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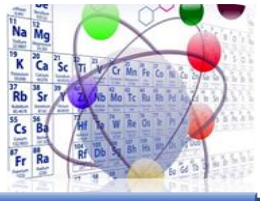

Creative Ice Cream Experiment Using the Freezing Point Depression Principle

Wulan Dwi Safitri[1*], Dian Wardana[1], Dwi Sapri Ramadhan[1], Jaman Fahmi[1], Moondra Zubir[1], Koriatul Jannah Siregar[2], Sunita Karin Purba [2], Nurdin Siregar[3]

[1] Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia
[2] Department of Biology, Faculty of Mathematics and Natural Sciences, Medan State University, Medan 20221, Indonesia
[3] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

*Corresponding author : wulandwisft@unimed.ac.id

ABSTRACT

This research aims to explore creative approaches in ice cream production by utilizing the effect of freezing point depression. Through these experiments, we employed various additives that influence the physical properties of ice cream, resulting in a final product that is softer, creamier, and able to maintain optimal texture at different temperatures. The experimental method involved varying the types of additives combined with the base ice cream mixture. The measured parameters included freezing point depression, texture, and softness of the produced ice cream. The collected data were analyzed to determine how each additive affected the physicochemical characteristics of the product. The results showed that differences in sugar content among the ingredients significantly influenced the degree of freezing point depression in the ice cream.

Keywords: Ice cream, Freezing point depression, Additives, Sugar content.

1. INTRODUCTION

Ice cream is a dairy-based processed product made through a freezing process by combining various ingredients simultaneously. In addition to its sweet taste, ice cream has become a product rich in innovation. Generally, ice cream is made using liquid milk as its main ingredient.[1] Ice cream production can be carried out using two approaches, namely the traditional method and the semi-modern method. These two methods are primarily distinguished by their processing stages, particularly in the freezing phase. The freezing stage plays a crucial role in determining the size and amount of ice crystals formed, thereby influencing the texture, flavor, and overrun of the final product.[2] In this study, one of the traditional techniques used involves the principle of freezing point depression, which is carried out by rotating the ice cream mixture in a container immersed in ice water with added salt.

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Freezing point elevation is a condition in which the freezing temperature of a liquid changes due to the presence of dissolved substances. In the ice cream–making process, salt such as sodium chloride is used to induce this change in freezing point. When salt is sprinkled onto ice, it dissolves and absorbs heat from its surroundings, allowing the temperature of the ice to drop below 0°C. A simple illustration of this phenomenon can be observed when salt is added to water. Pure water freezes at 0°C (32°F), but once salt is dissolved in it, the freezing point decreases. As a result, the temperature must be lowered further below 0°C for the water to freeze under these conditions.[3]

The principle of freezing point depression is an essential aspect of ice cream production because this mechanism regulates the formation of ice crystals during the freezing process. The addition of solutes such as salt to ice can lower the melting point of water, allowing the temperature of the mixture to drop below 0°C and creating a more stable freezing environment. This lower temperature promotes the formation of small and uniform ice crystals, which contributes to a smoother ice cream texture. This phenomenon aligns with the concept of freeze concentration described in the literature, where the reduction of freezing point and the control of heat transfer processes play a crucial role in determining ice crystal size and the microstructural properties of frozen dairy products.[4, 5] Thus, the application of freezing point depression not only accelerates the freezing process but also enhances the sensory quality of ice cream through more effective crystallization control.

The temperature of ice generally lies below 0°C. The addition of salt causes the ice to melt without requiring external heat, allowing the meltwater to remain below 0°C. This phenomenon demonstrates that salt lowers the melting point of water, causing ice to melt at temperatures lower than its normal melting point. During this process, the melting ice absorbs thermal energy, and in the absence of an external heat source, it draws heat from its surroundings, becoming increasingly colder. As the temperature of the ice decreases further, it is able to absorb more heat from the rotating ice cream mixture, causing the mixture to begin freezing. Through this simple mechanism, salt reduces the temperature of the ice sufficiently to freeze the ice cream mixture. Without the addition of salt, the ice would not reach a low enough temperature, and the stirred mixture would be unable to freeze. This freezing point depression principle is applied by rotating the ice cream mixture in a container submerged in a mixture of ice and salt, enabling the mixture to freeze at temperatures below the freezing point of pure water. When salt is added to the ice, the ice melts and forms brine, which reaches an even lower temperature. [6, 7]

