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W149-Bulk Tank Milk Quality

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Kristy H. Campbell, Extension Dairy Specialist, Animal Science

Who is responsible for the safety and quality of dairy products? Dairy producers? Processors? Retailers? Consumers? In fact, all of these parties – from farm to fork – share in this responsibility. What starts as a high-quality product on the farm can be ruined somewhere along this chain. However, a poor-quality, inferior raw product leaving the farm cannot be transformed into a safe and high-quality product for the consumer. Despite technical advances in milk processing, the safety and quality of dairy products is still determined on the farm. Pasteurization does provide a certain level of safety, but is not the ultimate tool for protecting and satisfying consumers. Many aspects of milk safety and quality cannot be changed through pasteurization. The dairy industry continues to develop and adopt testing methods to gauge the safety, quality and suitability of raw milk for processing. It is vital that dairy producers understand these tests and their role in producing a safe, high-quality and nutritious product.

Dairy Product Safety

Bacteria are present in raw milk as a result of milking cows with mastitis, contamination from the environment during milking, contaminated milking and handling equipment and/or bacterial growth during storage. Pasteurization is an effective method of destroying mastitis-causing bacteria, foodborne pathogens and other bacteria in milk. However, it does not destroy ***all*** bacteria, and it does not destroy heat-stable toxins produced by some bacteria found in bulk tank milk. Several bulk tank milk studies have detected the presence of foodborne pathogens in bulk tanks (5, 6, 9, 11, 15, 19, 21, 22, 23, 25, 26, 28, 29, 30, 31, 32, 34, 40, 41, 42, 44). Outbreaks of disease in humans have been traced back to the consumption of raw ***and*** pasteurized milk (1, 2, 8, 10, 12, 13, 17). Some pathogens such as *Listeria monocytogenes* can survive and thrive for extended periods in reservoirs on processing equipment and are difficult to eradicate. This can lead to recontamination of dairy products (33, 45, 46). Though this may appear to be an issue only at the processing level, reducing foodborne pathogens in raw milk will ultimately reduce consumers' risk. Additionally, some strains of bacteria, specifically *Staphylococcus aureus*, produce toxins and have been reported to cause a number of disease or food poisoning outbreaks because of ingestion of contaminated milk or dairy products (1, 2, 13).

Dairy Product Quality

Bacteria in milk, whether originating from the cow or the environment, can significantly impact the quality of dairy products and therefore consumer acceptance. Many bacteria produce heat-stable enzymes. These enzymes are not affected by pasteurization and continue to cause damage to fat and/or protein in the final product. Enzymes that break down milk fat release free fatty acids, which can result in off-flavors and rancidity (3). Enzymes that break down milk protein can cause bitter flavors in milk. Because of bacterial enzyme activity before and after pasteurization, milk quality is altered, resulting in reduced shelf life (24).

Somatic Cell Count (SCC)

It has long been recognized that milk containing a high number of somatic cells will have reduced cheese yield. However, in a fluid milk market, such as in the South, there seems to be much debate over the value of SCC as a safety and quality parameter. At this time, there is no known direct human health concern with consuming milk containing a high number of somatic cells (white blood cells) from cows (16). However, relationships do exist between elevated SCC and other safety parameters, in particular antibiotic residues (36, 37, 38, 43). Thus, the SCC of milk is an *indirect* indicator of product safety. In sensory evaluations (i.e., taste-tests), pasteurized milk made from milk containing a high number of somatic cells (>500,000 cells/ml) scored lower than milk containing a lower SCC (250,000 cells/ml) (27) and also had a reduced shelf life (24). Cows with elevated SCCs have experienced an intramammary infection, likely caused by bacteria.

As stated earlier, enzymes produced by bacteria cause compositional changes in milk before and after pasteurization, which can affect quality. Therefore, SCCs are used more as an *indirect* indicator of quality. Some processors place a lot of emphasis on SCC limits. Although the Pasteurized Milk Ordinance (PMO) sets the legal limit at 750,000 cells/ml (2005), one processor in Tennessee has a quality standard of 350,000 cells/ml. At this time, other processors do not place as much emphasis on SCC but rather set quality standards based on bacteria counts.

