



Investigating Milk and Bacteria Growth

Suggested Grade Level: 6-8 grades

Time: Three 45-minute class periods, plus observation time of a few days or a week

Subject: agriculture, science, social studies, ELA, counseling, FACS, library/information, and technology

Overview: This lesson uses pasteurized and **ultra-high-temperature (UHT) milk** to help students learn how different temperatures affect the growth of spoilage bacteria. Students compare refrigerated milk and shelf-stable milk, review the Kansas dairy industry, explore dairy-related careers, experiment on living food, and investigate technological advances that improve food safety.

Learning Objectives:

1. Identify living food
2. Explain milk processing practices
3. Compare the differences between pasteurized and ultra-heat temperature milk
4. Define the danger zone as it relates to food preparation and storage
5. Investigate bacteria growth
6. Work with a group to conduct an experiment
7. Form a hypothesis, record data, and draw conclusions from an investigation
8. Share facts about the Kansas Dairy Industry
9. List careers available in the dairy industry

Background Information:

Much of the food processing occurring between the farm and the grocery store aims to keep our food safe. How do we know if our food is safe to eat? Bacteria (*single-celled organisms*) are present everywhere. The bacteria in milk can multiply quickly, causing the milk to spoil. Spoiled milk can make us sick. There are many ways to limit and control bacteria in food.

Keeping food at safe temperatures is one of the easiest ways to prevent the growth of bacteria that cause illness. Leaving food at room temperature for too long can put the food into a "danger zone." By learning about how temperature affects the growth of bacteria, students will better understand how they should prepare and store food at home to help reduce bacterial growth.

The technology of dairy science is continually improving, but some fundamentals remain the same. Pasteurization and UHT are different ways of using heat to process raw milk to reduce bacteria.

Pasteurization:

A heat treatment is performed at the milk processing plant, which destroys harmful bacteria without affecting the quality of the milk. Milk may be pasteurized to kill bacteria using a low heat method (145°F or 63°C for 30 minutes) or a high heat method (162°F or 72°C for 15 seconds). Pasteurization does not kill all the bacteria in raw milk but kills pathogens that may cause disease. Bacteria that remain after pasteurization eventually cause milk to be sour (spoil). Pasteurized milk is refrigerated to slow the growth of spoilage bacteria. Why Pasteurize? There are risks to be considered when drinking raw, unpasteurized milk. Raw or unpasteurized milk can carry dangerous bacteria such as Salmonella, E. coli, and Listeria, which are responsible for causing numerous foodborne illnesses. These harmful bacteria can seriously affect the health of anyone who drinks raw milk or eats foods made from raw milk. Still, the bacteria is especially dangerous to pregnant women, children, the elderly, and people with weakened immune systems.

Homogenization

When milk is left un-homogenized, the fats eventually rise to the top and create a layer of cream (hence the phrase "only the cream rises to the top"). Homogenization breaks down fat molecules by heating and vigorously pounding the milk through tiny holes, allowing them to stay suspended in the rest of the liquid which then prevents the cream (fat) from rising to the top. Milk is treated mechanically (with no chemicals or additives) to create smooth, even consistency. This process also allows the milk to be filtered with different fat levels to create whole milk, 2%, and 1% milk. Milk can be pasteurized but not homogenized, and vice versa.

Ultra-high-temperature treatment

UHT milk has been heated to a high temperature and can be stored on a shelf for up to 90 days. Milk is heated to at least 280°F (138°C) for 1 or 2 seconds, then packaged in sterile, airtight containers. UHT milk contains fewer bacteria because of the high heat and special packaging than conventionally pasteurized milk. After opening, spoilage time for UHT milk is similar to that of conventionally pasteurized milk. Therefore open containers should be refrigerated just like pasteurized milk.

Kansas Connections:

Dairy Facts

- Within the United States, Kansas ranks 16th in milk production.
- Kansas is home to 173,000 milk cows on a mixture of more than 220 licensed small and large dairy farms that produced more than 470 million gallons of milk in 2020.



