000,000 bacteria in just eight hours. They are microscopic in size, i.e., an individual bacterium cannot be seen without the aid of a microscope. They are so small that a single drop of water from a cow's udder might contain up to 30 billion (30 with nine zeros!) bacteria.

Bacteria are part of our everyday world. Given the different genus, species and strains, literally thousands of bacteria have been identified.

Many bacteria are beneficial and necessary. For example, bacteria are part of animal digestive systems, play a role in fermentation processes and aid in many life processes. Other bacteria are pathogenic, i.e., disease causing, and if present in sufficient numbers can cause illness or other impairment to daily living. Pathogenic bacteria are commonly present on the skin, in the udders of cows suffering from mastitis and in cuts, wounds, scratches, etc. They are present in great numbers in various infectious disease problems.

Milk marketing standards, e.g. Pasteurized Milk Ordinance (PMO), and procedures have been developed to help assure a wholesome product entering the food chain. Pasteurization of milk is standard practice to eliminate pathogens in the products purchased and used by consumers.

The growth of many kinds of bacteria can be reduced or stopped by refrigeration and freezing--two important practices in the preservation of food, including milk. However, refrigeration alone will not kill most bacteria. This is best illustrated by the fact that at normal refrigerated temperatures, milk will still, in time, turn sour.

Several methodologies are used to evaluate the bacterial content of milk. The most common procedure and the one used by the State of Nebraska, Department of Agriculture, Bureau of Dairies and Foods is called the standard plate count (SPC). With this test a measured quantity of milk is incubated for 48 hours at 90°

F before the number of bacteria is counted.

A second test which has become prevalent in recent years is the preliminary or preincubated (PI) bacteria count. This involves incubation at 55°F for 18 hours. The PI count provides a better estimate of pyschrophilic (cold-loving) bacteria and the level of on-farm sanitation. Pyschrophiles are usually non-pathogenic but are able to multiply under cold conditions, i.e., in refrigerated milk. These organisms attack proteins and fats, causing off-flavors and shortened shelf life. Although most psychrophiles are killed by pasteurization, the undesirable effects of their activity remain. The result is reduced yield of milk products, shortened shelf life, off-flavors, rancidity, etc.

The maximum allowable number of bacteria (SPC) in milk to be marketed for human consumption is 100,000 bacteria per milliliter (about 10 drops) of milk. Some dairy producers are satisfied with any bacteria count so long as they can market their milk. (Perhaps these people are really just cow milkers rather than dairymen!) Producers across the state have repeatedly demonstrated that milk can be consistently produced with low bacteria counts. Each year the Nebraska State Dairymen's Association Quality Milk Award program receives entries with bacteria counts averaging less than 1,000 for the entire year.

To encourage producers to implement practices which help assure low numbers of bacteria, many milk markets will pay a premium for milk with low levels of bacteria. Bonuses or premiums commonly range from 5 cents to 25 cents per hundredweight of milk.

With today's knowledge of mastitis control, there is no reason--short of occasional equipment failures, e.g., a hot water heater or wash cycle solenoid--for elevated bacteria counts on any farm. SPC bacteria counts should always be under 5,000 and PI counts should be under 25,000. Elevated bacteria counts indicate a lack of dedication to the production of high quality milk--and an apparent dislike or misunderstanding of the value of quality bonuses.

Control of Bacteria

High quality milk can only be produced by healthy cows, i.e., cows free of udder infection. Cows with elevated somatic cell counts (SCC) or mastitis are incapable of producing high quality milk until the inflammation and infection in the udder are brought under control. Because the quality of milk cannot be improved following extraction from the cow, the production of high quality milk requires an effective mastitis control program.

Once milk leaves the cow, the retention or preservation of milk quality requires cleanliness, sanitation and careful handling. Maximum benefits are derived only when these traits are applied to all aspects of the milk production system: cows, cow environment, milking system, milking practices or procedures and milk storage or cooling system. A deficiency in any part of the overall system will result in decreased milk quality.

The key words in controlling bacteria in milk are cleanliness, sanitation and cooling. Cleanliness applies to the cow, cow environment, milking area, personnel involved in milking and the milk storage area. Sanitation applies to the milking system and bulk tank. Cooling refers to the temperature of milk after it leaves the cow and how quickly it is cooled.