In this study, several types of ice mixtures were used, namely Milo milk powder mix, sweetened condensed milk (SCM) mix, orange syrup mix, and lemon extract mix. SCM is a dairy product in the form of a thick liquid obtained from milk that has been combined with sugar and vegetable fats, followed by partial removal of water to achieve a specific concentration; it can also be produced by reconstituting milk powder with added sugar, vegetable fats or oils, and other ingredients. Milo contains various nutritional and energy-providing components, including malt, vitamins B2, B3, B6, B12, C, and D, as well as minerals such as calcium and phosphorus. This product also consists of other ingredients such as skim milk powder, sugar, cocoa powder, vegetable oil, and milk fat. ABC Orange Syrup, also known as ABC Squash Delight Florida Orange Flavor, is a syrup characterized by a fresh orange aroma. Its main ingredients include water, sugar, acidity regulators, synthetic orange flavoring, and artificial sweeteners, and it also contains vitamin C, which supports the immune system. Meanwhile, lemon contains various chemical compounds such as citric acid, flavonoids, tannins, vitamin C, vitamin A, vitamin B1, vitamin P, as well as minerals including potassium, magnesium,

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and bioflavonoids. Citric acid is the primary component responsible for the fruit's characteristic sour taste. In addition, lemon contains approximately 145 mg of potassium and 40–50 mg of vitamin C per 100 grams of fruit. [8, 9]

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

In this study, several tools and materials were used. The tools used are digital thermometers, digital scales, stirrers, jars (large containers) and also plastic for ice mixes. Salt that the materials used for this research are water, SKM, milo milk, orange flavor syrup and lemon flavor syrup.

2.2. Research Procedure

In this study, the first thing to do is to make a solution of each ingredient that has been prepared. Making milo solution. Mix 44 grams of milo with 220 ml of water and add 20 grams of sugar and stir until smooth, then put into plastic as much as 50 ml. Make SKM milk solution. Mix 76 grams of SKM into 200 ml of water and add 10 grams of sugar, then stir until well mixed. Then put into a plastic bag as much as 50ml. Make the syrup solution. Pour 64 grams of syrup into a container and add 200 ml of water, then stir until well mixed. Then put it in a 50ml plastic bag. For the lemon syrup solution, use the one already available in the store, then put it in a 50 ml plastic bag. Then each solution that has been put into the plastic is first measured the initial temperature using a thermometer, then record the initial temperature. Prepare a large container and fill it with ice cubes. For the first experiment sprinkle as much as 100 grams of salt on the container containing ice cubes. Then put each solution into the container and then close the container. After 2 minutes check the temperature of the ice cubes and salt using a thermometer and record the results. Next stir and shake the container for 2 minutes and see the changes that occur in the solution and record the results, then stir again and check the temperature again after 2 minutes (so a total of 6 minutes stirring). Perform the same steps by varying the amount of salt 200 grams and 300 grams. Record the temperature changes that occur and document them.

3. RESULTS AND DISCUSSION

3.1. Analysis of Characterization Results

After conducting ice cream making experiments on each mixture, namely milo mixture, SKM mixture, orange syrup mixture and lemon mixture with 3 different conditions, namely first with the addition of 100 grams of salt, then 200 grams of salt and finally with the condition of 300 grams of salt, the temperature difference in the mixture is obtained at every minute.

The experiment of making simple ice cream with milo mixture, SKM mixture, lemon water mixture, and orange water mixture can involve the concept of colligative properties of solutions and the effect of adding salt to ice cubes on the freezing point of the solution. Colligative properties of solutions are properties of solutions that depend on the number of dissolved particles, not the type of particles. The most relevant colligative property in ice cream making is the decrease in the freezing point of the solution. When a solute is added to a solvent, the freezing point of the solution will be lower than the freezing point of the pure solvent.