- Each cow produces about 7.5 gallons of milk a day which is more than 2,730 gallons a year.
- Kansas has six plants that produce dairy products. Kansas also has nine on-farm or specialty processing facilities that produce milk, cheese, and ice cream, among other products.
- In 2019, Kansas dairy exports totaled \$102 million.
- Dairies create a ripple effect on the rural economies of Kansas. For every dollar a dairy farm spends, roughly \$2.50 in wages and related business transactions is contributed to the local economy.
- Dairies offer jobs on the farm and throughout the industry in areas including trucking, breeding, sales, repair, veterinary, pharmaceutical, nutritional, quality control, and consulting.

Materials in the kit:

- “Investigating Milk Lab Journal”
- 30 test tubes with caps and labels (6 tubes for 5 groups)
- 16 oz shelf-stable UHT (10ml or 2 tsp. for each tube)
- 1 30 ml bottle Methylene blue dilute solution

Materials provided by teacher:

- refrigerator with freezing compartment
- copies of the “Investigating Milk Lab Journal” for each student
- markers to label test tubes (one for each group, 5)
- Write on tubes or use tape for labels
- 12 oz of 2% milk (10 ml or 2 tsp. for each tube)
- Pipettes, syringes, or measuring spoons to measure milk and fill test tubes (2 for each group)
- Containers to hold the tubes in each location (cups or tube racks)
- Paper towels to clean up any drips or spills

Instructional Format:

1. Share background information with students.
2. Conduct engagement exercises.
3. Complete preparation activities: dairy careers, food safety, and types of milk.
4. Follow procedures to conduct lab experiments.
5. Observe and record findings (3-4 days).
6. Finish observations and make conclusions.

Engagement:

Discussion questions: What do you know about dairy farms?
How do you know if the milk you are drinking is safe?



Show the YouTube video “[Virtual Dairy Farm of Hildebrand Farms in Kansas](https://www.youtube.com/watch?v=KatyIrqag00)” <https://www.youtube.com/watch?v=KatyIrqag00> (43:42).

Exercise: On the “Investigate Milk Lab Journal,” write three questions about milk safety.

Preparation Activities:

1. Review **related careers** associated with the farm table process of milk.
 - a. Brainstorm with students all the careers or jobs involved in the production of milk and dairy products (cheese, yogurt, and ice cream), and list careers on the board. Begin on the farm and progress through milk transportation, processing, and distribution. Prompt students as they brainstorm, and fill in the gaps as you go. Be sure to add a quality control manager to the board and circle it at the end of the session.
 - Dairy Farm Workers: farmer (plants and harvests feed for the cows), farm manager (oversees all operations), herdsman (cares for the cows), milking staff (takes shifts milking the cows twice a day every day of the year), sanitation (cleans pens, barn, and milking equipment).
 - Transportation: truck drivers (pick up and deliver raw and/or processed milk, diesel mechanics (work on farm equipment and trucks that haul milk), fuel services (buys, sells, and delivers fuel)
 - Processing plant: plant controllers (oversee financials of operation, hiring, etc.), processing plant workers (operate machines, manage incoming and outgoing products, etc.)
 - Quality Control: managers (monitor the quality of products and make process adaptations), quality assurance technicians (take samples and report findings).
 - Food Scientists develop products and study nutrition.
 - Retail: grocery store workers, managers, etc.
 - Other related professions: animal nutritionist, engineer, veterinarian, construction worker, maintenance worker, etc.
2. Introduce quality control concepts and milk safety.
 - a. Leading discussion: Have you ever wondered why milk is kept in the refrigerator? What might happen to milk if left out at room temperature overnight? What is room temperature? What is the temperature of the room now?
 - b. Introduce the “Food Danger Zone.” Bacteria grow most rapidly in the range of temperatures between 40°F and 140°F. This range of temperature is often called the “danger zone.” At danger zone temperature, the bacteria that contaminate food and cause illness can double in number in just 20 minutes.

