Ice Cream Making

IT WOULD be hard to find a person who does not enjoy ice cream. Ice cream has woven itself into the very fabric of our lives, making it as much of an American tradition as hot dogs and apple pie. Ice cream had its beginnings in the fourth century B.C. It is believed that explorers brought the recipes for ice cream back to Europe from China. Over time, the various methods of making ice cream and the various flavors, textures, and forms of ice cream have taken shape. The first large-scale ice cream manufacturing plant was built in Baltimore, Maryland, in 1851. Since then, people have been screaming for one of our favorite desserts, ice cream.

Objective:

Describe the physical changes that occur during ice cream making and explain the effects ingredients have on the texture and flavor of ice cream.

Key Terms:

conduction
convection
crystallization
emulsifier
freezing
homogenization

How Ice Cream Is Made

Ice cream is much more than just frozen cream. Physical changes occur in ice cream during freezing that are critical to its texture and "smoothness." Ice cream is actually a frozen, pasteurized mixture of milk, cream, solids-not-fat (SNF), sugar, stabilizers, and emulsifiers. **Freezing** is the change in the physical condition of a substance from a liquid to a solid state. Freezing occurs at 32°F (0°C). During freezing, heat must be transferred from the liquid to be frozen into a surrounding substance. Heat always flows from a warmer to a cooler substance. With ice cream, heat transfer can occur by two methods.

1. **Conduction** is the transfer of heat between two objects that are in direct contact with each other.
2. **Convection** is the transfer of heat between two objects through air or water.

Let us now take a closer look at the ice cream mixture itself. Ice cream is actually frozen milky foam. It is an emulsion, or finely divided solution of two liquids that would not normally mix. The added ingredients in ice cream are held in the milk suspension by an **emulsifier**, or an agent that supports the formation of an emulsion. A manufactured ice cream often uses an emulsifier to hold the mixture in suspension as it freezes. This improves the texture of the final product.

Ice cream has a liquid, or aqueous, phase as well as a solid, or nonaqueous, phase. The liquid phase consists of a solution of lactose, mineral salts, and added sugars. The solid phase consists of dispersed solids, such as stabilizers, proteins, and fat globules.

FIGURE 1. Ice cream is enjoyed by millions of people around the world.

FIGURE 2. A simple ice cream maker works on the basis of heat conduction—the ice cream mixture comes into direct contact with the cold container.

During freezing, churning of the ice cream mixture causes some of the milk fat to be released from the fat globules and form a thin layer around air cells. Only a portion of the water in the mixture is frozen into ice crystals; the actual amount depends on the temperature and the concentration of sugars and mineral salts in the solution. **Crystallization** is the formation of ice crystals into regular geometric shapes in which the crystals are arranged in orderly, three-dimensional, repeating patterns. The size and number of the ice crystals depend on the temperature and speed at which the mixture is frozen. Rapid freezing results in a large number of very small crystals and ice cream with a smooth texture. Slow freezing, much like you would experience with a home ice cream maker, results in fewer but larger ice crystals and ice cream with a rougher, or more grainy, texture.

UNDER INVESTIGATION...

LAB CONNECTION: Making Ice Cream

Ice cream and other frozen desserts are popular fixtures in many of our daily diets. Although some ice cream with high fat content can be harmful to our health if eaten in excess, ice cream also contains nutrients and vitamins that are beneficial. More than 924 million gallons of ice cream and 476 million gallons of ice milk are consumed annually in the United States.

Processing techniques, such as pasteurization and homogenization, have not only increased the safety of ice cream but enhanced the texture as well. Today, many methods and additives, including stabilizers and emulsifiers, are used to create a pleasing and longer-lasting ice cream product. Although ice cream can be created using no additives or artificial substances, most commercially produced ice cream contains many sweeteners and stabilizers to enhance the product during freezing, storage, and distribution.

A simple ice cream experiment can be conducted with a few ingredients and a plastic bag.