The following are key areas contributing to elevated bacteria counts and practices which can help inhibit bacterial growth:

- **Personnel--**Dirty clothes and dirty hands increase the risk of contamination of the cow and milking

system. Wear clean clothes during milking. Wash hands prior to starting milking and frequently during milking. Be sure to wash hands after handling any cow known or suspected of being infected and after contacting any part of the cow or her environment.

- **Cow Environment--**A dirty, muddy cow environment, including poorly maintained free-stalls or bedded-pack, will increase both udder infections, i.e., SCC scores, and bacteria counts. The cow environment should be clean, dry and comfortable at all times. Dry conditions inhibit bacterial growth. Poor or inadequate ventilation contributes to poor quality milk through enhanced bacterial growth (high relative humidity), cow immune system depression (stress from any source) and off-flavors (poor air quality in barn and milking area).

- **Cow Cleanliness--**Your goal should be to milk **clean**, not **cleaned**, cows. Clean cows reduce milking time labor, udder infections and bacterial contamination. Handling dirty cows is never fun--and being dirty is no treat for the cow either!

- **Clipped Udders--**The PMO requires udder hair to be kept short enough at all times to prevent udder hair from being drawn into the teat cup along with the teat. Unclipped udders accumulate more dirt, take more time to prepare for milking, decrease the ability to properly sanitize the udder prior to milking, and increase the likelihood of incomplete drying. A four-inch diameter circle around each teat is the minimum area that should be kept clipped. Clipping the bottom half of the udder is better than the 4 inch diameter and clipping the entire udder is recommended. As a minimum, clip the udders of all cows as they freshen and the entire herd each fall. Repeat as necessary. Some cows will need to be clipped three-to-four times per year.

- **Water Use--**Don't drown your cows in the milking area! If the cows enter with dirty udders, clean up the cow environment. Dirty teats and udders will nearly always become unhealthy eventually. Any part of the udder that is wetted at milking time must also be dried prior to milking.

- **Udder Wash--**Use water and an approved sanitizing product to wash teats prior to milking. (Laundry and dish detergents are not approved udder wash products.) A sanitizer is not a substitute for clean udders. Most, and perhaps all, sanitizers are quickly deactivated by organic matter, such as manure. Select an udder wash that is compatible with your choice of teat dip to minimize the risk of teat irritation.

- **Pre-dipping--**Pre-dipping is primarily a means of sanitizing teats with minimal wetting of the udder. Research results have been inconsistent and field studies and experience generally are non-supportive of pre-dipping as a means of controlling either SCC or bacteria levels. Pre-dipping is not a substitute for clean cows.

- **Udder Drying--**Clean and dry! High quality milk requires it. Control of udder infections demands it. Water draining and dripping off the udder during milking transports bacteria into the milk supply and to the teat end where the risk of entry into the udder is increased. Use single service paper towels. No towel should be used on more than one cow. Use as many towels per cow as necessary to get the udder and teats dry. Don't forget the ends of the teats! Paper towels are cheap compared to losses from mastitis, lost premiums, decreased milk yield, etc. The influence of various pre-milking teat preparation practices on bacteria levels in milk is illustrated in *Table I*. Note that regardless of the initial practice(s) used, drying causes an additional significant decrease in bacterial contamination.

Table I. Bacteria counts in milk associated with various teat preparation techniques (Source: Galton and Merrill, 1988).

Procedures on teats only					Bacteria in Milk* % Change
Water Hose	Wet towel	Pre-dip	Wash sanitizer	Manual drying	
X					- 4
X			X		- 3
X				X	-39
X			X	X	-49
	X				-27
	X		X		-30
	X			X	-63
	X		X	X	-68
		X			-34
		X		X	-54
*Percent change of bacteria in milk compared to no preparation.					

The influence of various pre-milking practices applied to both teats and udders on bacteria levels in milk is summarized in *Table II*. The data clearly show the importance of getting cows dry before milking.

Table II. Bacteria counts in milk associated with use of water hose in wetting both the teats and udder during pre-milking preparation procedures (Source: Galton and Merrill, 1988).

Water Hose	Wash Sanitizer	Manual Drying	Bacteria in Milk, % Change*
X			+13
X	X		-10
X	X	X	-68
*Percent change of bacteria in milk compared to no preparation.			