- c. Discussion: Quality control managers ensure milk never enters the food danger zone as it is processed and transported from farm to store. What are some other steps from the farm to the store? Milk is checked for bacteria before it is loaded into a truck, again before the truck is unloaded at the processing plant, in the storage tank at the processing plant, and after it is pasteurized. A quality control worker will continue to test the milk lots (batches of processed milk) daily for ten days after it is bottled.
3. Introduce pasteurization.
 - a. Leading discussion: After food leaves the farm, it is typically processed in some way. Can you name any food processing practices? (Pasteurization, Homogenization, UTH)
 - b. Share the Youtube video [What is Pasteurization?](https://www.youtube.com/watch?v=pFuemp0WBsk)
<https://www.youtube.com/watch?v=pFuemp0WBsk> (2 min 43 seconds)
 4. Introduce UTH milk.
 - a. Leading discussion: Why do we put milk in the refrigerator? How does refrigeration keep foods safe? Can any milk stay safe without being refrigerated?
 - b. Introduce the UHT milk and allow for taste testing if they wish. How many of you have seen UHT milk? UHT milk contains fewer bacteria than conventionally pasteurized milk because it's heated to a higher temperature. It's also packaged in sterile, airtight containers. Therefore, unopened UHT milk can be stored without refrigeration for up to 90 days. Once opened, bacteria can get into the UHT milk, and it must be refrigerated.
 - c. Watch the YouTube video [What is UHT milk?](https://www.youtube.com/watch?v=SSbqiBByoQ4)
<https://www.youtube.com/watch?v=SSbqiBByoQ4> (1 minute 28 seconds)

Procedures:

This lab introduces students to kinds of milk and the effect temperature has on reducing and controlling the growth of bacteria. Students will use conventionally pasteurized and UHT milk to observe how different temperatures affect the growth of spoilage bacteria. They will also learn about the importance of pasteurization in keeping food safe.

1. Design and Conduct the Lab (Have designated places for students to place the room temperature, refrigerated, and frozen test tubes of milk over the days or weeks you wish to follow the experiment.)
2. Arrange the class into five teams and assign them to a lab area. Have them create a short group name that can be used on the test tube labels.
3. Explain the items in the lab.
 - a. milk from the refrigerated dairy case of the supermarket
 - b. UHT or shelf-stable milk.



- c. Methylene blue is an indicator dye indicating a liquid's oxygen level. In anaerobic conditions, it is reduced to leucomethylene and becomes colorless. When methylene blue is added to fresh milk, it will dye the milk blue. As bacterial populations grow in the milk, they will use up the oxygen, and the methylene blue will lose its color. The rate at which the milk loses its color is a relative measure of bacteria present in milk.
4. Leading Discussion: What's an important difference between the two milk products? Is there any information on the labels that relates to the questions about the effect of temperature on bacterial growth? (one is pasteurized, and the other is UHT treated) How are pasteurization and Ultra-High-Temperature treatment the same and/or different? *(Both pasteurization and UHT treatment use heat to kill bacteria. UHT methods use higher temperatures than regular pasteurization. Also, UHT products are packaged in special airtight containers to prevent bacteria from getting into the product.)* How will the temperature of the milk affect bacteria growth?
5. Present Introductory Information: As bacterial populations grow, they use the oxygen in the milk. Adding methylene blue to milk will turn it a blue color, and it will remain blue as long as oxygen is present in the milk. The more bacterial activity there is, the faster the oxygen will be used, and the sooner the milk will turn white, indicating that it is spoiled. For the following activities, you will be monitoring the speed at which the milk changes from blue to white and making comparisons between the different methods of pasteurization and temperature. This rudimentary experiment will give you a sense of the differences between milk pasteurization methods, but it is not typically used by scientists to test milk quality. Instead, quality control studies are performed by directly examining the bacteria present in the milk, ensuring higher accuracy than the blue test and helping workers to find the source of bacterial contamination.
6. Groups will discuss and plan the steps for an experiment to help them answer the above questions.
5. Students will develop a hypothesis: Which location will create the most bacteria for the 2% milk, and which location will create the most bacteria for the UHT milk? Have them record these hypotheses in their "Investigating Milk Lab Journal."
6. Groups assemble experiments: (In a lab setting, it is helpful for students to number off. Person one does the first activity, person 2 does the second, etc.)
- Arrange the six tubes per group that will be used for this experiment.
 - Student 1 can label the test tubes with a short group name.
 - Student 2 will add 10 ml (2 tsp.) of the UHT milk into three test tubes and label them.

