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Effectiveness of Different Stabilizers on Physicochemical and Sensory Quality Cilembu Ice Cream

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ABSTRACT

Background: Ice cream is a dairy-based product that is widely enjoyed by people of all ages. The quality of ice cream is strongly influenced by its physicochemical properties, which are in part determined by the type of stabilizer used. Cilembu sweet potato is a local ingredient rich in nutrients, which can enhance the nutritional and sensory value of ice cream. This study aimed to determine the effect of different types of stabilizers on the physicochemical and sensory quality of Cilembu sweet potato ice cream.

Method: The research used the same ice cream formulation with four different stabilizers. The resulting products were analyzed for viscosity, overrun, melting rate, color, and evaluated through descriptive and hedonic tests.

Result: The results showed that CMC was the best-performing stabilizer, producing the highest viscosity (1.44 dPa.s), the highest overrun (3.52%), and the highest hedonic score (4.34 out of 5). Meanwhile, carrageenan yielded the slowest melting rate.

Conclusion: It can be concluded that the type of stabilizer significantly affects the physicochemical and sensory quality of Cilembu sweet potato ice cream, with CMC offering the best results in terms of texture, stability, and consumer acceptance.

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1. INTRODUCTION

Milk is one of the most nutritious food ingredients that is essential for human growth and development (Maris and Radiansyah, 2021). According to the Indonesian National Standard (SNI) 3713:2018, ice cream is defined as a frozen processed food product obtained through the emulsification of milk or its blends, pasteurization, and the incorporation of air to produce a smooth and homogeneous texture (Achmad *et al*., 2012). In addition, milk proteins also assist in the emulsification process during ice cream production.

At present, many commercial ice creams still use artificial flavorings added to non-fat dry matter. Innovation can be made by adding abundant local food ingredients with health benefits, such as the addition of Cilembu sweet potato. This sweet potato contains starch, which serves as non-fat dry matter (NFD) – a source of carbohydrates and fiber – and helps slow down ice cream melting (Spagnuolo *et al*., 2005). Processing Cilembu sweet potatoes into ice cream is one way to enhance the nutritional value and marketability of the product (Almadania, 2019).

Cilembu sweet potatoes have a unique characteristic compared to other sweet potato varieties: they produce a honey-like sap when roasted, earning them the nickname “honey sweet potato.” The heating process causes most of the starch in the flesh to convert to maltose, providing a natural sweetness (Maxiselly *et al*., 2024). The vitamin A content in Cilembu sweet potatoes reaches 8,509 mg/100 g, significantly higher than other tubers, which typically contain between 60 and 7,700 mg/100 g. They also contain 46 mg/100 g of calcium, beneficial for metabolism and bone and dental health, as well as various other vitamins such as B1 (0.08 mg), B2 (0.05 mg), niacin (0.9 mg), and vitamin C (20 mg) (Winarno, 2004).

A common challenge in ice cream production is low viscosity, minimal overrun, and rapid melting due to the lack of appropriate stabilizers. The type of stabilizer used greatly influences the quality and stability of ice cream. Stabilizers dispersed in the liquid phase bind significant amounts of water and form a network that restricts free movement of water molecules. According to Firdaus (2018), stabilizers play an important role in increasing the viscosity and homogeneity of ice cream batter by binding free water, preventing the formation of large ice crystals, and improving the final product’s texture. Additionally, stabilizers help maintain air stability in the batter, reduce fat hardness, and create a smooth texture. Common stabilizers used in ice cream production include CMC, gelatin, carrageenan, gum arabic, and pectin, typically used at doses ranging from 0.2% to 0.5% (Bayu *et al*, 2024). Each type of stabilizer has specific characteristics and can interact differently depending on the main ingredient of the ice cream.

This study aims to determine the most suitable type of stabilizer for the manufacture of ice cream based on Cilembu sweet potato and its effects on the quality and characteristics of the resulting product.

2. METHODS

2.1. Material and Equipment

The ice cream preparation used Ultra Milk brand UHT milk, oven-roasted Cilembu sweet potatoes from Kendal, skim milk powder, whipping cream, four types of stabilizers (carrageenan, CMC, gelatin, and guar gum), emulsifier ester, granulated sugar, and salt. Equipment for production included a Philips blender and mixer, Samono digital scale, spatula, Iwaki measuring cup, sieve, stove, freezer, and plastic gloves. For analytical testing, tools included a Shimadzu analytical balance, WR-10 colorimeter, aluminum dishes, oven

and desiccator, stopwatch, metal tweezers, Herma beaker, and assorted glass and plastic cups.

