

# Bacteria in Milk

**M**ILK from a healthy cow is free of all bacteria and microorganisms. Because preventing bacteria from contaminating milk is nearly impossible, the job of the processor is to minimize the damage that results from bacterial invasion.



## Objective:



Describe how bacteria can cause milk products to sour.

## Key Terms:



coagulate  
ecological succession  
mastitis  
pH  
pre-dipping  
putrefaction  
sanitation  
spoilage  
*streptococcus lactis*

## Controlling Bacteria in Milk

Before bacteria can be controlled, they must first be studied and identified. Milk bacteria will experience **ecological succession**, a gradual process in which a species population is replaced by the establishment of a new species. Many of the common forms of bacteria found in pasteurized milk appear in distinct stages, depending on the age of the milk.

***Streptococcus lactis*** is a common species of bacteria found in milk and normally the first kind of bacteria observed in souring milk. This type of streptococci bacteria will metabolize lactose (milk sugar), forming lactic acid as an end product. Eventually, lactic acid will cause the **pH**, or the measure of acidity or alkalinity of a solution, to become so acidic that streptococci are no longer able to grow. At this point, lactobacilli begin to populate the liquid milk.

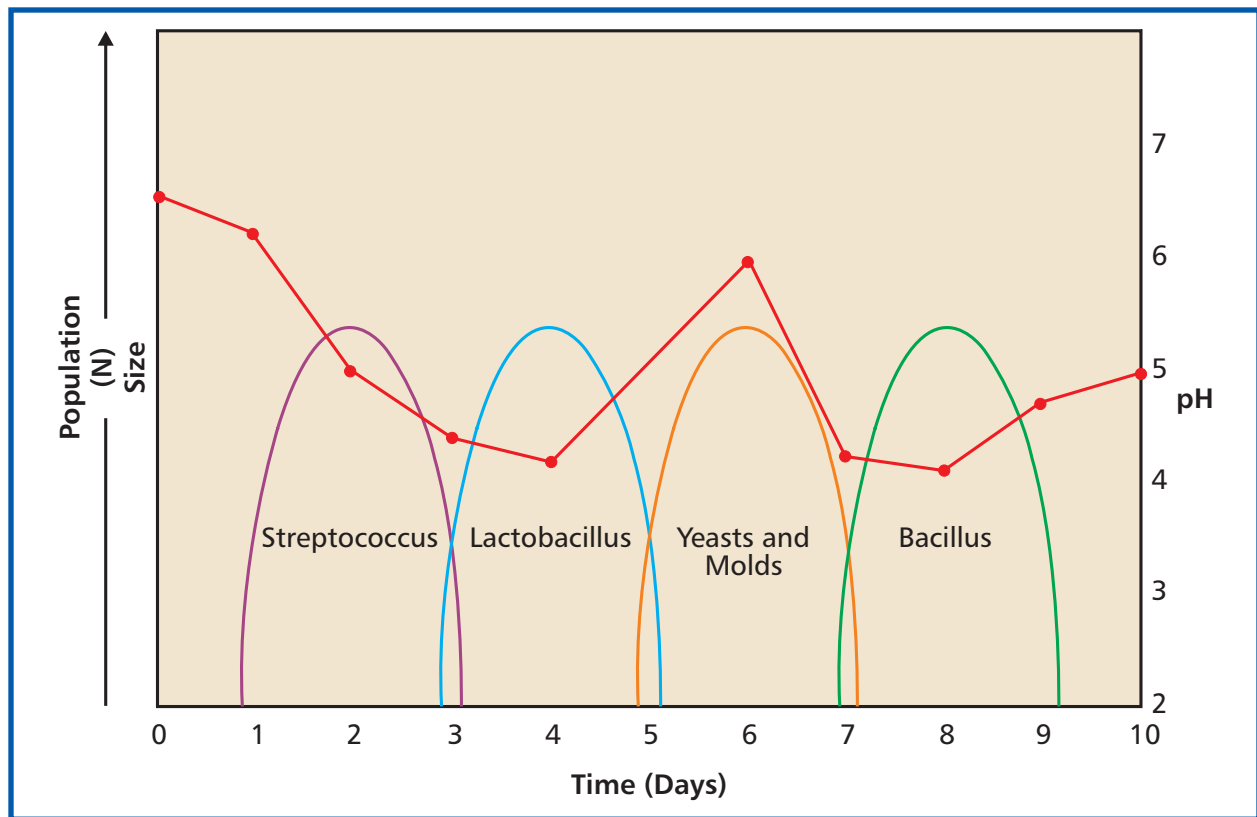


FIGURE 1. Ecological succession of bacteria in milk.