- **Infected Udders**--Most mastitis pathogens have little influence on bacteria counts. However, *Streptococcus agalactiae* (Strep ag) and *Prototheca* sp.--both causes of mastitis--are shed in numbers great enough to increase bacteria counts in tank milk.

- **Good Housekeeping**--Keeping the entire milking center clean reduces the risk of contamination of milking equipment and the cows' teats. Bacteria are easily transferred from the environment to the cow by the milker's hands or the milking system, e.g., a unit fall-off. A clean milking area and milk room have fewer bacteria present. A clean milking environment also reflects pride in producing good quality milk.

- **Sanitize before Milking**--The milking system should be sanitized immediately prior to each milking, within one hour of milking time. Failure to sanitize prior to every milking is a common

cause of erratic bacteria counts. Match the quantity of sanitizer to your water quality. The sanitizing solution should be circulated for 3-5 minutes and maintained between 95°F and 110°F throughout the cycle. Pre-milking sanitizing is required by the Federal and State PMO.

- **Minimize Air Admission**--Excess air admission through poor unit attachment technique, uncontrolled squawking, over-sized air vents and poor unit removal technique will degrade milk quality. Air in a milking area contains dust, moisture--and bacteria! In addition to introducing bacteria, excessive air causes foaming which increases rancidity and off-flavors, and decreases shelf life.

- **Dip Teats**--Dipping teats is a known requirement for an effective mastitis control program. Healthy teats will have fewer bacteria present because of greater ease of sanitizing the teat prior to milking. An effective teat dip will dilute or remove the residual milk film from the teat surface. The result is reduced opportunity for bacterial growth and reduced incidence of **new** infections. Dip teats with an effective product after every milking--year-round! Start each milking with a fresh supply of uncontaminated product and a clean dipping device. Teat dip applicators should be washed after every milking.

- **Maintain Rubber Goods**--Rough surfaces on inflations and milk hoses are nearly impossible to clean and sanitize. Chlorine-based detergents are detrimental to synthetic rubber, as commonly used for inflations and milk hoses, and can deteriorate the inner surface. Change inflations and milk hoses at regular intervals.

- **Clean the Milking System**--In an apparent attempt to save water and cleaning chemicals some producers run a complete wash cycle only once per day. Others run an acid rinse cycle only weekly or when they think their system needs it. Such practices contribute to erratic and elevated bacteria counts. Omitting the acid rinse hastens the deterioration of rubber goods and allows minerals from the wash water to accumulate in the milking system. Both situations make cleaning and sanitizing of the milking system more difficult. Use a complete wash cycle with appropriate cleansers or chemicals--at the appropriate concentration--after every milking.

- **Monitor and Maintain Washing System**--The performance of the wash cycle is influenced by water volume and temperature; slugging (by an air injector or other means) to wash the top side of pipes and milk lines, interior of claws, meters, weigh jars, etc.; chemical concentration; etc. When using powdered chemicals, be sure they dissolve. Periodically check cycle times and water temperature. Recommended parameters are: post-milking pre-rinse--3-5 minutes, 95-110°F; detergent wash--8-10 minutes, 120-160°F; and acid rinse--3-5 minutes, 95-110°F. The high temperatures are maximums at start of cycle. The low temperatures are minimums for end of cycle. Do not recirculate the post-milking pre-rinse water. Run clear water through just long enough to assure the return water is clear, and not a milky color.

- **Milkline Inlets**--Periodically inspect milk hose inlets to the milkline. The variety of angles and surfaces can be difficult to clean. The inlets should be in the upper half of the milkline.

- **Check Drainage**--The PMO requires all lines and hoses to be self-draining. Proper drainage enhances drying and reduces bacterial growth. Proper drainage also reduces the risk of violations due to added water or sanitizers, i.e., growth inhibitors, entering the milk supply.

- **Maintain Water Temperature**--Low end-of-cycle water temperatures are a common problem and make proper cleaning of a milking system more difficult. Low milk room temperatures, longer-than-necessary cycle times and inadequate start-of-cycle water temperatures make the problem worse. If

necessary, invest in a double wall insulated wash vat. A plexiglass cover placed over the wash vat will help retain heat and reduce cooling of the wash water. Some reports indicate a cover can reduce water cooling by 20-25°F. Be sure the water heater has adequate capacity and the temperature is set high enough. Increasing the milkroom and milking area temperature during the wash cycle is also beneficial.