- d. Student 3 will add 10 ml (2 tsp.) of 2% pasteurized milk in the remaining three test tubes and label them.
- e. Student 4 will place a single drop of methylene blue solution in 3 test tubes. (Be extra careful with the solution – it will stain clothing and surfaces blue).
- f. Student 5 will place a single drop of methylene blue solution into the remaining 3 test tubes.
- g. Students will secure the cap on each test tube and gently swirl the tubes to diffuse the dye evenly (one student will handle two).
- h. Students should record the color of the samples on the data table in the “Investigating Milk Lab Journal.
- i. Have students place tubes of milk in varying temperature locations to measure the effect of temperature on the rate of spoilage, keep one of each (UHT and 2% pasteurized) at room temperature, put one of each in the refrigerator and one of each in the freezer.
- j. Observe the color of the milk over the next few days or weeks and record color changes in the “Investigating Milk Lab Journal.”
- k. (optional) After recording the differences on days 2 and 3, have students leave chilled and frozen samples at room temperature and observe the change.

7. Review lab results.

(Expected Results) The blue tint will begin to fade as the milk spoils. As the milk in the tubes becomes completely white, students can begin to make a comparison and draw conclusions about how processing treatments deter bacterial growth. Room temperature samples: The pasteurized milk will turn white by lab day 2, indicating there are some spoilage bacteria present. At a temperature conducive to growth, bacteria will multiply. The UHT milk will still be blue by lab day 2 because it has fewer spoilage bacteria than the pasteurized milk. Bacteria do not multiply quickly in UHT milk. After another day or two, the color will turn white indicating spoilage bacteria will ultimately grow in UHT milk. Chilled and Frozen: Both the pasteurized and UHT samples will still be blue by lab day 2, indicating that cold temperatures slow bacteria growth. After leaving the chilled and frozen samples at room temperature for another day or two, the color will change to white. This color change indicates that when the temperature rises into the food danger zone, bacteria can grow. It may take longer for the UHT milk to change due to fewer spoilage bacteria.

Vocabulary:

- **raw milk:** A living food that has not been pasteurized or heated to the point that would destroy pathogens. (Examples of foods that are not alive include: gelatin, salt, sugar, and oil.)
- **pasteurization:** A process in which packaged and non-packaged foods (such as milk and fruit juice) are treated with mild heat, usually to less than 100 °C (212



°F), to destroy organisms that contribute to spoilage or risk of illness. The process kills harmful bacteria (pathogens) but not all bacteria and enzymes.

- **bacteria:** Small single-celled organisms found almost everywhere on Earth and are vital to the planet's ecosystems. Some species can live under extreme conditions of temperature and pressure. The human body is full of bacteria and in fact is estimated to contain more bacterial cells than human cells. Bacteria that cause illness or disease are referred to as pathogens.
- **pathogen:** a bacterium, virus, or other microorganisms that can cause disease. Bacteria are one type of pathogen. Not all bacteria are pathogens and there are other types of pathogens beyond bacteria.
- **homogenization:** A process by which the fat droplets from milk are emulsified and the cream does not separate.
- **ultra-high-temperature (UHT) milk:** Milk that is heated to at least 280 degrees (138 degrees C) for 1-2 seconds, then packaged in sterile, airtight containers, making it shelf stable or able to be stored without refrigeration. The high heat does kill all of the bacteria in the milk. This milk can have a cooked flavor.
- **methylene Blue**--An indicator dye that identifies oxygen levels; it is also used as a medication.
- **quality control:** a process through which a business seeks to ensure that product quality is maintained or improved.
- **food danger zone:** The temperature range in which bacteria grow most rapidly between 40 °F and 140 °F.
- **contaminate:** Something is made unpure by being exposed to a poisonous or polluting substance.

Assessment: Use the “Investigate Milk Lab Journal” or have students use their own journals to answer questions. The assessment can be completed as a group or individually. Students should use at least eight vocabulary words (underline vocabulary words) in the following entries: 1) What do chilling, freezing, and heating do to bacteria? 2) Were bacteria in the milk killed at different temperatures? Why or why not? How could you tell? 3)What is pasteurization? 4) What’s the basic difference between conventionally pasteurized and UHT milk? 5)Explain the importance of knowing about the Danger Zone in food safety. 6) Describe the careers that get milk from the farm to the table.

Standards:

Next Generation Science

MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells, either one cell or many different cells.

Kansas Curricular Content Standards for Library/Information and Technology Information Value

G8.1.2. encourage consideration of ideas and information from all group members.



G8.1.3. with guidance, analyze and explain information presented in various formats; recognize the relationships of parts and the whole in visual and/or oral messages.

Information Research as Inquiry

G8.3.1. develop essential questions that go beyond fact-finding.