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Based on the experiments we have done, a solution containing salt and ice cubes can lower the temperature of the surrounding solution, forming a colder salt-ice mixture. Solutions containing more sugar and fat tend to freeze faster. Therefore, the SKM solution and Milo Milk solution, which contain milk and sugar, take faster time to turn into ice cream compared to the orange syrup solution and lemon water solution and result in lower temperatures, as can be seen in the following graph:

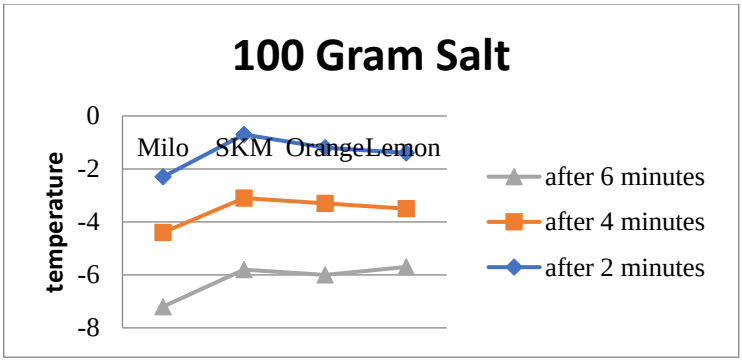

Figure 1. Graph of the results of making ice cream using 100 grams of salt

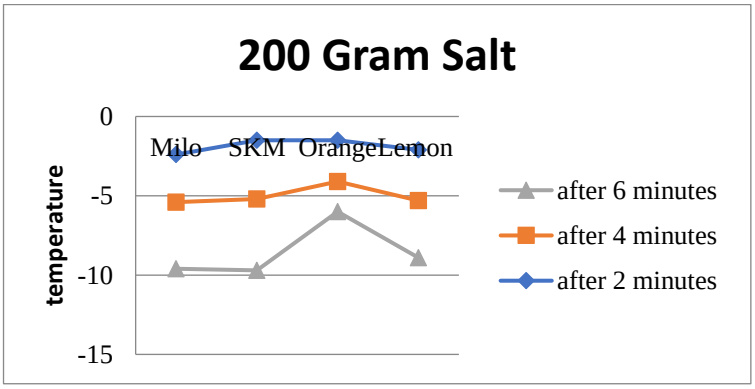

Figure 2. Graph of the results of making ice cream using 200 grams of salt

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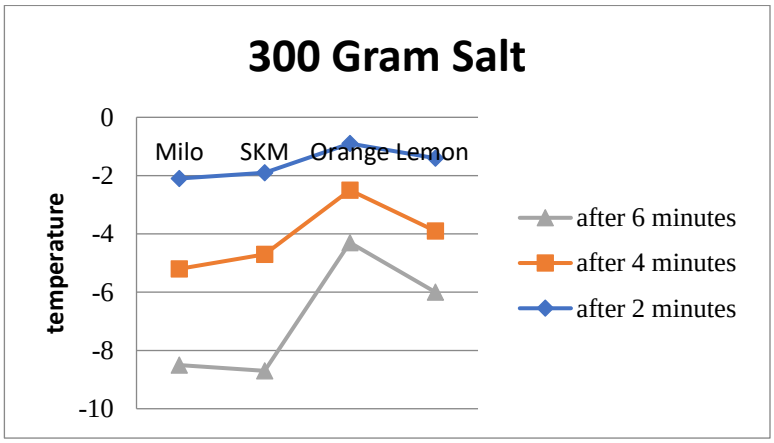

Figure 3. Graph of the results of making ice cream using 300 grams of salt

The more salt added to the ice cubes, the lower the temperature of the ice cubes and the lower the temperature of the solution. It turns out that the milo solution containing milk powder, cocoa powder, malt, sugar and other ingredients requires a much lower temperature than other solutions to reach freezing point. The content of milk powder in milo could be one of the causes, because milk contains sugar and protein that can affect the freezing properties of the solution.

Table 1. Experimental results of making ice cream with different amounts of salt

Solution	After 2 minutes			After 4 minutes			After 6 minutes		
	100 gr	200 gr	300 gr	100 gr	200 gr	300 gr	100gr	200 gr	300 gr
Milo	-2.3	-2.4	-2.1	-2.1	-3	-3.1	-2.8	-4.2	-3.3
SKM	-0.7	-1.5	-1.9	-2.4	-3.7	-2.8	-2.7	-4.5	-4
Orange	-1.2	-1.5	-0.9	-2.1	-2.6	-1.6	-2.7	-1.9	-1.8
Lemon	-1.4	-2.1	-1.4	-2.1	-3.2	-2.5	-2.2	-3.6	-2.1

In ice cream making, when salt is mixed with ice cubes, it creates an environment with a temperature below 0°C, which is necessary to freeze the ice cream mixture into a delicious texture. Thus, freezing point rise is an important concept in the ice cream making process that allows us to achieve lower cooling temperatures than what can be achieved with regular ice cubes.[10]