Lactobacilli are a type of bacteria that will continue to metabolize lactose and produce lactic acid. Eventually, the buildup of lactic acid will also inhibit the lactobacilli, and their growth will stop. Lactic acid causes milk proteins to **coagulate**, or form noncrystalline solids from a liquid. Coagulation by lactic acid will cause the liquid milk to form a viscous, jellylike substance by chemical reaction, not evaporation. The coagulation of milk proteins is also known as curdling, which eventually leads to milk spoilage.

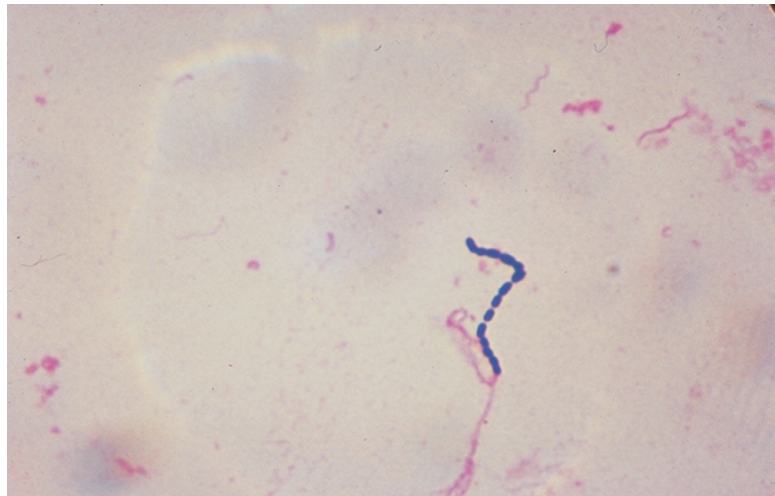


FIGURE 2. *Streptococcus lactis* is a common bacterium found in spoiling milk products. (Courtesy, USDA)

Yeasts and molds quickly take up where lactobacilli leave off. Both yeasts and molds enjoy the now acidic environment of the milk and flourish there. They begin to metabolize the lactic acid in milk into nonacid products as spoilage continues.

Finally, *Bacillus* species begin to populate the milk product. Proteins are the only nutrient source left in the acidic milk environment and are quickly used by *Bacillus* bacteria. These bacteria metabolize remaining proteins into ammonia compounds. This causes the pH level to rise, or become more alkaline. Using enzymatic action, *Bacillus* bacteria digest the remaining milk proteins for energy.

At this point, **spoilage**, or the change in a food product that makes it unacceptable for consumption, is evident by the offensive odor of the milk. Fluctuations in the pH of milk are due to fermentation and **putrefaction**, the chemical decomposition of organic matter. Milk that has spoiled tastes and smells bitter, sour, rancid, and putrid. These flavors and odors exist because of amino acids and peptides that remain after the milk proteins and sugars have been fermented.

Although bacteria cause milk products to spoil, bacteria that would harm humans are usually not found in milk unless introduced by a diseased or infected cow or an infected milk handler. Some bovine diseases can be transmitted to humans under the correct conditions. Brucellosis, tuberculosis, and mastitis are all dangerous diseases that can be passed to humans in infected milk. **Mastitis** is an extremely contagious infection of the udders of milking animals. It has been estimated that 40 to 50 percent of dairy cattle in the United States have been affected by mastitis in at least one-quarter of their udders.



**FIGURE 3.** Milk spoilage can be attributed to a number of environmental factors that encourage the growth of bacteria.



**FIGURE 4.** This cow's udder has a serious mastitis infection that makes the animal's milk unfit for human consumption. (Courtesy, USDA)





## UNDER INVESTIGATION...

### LAB CONNECTION: Pasteurized Milk as an Ecological System for Bacteria

From the earliest domestication of cattle and goats, milk has been one of the most important and nutritious foods for humans. Using beneficial bacteria and yeasts, milk can be transformed into some of our favorite fermented and cultured dairy products, such as yogurt, buttermilk, and sour cream.