Information as Conversation

G8.6.6. encourage consideration of ideas and information from all group members.

Kansas English Language Arts Standards

Research to Build and Present Knowledge

Writing

W.6.7 Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

Speaking and Listening

Comprehension and Collaboration

SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

Integration of Knowledge and Ideas

RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

Kansas Curricular Standards for School Counseling

Career Development

Standard 1.1 The student will develop career awareness.

Kansas Family and Consumer Sciences Middle Level/Junior High Program Nutrition, Wellness and Food Preparation

5.5 Analyze food sources and practices that impact the nutritional value of the food we consume.

National Ag Literacy Outcomes

T2.6-8 Plants and Animals for Food, Fiber & Energy Outcomes

f. Identify where labeling indicates the origin of food and fiber (fabric or clothing) **T3.6-8**

Food, Health, and Lifestyle Outcomes

e. Explain the benefits and disadvantages of food processing.

h. Identify forms and sources of food contamination relative to personal health and safety

j. Identify the careers in food production, processing, and nutrition that are



essential for a healthy food supply

Science, Technology, Engineering & Mathematics Outcomes T4.6-8

f. Explain the harmful and beneficial impacts of various organisms related to agricultural production and processing (e.g., harmful bacteria/beneficial bacteria, harmful/beneficial insects) and the technology developed to influence these organisms

g. Identify science careers related to both producers and consumers of agricultural products

T5.6-8 Culture, Society, Economy & Geography

b. Distinguish between careers in production (farmers and ranchers) with those that directly involve consumers (business and nutrition)

Companion Resources:

- KFAC Kansas Dairy Poster <https://ksagclassroom.org/ksresource/kansas-dairy/>
- Kansas Dairy Map <https://dairyinkansas.com/kansas-dairy-map/>.
- KFAC Food Safety 101 Poster <https://ksagclassroom.org/ksresource/foodsafety/>

Author: This lesson was adapted from NAITC “Blue’s the Clue: Souring Milk for Science: which is part of a larger unit of lessons focusing on food safety from farm to table, by Amy Benz, KFAC Curriculum Advisory Team Chair.

References:

“Kansas Dairy Facts.” (2021). The Kansas Livestock Association, <https://www.kla.org/dairy/kansas-dairy-facts>.

“Kansas Dairy Farms, Then and Now: Innovation, Conservation, Dedication.” (2021). *Midwest Dairy*, Midwest Dairy, <https://www.midwestdairy.com/resource/kansas-dairy-farms-then-and-now-infographic/>.

National Center for Agricultural Literacy at Utah State University (2013). “Blue’s the Clue: Souring Milk for Science.” <https://agclassroom.org/matrix/lessonplan/283/>



Investigating Milk

Name: _____ Date: _____ Class/Hour: _____

Use at least eight of the vocabulary words you have learned throughout these worksheet pages.

On the line in each box below, write a question you have about milk safety.

You will com back later to answer each question

1.

2.

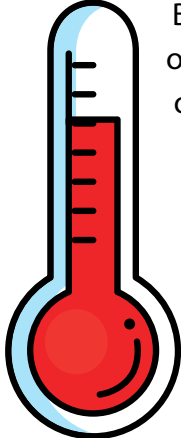
3.

Investigating Milk

Name: _____ Date: _____ Class/Hour: _____

Write a hypothesis in response to these questions:
 Which location will create the most bacteria for the 2% milk?
 Which location will create the most bacteria for the UHT milk?

Hypothesis









Bacteria grow faster or slower depending on the temperature

Bacteria double every

- 30 minutes at 9°
- 1 hour at 70°
- 2 hours at 60°
- 6 hours at 40°
- 20 hours at 32°
- 60 hours at 28°

1	2	3	4	5
Very Blue	Blue	Fading Blue	Slightly Blue	White

Days		2	3	4	5	6	7	8	9	10
 Room Temperature	Pasteurized									
 Room Temperature	UHT									
 Refrigerated	Pasteurized									
 Refrigerated	UHT									
 Frozen	Pasteurized									
 Frozen	UHT									

Investigating Milk

Name: _____ Date: _____ Class/Hour: _____

Review the experiment and write your conclusions.

Evaluate your hypothesis. How did the data support or reject your hypothesis?

What careers are involved in getting milk from the farm to the table?
List the career and function of the career as it relates to milk below.