Standard Plate Count (SPC)

The SPC is specified by the PMO as the official regulatory test used for estimating bacterial numbers in raw milk. For Grade A milk, the PMO requires a SPC < 100,000 colony forming units(cfu)/ml (2005). However, industry standards may be much lower than this. A SPC is run by incubating a sample at 89.6 degrees F (32 C) for 48 hours, followed by counting bacterial colonies (35). Since bacteria are miniscule in size, the incubation period provides bacteria an ideal environment to grow and proliferate to a size that can be detected and counted. However, there are problems associated with using the SPC alone. The SPC gives no indication as to the types of bacteria present and does not indicate the specific source of contamination. Moreover, the SPC may not give a complete count of all bacteria in milk, because some bacteria only grow at lower temperatures. So cold-loving bacteria are still present in the milk and could damage the product, but this would not be apparent with a SPC alone (7).

Preliminary Incubation Count (PIC)

The PIC has gained importance in quality testing as it measures bacteria that thrive in lower temperatures. Psychotrophic (i.e. cold-loving) bacteria can grow at temperatures from 32 to 68 degrees F (4) and are mostly comprised of gram-negative bacteria (pseudomonas, coliforms, flavobacterium and alcaligenes) (7).

The PIC is a two-step process. First, the sample is "pre-incubated" at 55 degrees F (12.7 C) for 18 hours. This allows cold-loving bacteria to grow and get a 'jump start' on bacteria that require warmer temperatures. The second step is to incubate at 89.6 degrees F (32 C) for 48 hours (a typical SPC) to allow the warm-loving bacteria to grow. Following incubation, all bacteria are counted (7). Because of this two-step approach, it is possible to conduct a SPC and a PIC on the same sample and get completely different results. However, this process also gives a more complete and accurate determination of the bacterial population in milk. Unfortu-

nately, as with the SPC, a PIC does not indicate the specific source of contamination and requires a very broad approach when problem-solving milk with high PICs.

Laboratory Pasteurized Count (LPC)

At one time, the LPC was an important quality parameter for many processors, but emphasis is now changing from LPCs to PICs. However, it is still important to recognize and understand this method of testing. The LPC is conducted by heating a sample to 145 degrees F (62.8 C) and holding it at that temperature for 30 minutes. This method simulates a low-temperature, long-time pasteurization process. After incubation, the number of bacteria are counted (35). The purpose of the LPC is to determine the levels of bacteria that can survive pasteurization. These heat-loving bacteria (thermoduric) are typically found in soil and often form spores, a survival mechanism making them resistant to many agents, including sanitizers (18). Thermoduric bacteria include: Micrococcus, Microbacterium, Lactobacillus, Bacillus, Clostridium and occasionally *Streptococci* (35). These bacteria retain their activity and can affect quality of a post-pasteurized product.

Coliform Count (CC)

The CC is performed by culturing dilutions of raw milk on selective media and incubating at 90 degrees F (32 C) for 24 hours to promote growth of coliform bacteria (35). Typically, the CC is used as an indicator of unsanitary production practices. High CCs can originate from dirty cows, poor milking hygiene, poor cleaning and/or sanitizing of equipment or bacterial growth on milking equipment. Additionally, CCs may also be influenced by coliform mastitis. This fact is somewhat dismissed, because typically, cows infected by coliforms either shed relatively low numbers or are acutely infected and their milk is not likely placed in the bulk tank (18, 20). However, in some coliform infections, the number of coliform bacteria can reach several million/ml in the infected quarter before clinical signs are visible (39). Milk from the infected cow would not be held out of the bulk tank until the next milking when signs of infection are apparent.

Conclusions

Providing a safe, high-quality and nutritious dairy product is challenging, because all aspects of the production chain, from the farm to the consumer must be considered. However, the initial responsibility rests with dairy producers that provide raw milk. A high incidence of mastitis (subclinical or clinical) and on-farm contamination of milk with bacteria found in the dairy farm environment leads to safety and quality issues during processing. The dairy industry has developed many direct and indirect measurements of raw milk safety and quality. A better understanding of these measurements will allow producers to adopt production practices that will result in a safer and higher-quality raw product that meets legal standards, industry-placed quality standards and consumer acceptance.

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