A simple ice cream can be made in your own classroom. Place measured amounts of milk, cream, sugar, and vanilla favoring in a quart-size resealable bag and mix it thoroughly. Place this bag inside a gallon-size resealable bag. Add a mixture of salt, ice, and water around the smaller bag. The salt and ice provide an environment that conducts heat away from the ice cream mixture, causing the mixture to freeze. Shaking the larger bag vigorously speeds the rate of heat transfer. In 5 to 10 minutes, remove the smaller bag from the larger one, open it, and enjoy eating your ice cream.

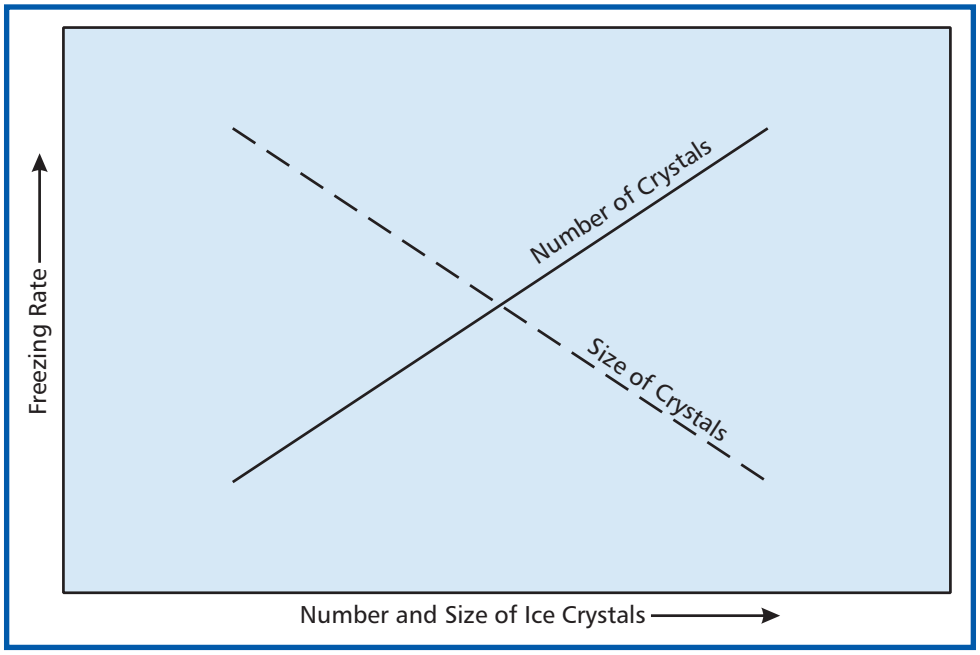

FIGURE 3. Both temperature and rate of freezing play roles in the size and number of ice crystals formed during freezing.

ADDITIVES AND THEIR EFFECT ON FREEZING

Any additive—or other substance, for that matter—when added to a liquid will have an effect on the freezing of that liquid. Some additives may cause a liquid to freeze more quickly, but most have the opposite effect. Sugar, salt, and other similar molecules have interesting effects on the freezing of water.

Ice cream is usually frozen by the process of conduction. Heat from the ice cream mixture is removed by placing the container holding the mixture into contact with a colder substance—an ice water mix, for example. The greater the temperature difference between the ice cream mixture and the colder ice water mixture, the more quickly heat will be removed from the ice cream and the more quickly the ice cream will freeze. This transfer of heat will continue until the two substances are in equilibrium, or resting at the same temperature.

Adding salt to a mixture of ice and water interferes with the formation of ice crystals and therefore lowers the freezing temperature of the

FIGURE 4. Salt on this sidewalk interferes with the formation of ice crystals, lowering the freezing point of water.

FURTHER EXPLORATION...

ONLINE CONNECTION: The History of Ice Cream

Many myths and interesting stories surround the history of ice cream and the desserts made with it, such as sundaes. To find out more about the "discovery" of ice cream and ice cream products, visit the link below:

http://www.zingersicecream.com/history.htm

water. This same principle applies to the salting of roadways during icy weather to keep them clear of ice. In ice cream production, as the salt lowers the freezing point of the ice water mixture, it increases the temperature difference between the ice cream and the ice water. This increased temperature difference will cause heat to be removed from the ice cream more quickly and cause the ice cream to freeze faster. Remember from earlier in this e-unit, the more rapidly ice cream is frozen, the smaller the ice crystals and the smoother the texture will be.

