Dairy Science

SWIRLING MILK

This is a simple, colorful, experiment that is easy for children to do at school. Some very unusual things happen when you mix a little milk, food coloring, and a drop of liquid soap. Use the experiment to amaze your students and uncover the scientific secrets of milk and soap.

MATERIALS

1 flat bowl or aluminum pie pan, about 5-7" diameter and at least 1" deep (use one bowl for each 4-6 students, if possible)

Milk – whole, 2%, 1%, skim, and even reconstituted dry milk works (water does not work) – enough to cover the bottom of the container about 1/2" deep)

Box of different colors of food coloring (red, yellow, blue, and green work well; screw-capped vials of food coloring, if you can find them, are less messy)

Liquid dishwashing detergent ("Dove" or "Dawn" works well; "Joy" does not)

Toothpicks or cotton swaps

PROCEDURE

1. Pour about 1/2" of milk into the bowl.
2. Stand back from the table so that the milk becomes motionless.
3. Imagine the bowl as the face of a clock. Squeeze 2 drops of each food color carefully into the milk near the outside edge of the bowl, one color at 12 o'clock, the second color at 3 o'clock, the third color at 6 o'clock, and the fourth color at 9 o'clock, in any order. There should be one spot each of red, yellow, blue, and green. Do not bump the table or do anything else to mix the colors.
4. Holding one end, dip the other end of the toothpick or cotton swap into the dishwashing detergent.
5. Touch the detergent end of the toothpick or cotton swap into the middle of the bowl of milk, and hold it there for at least 30 seconds. Observe the behavior carefully. Do not stir the milk.
6. Lift the toothpick or cotton swap, and touch it to the milk in the center of one of the colors. Observe the behavior carefully.
7. Touch the toothpick or cotton swap into other areas of the milk, dipping it first into the detergent again if necessary. Observe the behavior carefully.

OBSERVATIONS

Initially, the food colors swirl in different patterns across and under the surface of the milk for several minutes. Note that the colors do not actually mix with each other, but continue in separate swirling patterns. The time of swirling may depend on the temperature of the milk (set up one dish of cold milk and one at room temperature to see the change in speed) and amount of dishwashing liquid you use. Moving the toothpick or cotton swap to a new spot can later result in mixing of the various colors.

EXPLANATION

Milk is mostly water but it also contains vitamins, minerals, proteins, and tiny droplets of fat suspended in solution. Fats and proteins are sensitive to changes in the surrounding solution (the milk). When you add soap, the weak chemical bonds that hold the proteins in solution are altered. It's a free for all! The molecules of protein and fat bend, roll, twist, and contort in all directions. The food color molecules are bumped and shoved everywhere, providing an easy way to observe all the invisible activity. At the same time, soap molecules combine to form a cluster of soap molecules. These soap clusters distribute the fat in the milk. This rapidly mixing fat and soap causes swirling and churning where a soap cluster meets a fat droplet. When there are soap clusters and fat droplets everywhere the motion stops. There's another reason the colors explode the way they do. Since milk is mostly water, it has surface tension like water. The drops of food coloring floating on the surface tend to stay put. Liquid soap wrecks the surface tension by breaking the cohesive bonds between water molecules and allowing the colors to zing throughout the milk.

DAIRY COUNCIL OF FLORIDA

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SEPARATION OF MILK PARTICLES

Goal: To demonstrate that milk is made of particles suspended in water.

MATERIALS

1 cup whole milk

2 tablespoons of vinegar

1 coffee filter

2 12 oz. or larger cups

PROCEDURE

1. Pour about 1 cup (8 oz.) of Whole milk into a cup.
2. Add about 2 tablespoons of vinegar to the milk and stir.
3. Filter the mixture through the coffee filter into another cup.

OBSERVATIONS

With the addition of the vinegar, you should observe small white particles in the milk. These are large enough to filter out.

EXPLANATION

The added acid (like acetic acid found in vinegar) acts the same way as when bacteria converts the lactose to lactic acid in the cultured dairy products such as yogurt. Lactic acid, or in this case acetic acid, promotes coagulation of the casein (protein) particles. These are the visible white clumps that can be filtered out. The addition of heat actually helps promote polymerization (small molecules combining to make a network of molecules) of the protein.

ADDITIONAL RESULTS

This experiment can also be performed with skim, low fat or reduced fat milk. The clumps will be smaller as you reduce the fat content of the milk.

DETERMINATION OF FAT CONTENT IN MILK

Goal: To demonstrate that the amount/concentration of fat in milk.

MATERIALS

whole milk

skim milk

half-and-half or cream

three shallow pans or bowls

food coloring

PROCEDURE

1. Pour a small amount of each kind of milk into separate bowls.
2. When the milk is steady and not moving, add one drop of food coloring to each bowl — the bowl and milk must be perfectly still.
3. Watch how the color spreads.

OBSERVATIONS

The food coloring in the skim milk should spread quickly and become faint in color. The coloring in the cream will not spread as much or as fast as in the skim milk. The whole milk should behave somewhere in between.

EXPLANATION

The food coloring is water-based and will travel and diffuse better through the aqueous (water) medium than through the fat. So in skim milk, which has a very low fat content and is predominantly water, the food coloring spreads rapidly, whereas in cream the food coloring will take longer to disperse since there is less water for it to travel through.

These Experiments have been adapted from:
1. Science Fun with Dairy Foods, Ohio Cooperative Extension Service, 4-H 490.
2. Thomas W. Shiland, Science and Children, 1997, 35(3), 14.
3. Princeton University, Princetion Materials Insititute K-12 Outreach, http://www.princeton.edu/~pccm/outreach/scsp/mixturesandsolutions/milk/activities.htm