Bacterial succession is the primary reason for milk spoilage. Dairy products, like all perishable foods, are subject to bacterial contamination and will ultimately spoil. Most of the bacteria that cause spoilage are introduced to milk during collection and processing. By studying the methods used and maximizing sanitation techniques during milk collection and processing, bacteria can be held in check, giving milk, as well as other dairy products, longer usable shelf lives. In an effort to inhibit bacterial growth and preserve milk products, scientists are continually studying the bacteria that spoil milk.

Through laboratory experimentation, milk can be monitored for changes in pH levels as bacteria populate the milk. Whole milk, fat-free milk, buttermilk, and chocolate milk samples are placed in flasks and inoculated with bacteria. The samples are stored at different temperatures. Portions of the samples are then transferred to agar plates. The pH, odor, color, and bacterial growth of each milk sample at each temperature are monitored daily, and a record is kept of the observations.



The pH level of milk can be used to determine the rate of bacterial succession.

## MILK SPOILAGE

All milk, regardless of processing method, will ultimately begin to spoil. Several factors, however, will determine how quickly bacteria will grow in milk and cause the product to sour.

Bacteria found in milk are similar to bacteria found elsewhere in our world. They rely on the same environmental conditions to live, grow, and reproduce as nearly all species of microorganisms.

Most bacteria prefer a warm temperature at which to thrive. The bacteria found in milk will reproduce more quickly as the temperature rises, up to the temperature where they are destroyed. Bacteria also prefer an environment that is acidic, or less than 7 on the pH scale. The acidic environment provides the food sources that bacteria thrive on and encourages their

growth up to the point where they are inhibited by strong acidic conditions. Finally, bacteria prefer unsanitary conditions. Milk that has come from a diseased cow or has been contaminated during the milking or handling process will have higher counts of bacteria. This, in turn, will cause rapid spoiling of the milk.

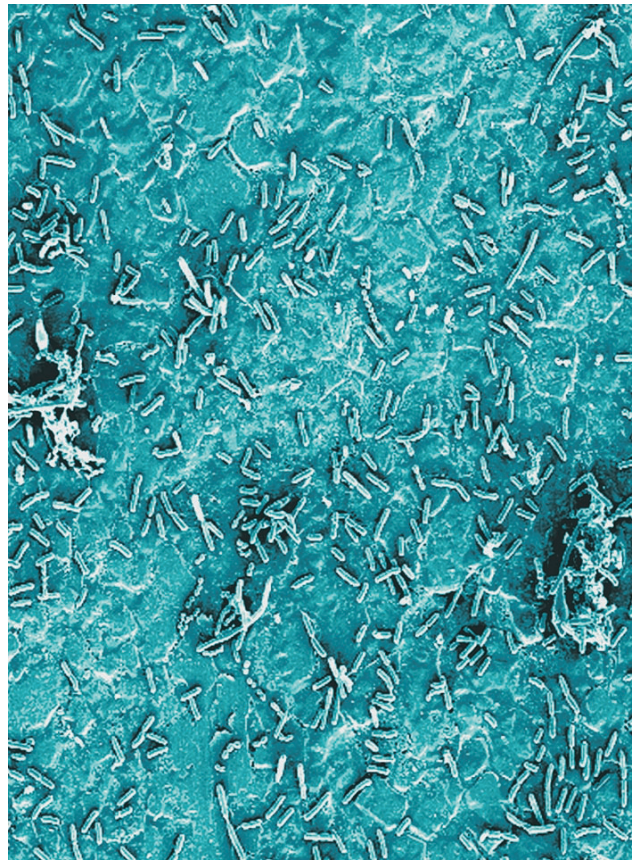
### Reducing the Rate of Spoilage

Milk spoilage, although unpreventable, can at least be inhibited or slowed down. Several procedures commonly practiced by dairy producers can impede the rate of bacterial growth and milk spoilage.

The most common procedure practiced by all milk processors is pasteurization, or the heating of milk to kill harmful microbes. Pasteurization greatly reduces the number of bacteria present in milk but does not kill all bacteria. Thus, milk spoilage still occurs over time. Many times, pasteurization is completed at a processing plant where milk is also homogenized, packaged, and shipped to retail stores.

