**Purpose** To investigate the Colligative property of Freezing Point depression in a most yummy and delightful way!

**Materials**

½ Cup Whole Milk (half & half cream?) 4 Cups Crushed Ice

½ Teaspoon Vanilla Extract 1 Tablespoon Sucrose (table sugar)

4 Tablespoons Rock salt, NaCl Water (optional)

2 Zip-lock Freezer Bags (quart size) 1 Zip-lock Freezer bag (gallon size)

Sink or basin Gloves, mittens or paper towels

**Safety Precautions**

The salt–ice water mixture will get VERY cold and will become too cold to handle — wear gloves or mittens or use a towel between your hands and the bags you handle.

**Procedure**

1. Place ½ cup of milk, ½ teaspoon of vanilla extract, and 1 tablespoon of sucrose in one of the quart sized freezer zip-lock bags.

2. Force as much air as possible out from the bag before sealing the zip lock bag securely.

3. Check that the bag is well-sealed, then place it inside another quart sized zip-lock bag.

4. Force as much air as possible out from the second zip lock bag before sealing it securely.

5. Mix the contents by shaking and kneading the bag without breaking it open.

6. Place the two quart sized bags into a one gallon freezer zip-lock bag.

7. Fill the bag with about 4 cups of crushed ice and pour 4 tablespoons of salt over the ice.

8. Again, let all the air escape the large bag and then seal the large zip-lock bag securely.

9. Gently roll, knead or toss the large zip-lock bag for 5–10 minutes. Make sure that the ice surrounds the cream mixture.

10. As the bag gets cold, hold the bag by the corners, wear gloves or wrap the bags in a paper towel. Take care not to break the bag open.

11. After 10 minutes, place the large zipper-lock bag in a sink or basin. Carefully open the bag and remove the smaller zip-lock bag containing the cream mixture.

12. If the ice cream is solid, proceed on to step 13. If the ice cream is not solid, place it back into the salt–ice water mixture and continue cooling. Additional salt or ice may have to be added.

13. Rinse the saltwater off the outside of the ice cream bag.

14. Transfer the ice cream to cups and enjoy.

**Disposal**

Although the saltwater and ice cream ingredients may be disposed of down the drain, it is best disposed of it in the trash. It makes a mess in the sink & your parents will blame the teacher!

## Tips

* The salt–ice water mixture must be well agitated to evenly distribute the sugar and flavors in the ice cream and also to facilitate the cooling process.
* The salt–water mixture has a temperature lower than pure ice. The freezing point depression of sodium chloride is substantial and it is not uncommon to reach temperatures of –15° C.
* Additional ingredients such as fruit syrups or preserves, chocolate chips or syrup, or crushed cookies may also be added along with the sugar and vanilla.
* Substituting Half & Half, whipping cream, or heavy cream for the milk will make the ice cream thicker and tastier but also add to the calorie content.
* Some teachers use dry ice or liquid nitrogen to make ice cream. These materials greatly speed up the process, but are more expensive and increase the risk of frostbite.
* Have students calculate the approximate molality of the saltwater solution and the theoretical freezing point depression for the salt–ice water mixture.

**Alternative Method 🡪 Coffee Can Ice Cream**

1. Use the same recipe or increase it by some multiple because the coffee can hold more. However, understand that the time required to “set” the mixture will vary depending on the number of servings in the can.

1. Put the mixture in a standard coffee can and seal the top with a plastic lid. Duct tape the lid onto the can to insure that the cream mixture does not spill out.

3. Place the coffee can inside a larger can and pack the space between the cans with ice.

4. Pour salt over the ice and then seal the larger can with a strong plastic lid. Duct tape the lid onto the larger can to avoid spillage.

5. Shake, roll, toss the can for 10-15 minutes … the cream mixture needs to “set up” (solidify).

**Discussion**

For people who want to combine a love of science with a love of food, food science offers exciting opportunities. There is a tremendous amount of science necessary for the preparation of our modern-day convenience foods. Chemical principles play a vital role as food scientists seek ways to improve the taste and safety of foods and to keep food fresh longer.

We have worked with one colligative property already: boiling point elevation. Now we will consider another one using ice cream. Everyone loves ice cream! Ice cream is a frozen (*solid*) foam (*gas, liquid, solid*) consisting of air mixed in a solution of sugar, protein, and fat in water. The protein and fat molecules dispersed in the milk are very large particles and thus form a colloidal mixture rather than a true solution. Ice cream will not form at 0° C. In order to form ice cream, a temperature of–10° C or lower is necessary.

In this demonstration, the below-freezing temperature is obtained from a salt–ice water mixture that freezes at about –15° C. Salt lowers the temperature of ice water because the freezing point of a solution is always lower than the freezing point of a pure solvent. When a solute, such as sodium chloride, dissolves in a solvent, such as water, it lowers the temperature at which the solution freezes. The amount that the freezing point is reduced is called the freezing point depression. Freezing point depression depends on the concentration of the solute, the number of solute particles formed, and the properties of the solvent. For example, a 10 % salt solution freezes at -7° C, while a 20 % salt solution freezes at -17° C.

**Calculations and Data**

1. How did your ice cream taste? Would you do anything different next time?

2. Give some of the reasons why your ice cream may not have turned out great. (Hint: possible errors.)

**Conclusions and Questions**

1. Why was salt necessary to produce the ice cream?

2. What similarity is observed in the boiling point elevation activity and this activity?

3. What type of matter is ice cream (be specific)?

4. A 10 % salt solution freezes at -7° C, while a 20 % salt solution freezes at -17° C.

 a. Which percent solution did we need to make ice cream?

 b. What is the equation to calculate the percent by volume and percent by mass of a solution?

**Calculations and Data**

1. How did your ice cream taste? Would you do anything different next time?

* **Students might want to add flavoring**
* **Students may want to “freeze” the mixture longer for a more solid consistency**
* **Using “Half & Half” produces a sweeter, thicker ice cream**

2. Give some of the reasons why your ice cream may not have turned out great. (Hint: possible errors.)

* **Did not allow the mixture to cool long enough in the ice-salt**
* **The bags were not sealed securely and leaked**
* **Students did not mix the ingredients and cooling agents well enough so consistency varied (parts were frozen, other parts were liquid)**
* **Students spilled contents**

**Conclusions and Questions**

1. Why was salt necessary to produce the ice cream?

**Ice cream can only be produced at temperatures lower than 10° C. Ice alone cannot accomplish this. Salt lowers the temperature of ice water because the freezing point of a solution is always lower than the freezing point of a pure solvent. When a solute, such as sodium chloride, dissolves in a solvent, such as water, it lowers the temperature at which the solution freezes.**

2. What similarity is observed in the boiling point elevation activity and this activity?

**Both boiling point elevation and freezing point depression are “colligative properties” and depend on: (1) the concentration of the solute, (2) the number of solute particles formed (ionic compounds break apart and form ions, therefore, more particles), and (3) the properties of the solvent.**

3. What type of matter is ice cream (be specific)?

 **Heterogeneous mixture 🡪 colloid**

4. A 10 % salt solution freezes at -7° C, while a 20 % salt solution freezes at -17° C.

 a. Which percent solution did we need to make ice cream?

**Since ice cream needs temperatures below –10 C, one would need an approximately 15% salt solution to produce it.**

 b. What is the equation to calculate the percent by volume and percent by mass of a solution?

percent by mass = mass of solute x 100 %

 mass of solution

 percent by volume = volume of solute x 100 %

 volume of solution