- **Milk in Proper Direction**--In a tie-stall barn with an around-the-barn pipeline, start milking at the low end of the milkline (usually at the milkroom) and work towards the high end. (This is opposite of the practices of most producers!) This prevents drying of milk or the accumulation of milk fat on the cool line at the high end of the system. The result is easier and more complete cleaning with less water and chemicals.

- **Use Proper Cleaning Chemicals**--Most chemicals have a fairly narrow temperature range for maximum effectiveness. Be sure the water temperatures and optimum chemical temperatures are matched in your system. Match water quality and cleaner quantity for most economical and effective use of your cleaning chemicals. Check water quality at least annually.

- **Store Cleaning Chemicals Properly**--High temperatures and open surfaces allow the chlorine in the chlorinated detergent to escape as a chlorine gas. The result is less effective cleaning. Monitor shelf life. Buy chemicals in lot sizes consistent with your usage rate and the storage time of the chemicals. Monitor expiration dates. Insist on fresh chemicals from your supplier. Most chemicals must also be protected from freezing.

- **Assure Adequate Airflow**--More airflow (cubic feet of air per minute or cfm) is required to wash a milking system than to milk cows. Some producers use two or more pumps in parallel for milking but fewer pumps for washing. In general, this practice results in less than optimum cleaning. Do not reduce airflow capacity during the wash cycle. The energy saved is easily offset by poor cleaning and reduced milk quality.

- **Monitor Cleaning Cycle Effectiveness**--A greasy film or beads of water on the inside of milklines, receiver, claws, etc. or a shiny appearance on a dry surface indicates inadequate cleaning. A properly installed and maintained milking system is easy to keep clean.

- **Check Water Quality**--State regulations require periodic checking of the farm water supply for coliform bacteria. A water supply can be free of coliform bacteria but loaded with other types of bacteria. Such conditions are usually the result of poor system design and/or maintenance.

- **Prevent Back-siphoning**--High pressure pumps, cattle watering devices, etc. must be equipped with air gaps or some other positive-closure device to prevent backflow into the potable water system. The absence or failure of a backflow prevention device can cause a contaminated water supply.

- **Keep Milk Mixed**--Failure to operate the bulk tank agitator during milking can result in "pockets" of warm milk in which bacteria can multiply rapidly. Be sure the agitator starts at the beginning of milking. Keeping warm and cooled milk blended will result in more uniform cooling and reduced bacterial growth.

- **Cool Milk Quickly**--To enhance milk quality, milk from the first milking should be cooled to 40°F or less within 30 minutes. The blend temperature on subsequent milkings should be kept below 45° F. A maximum blend temperature of 40°F is better. The maximum blend temperature permitted by the Federal and State PMO is 50°F. Milk should be stored at 35-36°F. Check your bulk tank thermometer to ensure it is registering the correct temperature. Storage temperatures below 35°F

will lower fat tests and cause rancid flavor due to freezing of a thin layer of milk on the cooling plate.

- **Check Bulk Tank**--Examine the interior of the bulk tank after washing and allowing to dry. A greasy or shiny surface indicates inadequate washing. Check the tank washer, water temperatures and chemical dispenser(s) for proper settings and function.

- **Don't Use Drain**--Using the bulk tank drain to extract milk for calves, household use, etc. is convenient but is not recommended. Proper and thorough cleaning of the valve assembly after such use is impossible. The milk left within the valve assembly will not be maintained at a low enough temperature and will enhance bacterial growth, especially during warm weather. Some people discourage accessing the tank through the lids but that procedure is better than using the drain. Always use a clean, sanitary dipper to extract milk. Do not dip pails, jars, etc. into the tank.

Conclusion

Trouble-shooting a high bacteria count problem requires looking at and evaluating nearly every aspect of the milk production system. To consistently produce high quality milk with low bacteria counts requires continual attention to numerous details. You would not be satisfied with any other product or equipment on your farm that just barely met minimum performance standards. Don't accept minimum standards in the product you sell either. Your future could depend upon a better dairy product.

QUALITY PAYS!

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