2.2. Research Design

2.2.1. Preparation of Cilembu Sweet Potato Ice Cream

Table 1. Cilembu Sweet Potato Ice Cream Formulation

No	Ingridient	Sample Code			
		KG	CMC	GL	GG
1	UHT Milk	250 ml	250 ml	250 ml	250 ml
2	Cilembu Sweet Potato	100 gr	100 gr	100 gr	100 gr
3	Skim Milk	50 gr	50 gr	50 gr	50 gr
4	Sugar	37,5 gr	37,5 gr	37,5 gr	37,5 gr
5	*Whipping cream*	15 ml	15 ml	15 ml	15 ml
6	Ester	2,5 gr	2,5 gr	2,5 gr	2,5 gr
7	Salt	0,5 gr	0,5 gr	0,5 gr	0,5 gr
8	Carrageenan	0,5 gr	0	0	0
9	CMC	0	0,5 gr	0	0
10	Gelatin	0	0	0,5 gr	0
11	Guar gum	0	0	0	0,5 gr

The procedure for making cilembu sweet potato ice cream begins with the preparation of ingredients, namely 100 grams of oven-baked cilembu sweet potato, 250 ml of UHT milk, 50 grams of skim milk powder, 37.5 grams of granulated sugar, 37.5 grams of sugar, 15 mL of whipping cream, 2.5 grams of ester, 0.5 grams of salt, and 0.5 grams of stabilizer (gelatin, guar gum, carrageenan, and CMC). Next, UHT milk, sugar, skim milk powder and salt were mixed in a container and blended for 2 minutes. After that, pasteurize for 15 minutes at 75°C and add stabilizer. After pasteurization, it was mixed at speed 5 for 10 minutes. After that, it was frozen in a freezer at 0℃ for 4-5 hours. After that, the frozen dough was added with ester and whipping cream. Then the dough was mixed again at speed 3 for 15 minutes. After that, the dough is poured into a container and then the ice cream dough is frozen in a freezer at a temperature of 0℃ for 12-24 hours.

2.3. Analysis

The analysis used in this study was overrun (Clarke, 2005), dough viscosity (Viscometer), melting rate, color (Colorimeter), descriptive test, and hedonic test.

3. RESULTS AND DISCUSSION

3.1. Ovverun Analysis

Overrun is the process of increasing the volume of ice cream before and after the freezing process due to the process of air binding during the churning process (Haryanti and Zueni, 2015). Overrun is formed due to churning during the freezing process. Without overrun, ice cream will form hard lumps. Measurement of ice cream overrun is done to determine the growth of ice cream (Istiqomah *et al*., 2017). Based on the results of research that has been done, it shows that the value of ice cream overrun ranges from 3.10% - 3.52%. With the lowest result obtained from the addition of gelatin stabilizer and the highest from CMC stabilizer. The results of variance showed significant differences in ice cream using

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carrageenan stabilizer (KG) and gelatin (GL), as well as between Carboxymethyl cellulose (CMC) stabilizer and gelatin (GL)% which can be seen in Table 2.

Table 2. Overrun Value of Cilembu Sweet Potato Ice Cream

Treatment	Overrun (%)
Carrageenan	3,48±0,19[b]
CMC	3,52±0,08[b]
Gelatin	3,10±0,31[a]
Guar gum	3,40±0,16[ab]

Notes: The same letter notation in the analysis results shows no significant difference at the 5% significance level using the Duncan test

Based on Table 2, it can be seen that the use of stabilizer types can affect the overrun results in ice cream. The highest overrun value is shown in the use of CMC and gelatin produces the lowest overrun value. This is in line with the research of Mailoa et al., (2017) where CMC has a long and rigid molecular structure and contains a negative charge from the carboxyl group. This structure helps CMC improve the texture of ice cream by keeping the water content from freezing easily and reducing the formation of ice crystals. Meanwhile, other studies argue that gelatin increases the viscosity and viscosity of the dough through the formation of a gel matrix that is able to hold the dispersed liquid phase. As a result, surface tension increases so that air is difficult to enter the dough, which ultimately leads to low overrun value (Puspa *et al.,* 2018). The effect of stabilizers on the overrun value of ice cream products is highly dependent on the ingredients used. This shows that the effectiveness of stabilizers is strongly influenced by their chemical and physical properties and interactions with ice cream raw materials.

