Curdled Milk

One material in this activity is milk. Milk contains casein, a protein. When milk sours, the curds that form are coagulated casein. Another material in this activity is rennin (sold as Junket), an enzyme. Obtained from the stomach lining of calves, rennin is used to make ice cream and cheese. A third material is vinegar, which contains acetic acid, a weak acid. What happens when either rennin or vinegar is added to milk? Will changing the temperature affect the functioning of rennin? Try this activity and find out.

Materials

- 4 half-tablets of rennin (Junket)
- cup of whole or 2% milk
- sauce pan or appropriate heat-safe container
- thermometer
- tablespoon measure
- teaspoon measure
- 4 clear, plastic cups or glasses
- container of ice water large enough to place one clear, plastic cup in
- paper towels
- stove, hot plate, or microwave
- 1 tablespoon vinegar
- 1 teaspoon baking soda
- water

Exploration

Step 1 In the heat-safe container, warm (do not boil!) 1 ounce (2 tablespoons) milk to approximately 110°F (45°C). Stir one half-tablet of rennin into the milk and record your observations. What can be said about the effect of rennin? Gather any solid material (curds) with a paper towel and squeeze out and discard any excess liquid (whey). Save any curds you collect for Step 5.

Step 2 Heat another 1 ounce (2 tablespoons) milk to approximately 180°F (80°C). Stir one half-tablet of rennin into the milk. Do curds form? Do curds form after the milk cools to 110°F (45°C)? Add another half-tablet of rennin; do curds form? How can you explain your observations? Again, gather and save any curds for Step 5.

Step 3 Put another 1 ounce (2 tablespoons) milk into a clear plastic cup or glass, and place it in the container of ice water until the milk temperature is below 50°F (10°C). Add one half-tablet of rennin, stir, and wait 10 to 15 minutes; record your observations. Pour the mixture into the heat-safe container and gently warm to 110°F. What can be said about the effect of rennin?

Step 4 Place another 1 ounce (2 tablespoons) milk into a clear plastic cup or glass and stir in 1 tablespoon vinegar. Compare your observations with those from Step 1. Again, gather and save any curds for Step 5.

Step 5 Chop the curds into small pieces. Add 1 tablespoon water and 1/4 teaspoon baking soda. What happens? You have just made a well-known product—what do you think it is? (Hint: Use it to stick things together. Try it. How does it work?)

Challenge

What effect do rennin and vinegar have on milk, and how does temperature affect the action of rennin?

Curdled Milk

Concepts

enzymes, denaturation

Expected Student Responses to Exploration

Step 1 Large, fluffy, and sour-smelling curds form. At approximately 110°F, rennin causes coagulation of the protein, casein.

Step 2 (a) Curds do not form when the mixture is heated to 180°F.
(b) Curds do not form upon cooling the mixture down to 110°F (the same temperature as in Step 1).
(c) Curds do form at 110°F when more rennin is added.
(d) The higher temperature does not affect the casein, because it still coagulates when fresh rennin is added. When the milk is heated to the higher temperature, the rennin which was added to it permanently loses its ability to cause coagulation of casein. Additional rennin (which has not been heated) must be added to cause coagulation.

Step 3 There is no apparent formation of curds when the temperature is below 50°F. A temperature somewhere between 50°F and 110°F is necessary for rennin to cause coagulation of casein.

Step 4 Curds form faster, but are smaller and less fluffy than in Step 1.

Step 5 (a) The mixture turns into a sticky material.
(b) The natural product that has been produced is casein glue.

Expected Student Answer to Challenge

Both rennin (an enzyme) and vinegar (containing an acid) can coagulate casein, a protein found in milk. Although rennin will not operate below a minimum temperature, too high a temperature permanently negates its ability to function as an enzyme.

Reference

"Curdling of Milk"; *Fun with Chemistry: A Guidebook of K–12 Activities;* Sarquis, M., Sarquis, J., Eds.; Institute for Chemical Education: Madison, WI, 1993; Vol. 1, pp. 63–66.

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