For an even greater effect by the salt, more water can be added to the ice water mixture to help melt the ice and provide greater contact between the salt and the ice water solution. Sweeteners, such as cane and beet sugar, corn sweeteners, and honey, can all be added to ice cream to enhance the flavor. These additives have the same effect on the ice cream as the salt has on the ice water mixture. Sweeteners will interfere with the freezing of the ice cream mixture by lowering the freezing point of the ice cream. This means that a greater temperature difference will then be required to freeze the ice cream mixture.

FACTORS AFFECTING THE CHARACTERISTICS OF ICE CREAM

Most ice cream commercials will entice consumers with a description of ice cream whose texture is "smooth and creamy." Nobody wants to buy or eat ice cream whose texture is depicted as "rough and lumpy." Certain ingredients added to the ice cream mixture play major roles in producing the desired characteristics of ice cream.

The main contributor to the texture of ice cream is milk fat. During the churning process, milk fat globules are dispersed throughout the ice cream mixture, giving a smooth feel to the end product. Ice cream with a high fat content will also

FIGURE 5. Most consumers desire ice cream with a smooth and creamy texture. (Courtesy, USDA)

have smaller ice crystals and a slower rate of air incorporation, both factors that enhance smoothness.

To be labeled as ice cream, a product must have at least 10 percent milk fat. Ice milk contains only 2 to 7 percent milk fat. While ice cream and ice milk are different in this aspect, many people cannot taste the difference between the two. Ice cream normally contains 10 to 15 percent sucrose, 5 to 7 percent corn sweetener, 0.2 to 0.3 percent stabilizers, 0.1 percent emulsifier, and natural or artificial flavorings and colors.

Another factor that increases smoothness of ice cream is the process of homogenization. **Homogenization** is a processing method in which milk is forced through a small screen to decrease the size of milk fat globules. Milk proteins attach to the small fat globules following homogenization, making the final ice cream product more stable and smooth.

FIGURE 6. The process of homogenization will lead to a more stable and smooth ice cream product.

Milk also contains natural substances that will increase the creamy and smooth texture of ice cream. Casein and whey proteins, along with other natural stabilizing and emulsifying compounds, allow a high-quality ice cream product to be created without the use of additives. Egg yolk can also be used as an emulsifier that will produce smaller ice crystals and air cells, giving the final product a stiffer, smoother texture.

The holding temperature for ice cream can also play a role in the texture of the product. As we discussed earlier, the rate of freezing is important to the size and number of ice crystals formed. As ice cream is warmed and then refrozen, ice crystals will thaw and then refreeze into larger crystals, giving the ice cream a grainy texture. The more times the ice cream is thawed and refrozen, the rougher the texture will become. Eventually, ice crystals will form on the surface of the ice cream, producing a fuzzy appearance. Although the ice cream is harmless to eat, the product at this point will not be very appealing.

FIGURE 7. Thawed ice cream, when refrozen, will likely contain larger ice crystals, giving it a grainy texture.

Stabilizers in the ice cream mixture can prevent the formation of larger ice crystals by binding with water when thawing occurs. Too much of the stabilizers, however, along with frequent freezing and thawing, can produce a gummy texture in older ice cream products.

Summary:

Ice cream may be the most popular of all dairy products and one of the easier products to create. A mixture of milk, cream, solids-not-fat (SNF), sugar, stabilizers, and emulsifiers is used to create an ice cream product with a smooth, creamy texture. Ice cream is processed into an endless variety of forms and flavors and is enjoyed the world over.

Checking Your Knowledge:

1. Discuss how salt can lower the freezing point of an ice water mixture.
2. What effect do temperature and rate of freezing have on the texture of an ice cream product?

Expanding Your Knowledge:

Visit an ice cream manufacturing plant to observe how ice cream products are processed for distribution to consumers.

Web Links:

Ben & Jerry's "From Cow to Cone"—How Ice Cream Is Made

http://www.benjerry.com/fun_stuff/cow_to_cone/

Ice Cream in a Bag

http://chemistry.about.com/cs/howtos/a/aa020404a.htm

Agricultural Career Profiles

http://www.mycaert.com/career-profiles