Other ways of preventing bacterial contamination are usually practiced right in the milking parlor before, during, and after a cow has given milk. These practices include:

- ◆ Utilizing proper **sanitation**, the practice of keeping employee hands, clothing, and equipment free of bacterial contamination.
- ◆ Keeping all milking stalls clean from mud, manure, and other foreign material that could harbor bacteria.
- ◆ Keeping the udders clean from mud and manure and keeping udder hairs clipped short to prevent a location for bacteria to grow.
- ◆ Washing, drying, and **pre-dipping** (a process of dipping each teat into an antibacterial solution before milking) to reduce the number of bacteria present on the exterior of the udder.
- ◆ Washing and sanitizing all milking equipment regularly, including the milking units, collection hoses, and storage tanks.
- ◆ Cooling the milk to a temperature of 40°F (4.4°C) as soon as possible after milking. Dairy producers must have the facilities to cool the milk on site to prevent bacteria from growing before the milk can be transported to a processing plant.



**FIGURE 5.** The bacteria that infect milk rely on the same environmental conditions required by nearly all bacteria. (Courtesy, Agricultural Research Service, USDA)



## UNDER INVESTIGATION...

### LAB CONNECTION: Souring Milk

Milk is a liquid rich in nutrients to help our bodies grow strong and healthy. Milk contains carbohydrates in the form of lactose (milk sugar), nitrogen in the form of casein (a milk protein), and minerals, including calcium and phosphate. The components of milk make a perfect food for the energy our bodies need on a daily basis. Unfortunately, milk is also equally favorable for the growth of bacteria and other microorganisms that will spoil the product.

To prevent the growth of microorganisms, specifically bacteria, in milk, the process of pasteurization is commonly used. With pasteurization, milk is heated to high, but not boiling, temperatures that kill nearly all the bacteria present in the milk. Pasteurization, along with proper handling, processing, and refrigeration methods, has increased the shelf life of liquid milk and other dairy products. The quality of milk for human consumption is based on the number of bacteria present in the milk at a given time. Scientists and milk processors are continually monitoring fresh milk, testing levels of bacteria to ensure that the consumer is receiving a quality and safe milk product.

An experiment can be performed to monitor the rate of bacterial growth in milk by testing the acidity of the milk liquid. As bacteria grow and reproduce in milk, the pH level of milk drops. This indicates the succession of bacteria in the liquid. The final stage of bacterial growth by *Bacillus* species will actually cause a slight rise in the pH level of the milk. The percentage of acidity of milk samples is determined by adding sodium hydroxide and an indicating solution.



A variety of milk products can be used to experiment with factors that affect milk spoilage.



**Table 2. Decrease in Bacterial Count Due to Various Udder Preparation Methods**

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 with no preparation.

Source: Galton and Merrill, 1988.

## Summary:



Milk bacteria experience ecological succession, a gradual process in which a species population is replaced by the establishment of a new species. Although bacteria cause milk products to spoil, bacteria that would harm humans are usually not found in milk unless introduced by a diseased or infected cow or an infected milk handler.

All milk, regards of processing method, will ultimately begin to spoil. Most bacteria in milk reproduce more quickly as the temperature rises, up to the temperature where they are destroyed. Bacteria also prefer an environment that is acidic, up to the point where they are inhibited by strong acidity. Finally, bacteria prefer unsanitary conditions. Dairy producers commonly practice several procedures that impede the rate of bacterial growth and milk spoilage.

## Checking Your Knowledge:



1. What is the correct order of bacterial succession in milk?
2. What is mastitis?
3. What are four ways of decreasing bacterial contamination in fresh milk?

## Expanding Your Knowledge:

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Take a field trip to a local dairy farm to observe milk collection and handling. List the procedures and precautions used to protect collected milk from bacterial contamination.

## Web Links:

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### University of Nebraska—Bacteria in Milk Sources and Control

<http://ianrpubs.unl.edu/dairy/g1170.htm>

### Pasteurization

<http://www.foodsci.uoguelph.ca/dairyedu/pasteurization.html>

### Agricultural Career Profiles

<http://www.mycart.com/career-profiles>