



Whipping Butter into Shape

Overview: In this STEM lesson, students investigate the physical change that occurs as milk is turned into butter.

Objectives: The student will be able to:
explain the process of turning milk into butter
explain the difference between a physical and a chemical change

Grades: 3-5

Materials:

Making Butter Observation Sheet for each student or group
Heavy whipping cream at room temperature
Baby food jars or small jam jars, 1 per group
Timers, one per group
Kitchen scale
Butter knife, 1 per group
Crackers
Glass bowl (optional)
Microwave (optional)
Hand mixer (optional)



Vocabulary:

buttermilk - the liquid that is left after butter has been made from milk or cream

chemical change - a change that results in the formation of a new chemical substance through the making or breaking of bonds between atoms

churn - to make (butter) by stirring or shaking cream

colloid - a substance in which particles of one substance are dispersed through another substance

emulsion - a mixture of liquids in which small drops of one liquid are mixed throughout another liquid

homogenization - the process of reducing the size of fat globules in milk to extremely small particles so the cream does not separate from the milk

physical change - a change in a substance that does not alter its chemical identity, including changes in shape, physical state, size, or temperature; this type of change is usually reversible

Background

Milk, typically produced by cows, is used to make butter, cheese, ice cream, yogurt, and other dairy products.

Fresh milk is a mixture of cream and milk. The cream is less dense than the milk causing it to separate and rise to the top where it can be skimmed off. The milk left behind is called *skim* or *fat-free* milk. When fresh milk is taken from the dairy farm to a milk processing plant, it is separated from the cream in order to mix the precise amount of cream and milk to make 1%, 2% or whole milk. This process is called **standardization**. To accelerate the separation of cream from milk on a large scale, dairy processing plants use a machine called a centrifugal separator to help with this process.

Milk purchased from a grocery store does not separate. This is possible due to a process called **homogenization**. Homogenization shears the fat globules in the cream into smaller pieces, making the milk and cream the same density so it does not separate.

Butter is a dairy product made by **churning** cream to separate the buttermilk from the butterfat. Heavy cream is an **emulsion**. Tiny globules of fat are suspended in a watery solution. Churning the cream forces the fat globules to slam into one another. If they hit each other with enough force, they will stick together eventually forming a chunk of butter. After removing the butter, a watery liquid will remain with small butter grains floating in it. This liquid is called **buttermilk**. The butter is rinsed, pressed, and kneaded to remove any remaining pockets of buttermilk or water. Butter remains a solid when refrigerated, softens to a spreadable consistency at room temperature, and melts to a liquid consistency at 32-35°C (90-95°F).

A **chemical change** is a change that results in the formation of a new chemical substance through the making or breaking of bonds between atoms. A chemical change creates a new chemical substance that typically has different physical properties when compared to the original substance. When a substance has undergone a chemical change, the process cannot be reversed.

A **physical change** is a change from one state (solid, liquid, or gas) to another without altering the chemical composition of a substance. When a substance has undergone a physical change, the process can be reversed.

Three basic states of matter found on Earth are solid, liquid, and gas. The term **colloid** describes a substance that is a combination of different states. Colloids are made of tiny particles of solid, drops of liquid, or bubbles of gas that are evenly distributed throughout a liquid. They are not dissolved in the liquid and do not settle to the bottom or float to the top. Emulsions and foam are two types of colloids. Milk and cream are emulsion colloids with tiny globules of fat thoroughly mixed throughout water. Whipped cream is a foam colloid with tiny air bubbles thoroughly mixed throughout liquid cream.

Turning milk into butter is a physical change because the milk is changed from a colloid (cream) to a solid (butter) without altering its chemical composition. This physical change is reversible. The butter can be melted and mixed with the leftover buttermilk to make cream again.



Procedure:

Organize students into small groups. Provide each group with a small jar, heavy whipping cream, a timer, access to a kitchen scale, crackers, and a butter knife. Each group should weigh their empty jar with the lid and record the weight on their Making Butter Observation Sheets.

Instruct the groups to pour the whipping cream into the jars until each jar is half full. Have the students note the appearance and consistency of the cream and record their observations. The groups should seal the lids tightly, weigh the jar, and then record the weight.



Tell the groups to start their timers and begin shaking the jars. Group members should take turns shaking. You may choose to play music to encourage the movement. Instruct the groups to stop shaking, pause their timers, and observe the contents of their jar every two minutes. Have them note the appearance and consistency of the cream and how it is changing on their observation sheets.



The groups should stop their timers and record the time when the solid butter has separated from the buttermilk. It will take 4-10 minutes to get to this point.

Allow time for the groups to weigh their jar of butter and buttermilk with the lid. Record the weight. Ask students to compare the weight of the heavy whipping cream to the weight of the butter and buttermilk. Did the weight change? Explain to the students that the weight of matter stays the same when it changes form.

Have the students spread their freshly made butter onto the crackers for a taste test.

Use the Background information of this lesson to discuss the difference between chemical and physical changes. Ask the students, "Is turning cream into butter a chemical change or a physical change and why?" (It is a physical change because the change did not alter the chemical composition of the cream.)

"What factor caused the physical change?" (churning) "What states of matter were observed during the different stages of the butter-making process?" (The cream is a

colloid. When it is churned, it first turns into a foam (whipping cream) and then separates into a solid (butter) and a liquid (buttermilk).

Remind students that physical changes are reversible. Demonstrate the process of changing butter back into cream. In a microwave, melt the butter in a glass bowl. Pour in the buttermilk that was leftover from making the butter. Use a hand mixer to beat the mixture until it reaches the consistency of cream.

Evaluation:

Students write a paragraph describing the process of turning milk into butter and describing the changes they observed.

New Jersey Learning Standards:

Science - Engineering Design

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Making Butter Observation Sheet

1. Weight of the empty jar _____
2. Weight of the jar with heavy whipping cream _____
3. Weight of the cream before churning _____
4. Record your observations of the churning cream.

Time	Observations
Before Churning	
2 Minutes	
4 Minutes	
6 Minutes	
8 Minutes	
10 Minutes	

5. How long did it take to make butter?
6. Weight of jar with butter and buttermilk
7. Weight of butter and buttermilk
8. Weight difference between the cream before churning and the butter with buttermilk