The freezing process is a critical stage in ice cream production because it determines ice crystal size, texture, and the final stability of the product. Freezing conditions including cooling rate, freezing method, and shear intensity during processing play a significant role in determining ice crystal size and the connectivity between crystals. The study demonstrated that different freezing techniques, such as the use of a batch freezer or liquid nitrogen freezing, lead to variations in ice crystal size and the internal structure of ice cream, which

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in turn affect product hardness, viscoelastic properties, and melting behavior. These findings emphasize that controlling the freezing process is a key factor in producing ice cream with a smooth texture and optimal stability.[11] As described by Harfoush et al. (2024), freezing dynamics in the ice cream industry are strongly influenced by cooling conditions, including the temperature of the cooling medium and the freezing rate, both of which are closely related to the phenomenon of freezing point depression.[12] When the cooling temperature is lowered further as occurs with the freezing point depression effect produced by adding salt to ice, the nucleation rate increases, resulting in smaller and more uniform ice crystals. This aligns with findings from dynamic freezing studies using scraped surface heat exchangers (SSHE), which demonstrate that lower cooling temperatures accelerate the formation of fine ice crystals and thereby improve the textural quality of ice cream. Thus, the application of freezing point depression, whether in traditional or industrial-scale processing, plays an important role in regulating freezing kinetics and producing ice cream with smoother texture and improved stability.

Ice cream making experiments using various solutions such as milo, SKM, orange and lemon syrup with the addition of salt and ice cubes will result in differences in flavor, texture, and characteristics of each ice cream. Here are some of the differences that may occur. Taste and Aroma: Each solution used (milo, SKM, orange and lemon syrup) will impart a different flavor and aroma to the ice cream. The syrup may give a distinctive sweetness, Milo will give a chocolate flavor, lemon will give a lemon flavor, and sweetened condensed milk will give a sweet and creamy flavor. Texture: The chemical composition of each solution will affect the texture of the ice cream.[13] Sweetened condensed milk, for example, will give a creamier and smoother texture, while lemon may produce a more bubbly ice cream due to the gas in the drink. Syrups can give thickness to the ice cream. Color: Based on the solution used, the color of the ice cream will also differ. Milo will give a brown color, lemon will give a transparent white color, and syrup will give a color according to the type of syrup used which is orange. Chemical Reaction: lemon produces a chemical reaction with salt and produces a unique froth or bubble effect in the ice cream.

The agitation speed during the freezing process is an essential factor that determines the physical characteristics of ice cream, particularly ice crystal size, air bubble size, and the stability of the final structure. Masuda (2023) reported that increasing agitation intensity during freezing accelerates the dispersion of air bubbles and fat globules, thereby inhibiting the growth of large ice crystals and resulting in a smoother texture. In addition, stronger agitation increases mechanical shear within the mix, which helps break down forming ice crystals and maintain a more uniform crystal distribution.[14] These findings are consistent with Sawano (2021), who demonstrated that variations in agitation speed influence not only ice crystal size but also melting behavior and the structural strength of ice cream. Higher agitation speeds produce smaller ice crystals and enhance the stability of the air fat matrix, ultimately improving the texture quality and overall consistency of the final product.[15] In addition, the effects of adding salt and churning in the ice cream may affect the final texture and consistency. Salt can help lower the freezing point of ice cubes and speed up the freezing process.

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4. CONCLUSION

The results show that adding a certain amount of salt significantly affects the freezing point raising effect of ice cream. The results show that making ice cream by adding 200 grams of salt to the ice cube is the most suitable amount. Higher freezing point rise can create softer and creamier ice cream. Sugar plays a crucial role in creating optimal texture and softness in ice cream. A balanced sugar level can increase the viscosity of the solution, create a finer crystal structure, and contribute to the softness of the final product. An optimal combination of the amount of salt added and the sugar content can produce ice cream with an optimal freezing point rise effect. The interaction between these two ingredients creates a synergy that leads to a better texture, providing a satisfying consumption experience. The results highlight the importance of understanding the proportions of ingredients in ice cream making. Carefully determining the amount of salt and sugar can be key in creating a product with the desired characteristics. And ingredient composition also greatly affects the texture and flavor of ice cream. The findings have important relevance for the food industry, particularly ice cream manufacturers, in developing more innovative formulations and producing higher quality end products.

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