3.2. Dough Viscosity Analysis

Viscosity is one of the important physical parameters in the ice cream industry because it greatly affects the texture characteristics, stability, and melting power of the final product. The level of viscosity is influenced by various factors such as temperature, pressure, type of solvent, and solution concentration. According to Fatimah *et al*., (2012), viscosity is also influenced by temperature, the attractive force between molecules, and the number of dissolved molecules. The higher the temperature of the solution, the viscosity will decrease because the particles in the system move faster. Too high a viscosity of ice cream batter can cause a bottleneck in the whisking process as it requires more energy for mixing. This reduces the ability of the batter to capture air, so the overrun value tends to decrease. Conversely, a viscosity that is too low can cause the ice cream to melt quickly and is less structurally stable. Therefore, a balance of viscosity is needed to produce ice cream with a soft, stable texture and optimal overrun. Based on the results of the research that has been done, it shows that the viscosity value of ice cream ranges from 1.1316 dPa.s - 1.4417 dPa.s. The results of variance showed significant differences which can be seen in Table 3.

Table 3. Viscosity Value of Cilembu Sweet Potato Ice Cream Dough

Treatment	Speed (rpm)	Viscosity (dPa.s)
Carrageenan	3	1,13±0,028[a]
CMC	3	1,44±0,026[c]
Gelatin	3	1,32±0,020[b]
Guar gum	3	1,27±0,028[a]

Notes: The same letter notation in the analysis results shows no significant difference at the 5% significance level using the Duncan test.

The use of stabilizer in ice cream formulation aims to control viscosity, form a

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homogeneous structure, and stabilize the mixture during storage and consumption. Carrageenan stabilizer has a low viscosity value compared to other stabilizers. This value can be influenced by the reaction between carrageenan and milk protein in ice cream. This reaction causes the formation of a dough that is not so thick, thus affecting its viscosity. CMC stabilizer has a high viscosity value. CMC can increase viscosity due to its ability to absorb water and form a thick colloidal solution. The thicker the dough, the higher the viscosity value. According to Goff and Hartel (2013) stabilizers such as carrageenan, CMC, guar gum, and gelatin have hydrophilic groups that are able to form hydrogen bonds with water molecules, thereby increasing the viscosity of the system. The greater the waterabsorption capacity and the ability to form a gel network, the higher the viscosity.

The chemical structure characteristics of the stabilizer also affect the viscosity of the ice cream dough. Stabilizers with long and branched polymer chains, such as guar gum and CMC, tend to produce higher viscosity because they create a denser and more viscous system. In contrast, stabilizers with weaker gelling ability such as gelatin result in relatively lower viscosity. The interaction between stabilizers and other components such as proteins, fibers, and fats can also increase viscosity through the formation of physical networks within the solution (Fidyasari *et al*., 2022).

3.3. Melt Rate Analysis

Ice cream melting rate is the time required for ice cream to maintain its shape and texture, as well as the time until the ice cream melts completely at room temperature. This parameter is important because it reflects the physical stability of the product after being removed from the freezer (Seno and Lewerissa, 2023). Stabilizer serves to prevent ice crystals in the manufacture of ice cream. Stabilizers have properties which easily absorbs water which will affect the viscosity of the dough in the ice cream and make the texture of the ice cream smooth (Aprillia *et al*., 2023).

Based on the results of research that has been done, it shows that the value of the ice cream melting rate ranges from 21.64 - 25.08 minutes. The results of variance showed significant differences in ice cream using carrageenan stabilizer (KG) and Carboxymethyl cellulose (CMC), carrageenan (KG) and guar gum (GG), gelatin (GL) and Carboxymethyl cellulose (CMC) and guar gum (GG) and gelatin (GL) which can be seen in Table 3. The highest melting time was produced by carrageenan stabilizer and the lowest was produced by CMC stabilizer. Meanwhile, gelatin and guar gum stabilizers have melting times that are not much different. The addition of carrageenan stabilizer causes the melting time of ice cream to tend to be longer, because carrageenan is able to bind ice particles in ice cream dough so as to make the ice cream dough thicker and the water binding power becomes stronger. So as to produce a product that does not melt quickly.

Table 4. Melting Rate Value of Cilembu Sweet Potato Ice Cream

Treatment	Melting Rate (Minutes)
Carrageenan	25,08±0,94^{b}
CMC	21,64±0,51^{a}
Gelatin	24,82±1,55^{b}
Guar gum	23,84±0,76^{a}

Notes: The same letter notation in the analysis results shows no significant difference at the 5% significance level using the Duncan test.

From the table above, carrageenan has a high melting power compared to other stabilizers. This is due to the reaction between carrageenan and proteins in milk that form

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carrageenan protein fish (Nugraha *et al.,* 2022). This bond is able to stabilize the ice cream dough that is formed and is able to bind the ice cream structure so that it has a longer melting power. CMC stabilizer has a low melting value because the high viscosity of the dough causes the ice cream to not melt.

One of the factors that affect the melting rate is the occurrence of syneresis, which is the release of water molecules from the ice cream structure that causes melting. The addition of stabilizers plays an important role in inhibiting syneresis by binding free water in the dough and preventing the formation of ice crystals between water molecules that can accelerate melting (Fikri *et al.,* 2022). In addition, the stability of the emulsion in the dough also determines the melting rate of ice cream. Products with stable emulsions tend to have slower melting rate because the distribution of fat and water in the dough is more even. According to Padaga & Sawitri, (2005) good ice cream has an average melting time of about 15-20 minutes at room temperature. Meanwhile, Marshall *et al.,* (2003) stated that the melting rate of ice cream is generally influenced by the addition of stabilizers, salt balance, emulsifying ingredients, as well as processing and storage. Stabilizers are able to form strong bonds with ice particles, thus slowing down melting.

3.4. Color Analysis

Color is an important factor in determining consumer acceptance of food products, so it needs to be analyzed. Cilembu yam ice cream color can be analyzed using Colorimeter WR-10 with Hunter L, a*, b* color system. The L value describes the level of brightness, the a* value describes the intensity of red (+) and green (-) colors, while the b* value shows the intensity of yellow (+) and blue (-) colors. The results of the color analysis of cilembu sweet potato ice cream can be seen in Table 4 below:

Table 5. Results of Color Analysis

Treatment	Color Profil		
	Lightness (L*)	*Redness* (a*)	*Yellowness* (b*)
Carrageenan	70.03±0,74^{a}	1,37±0,07^{a}	20,76±0,53^{a}
CMC	75,86±1.14^{bc}	2,55±0,11^{b}	23,36±0,11^{c}
Gelatin	77,37±0,25^{c}	1,47±0,28^{a}	21,84±0,18^{b}
Guar gum	75,00±2.95^{b}	1,63±0,04^{a}	22,10±0,16^{b}

Notes: The same notation in the same column indicates values that are not significantly different at the 5% significance level using the Duncan test.

In the L* value, the color of ice cream with the addition of different stabilizers shows that the ice cream treatment with carrageenan stabilizer is significantly different from ice cream with gelatin and guar gum stabilizer. Ice cream with the addition of CMC stabilizer is significantly different from ice cream with carrageenan stabilizer, but not significantly different from ice cream with gelatin stabilizer and guar gum (Clarke, 2005). The L* (lightness) value relates to how light or dark the color of the product is, and this is influenced by the stabilizer's ability to retain air (overrun) and the distribution of fat and water in the ice cream matrix. Stabilizers such as gelatin (GL), tend to produce a smoother and more stable ice cream structure, which reflects more light and appears brighter. In contrast, Carrageenan (KG) forms a denser gel network, causing less light reflection and darker appearing colors (Goff and Hartel, 2013).

In the a* value, producing ice cream with carrageenan stabilizer is not significantly different from ice cream with gelatin and guar gum stabilizer, but ice cream with CMC addition is significantly different from carrageenan, gelatin, and guar gum ice cream. The value of a* (red or green color tendency) can also be influenced by how the stabilizer

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interacts with natural color compounds or coloring additives in the ice cream formulation. Stabilizers that accelerate or stabilize certain chemical reactions, such as Maillard or mild oxidation, can amplify redness. CMC, which yields the highest a-value improves the dispersion of coloring ingredients or strengthens the visual effect of red by reducing flocculation or clumping of color particles. Acidic components or slightly different pH effects between stabilizers can also influence how color pigments appear visually (Marshall *et al*., 2003).

On the b* value, ice cream with the addition of gelatin was significantly different from ice cream with the addition of guar gum. Ice cream with the addition of cargenan and CMC is significantly different from ice cream with gelatin and guar gum stabilizer. The difference in b value (yellowness) indicates that each stabilizer affects the perception of yellow color differently. Stabilizers such as CMC and GG (Guar gum) can maintain emulsion stability and even distribution of color particles, resulting in a more intense yellowish color. Yellow is usually associated with a stable distribution of fat and protein, two components that visually contribute to the color of ice cream. In contrast, KG causes particle agglomeration or the formation of gel structures that inhibit even color distribution, resulting in a weaker yellowish color (Goff & Hartel, 2013).

3.5. Organoleptic Test

3.5.1. Descriptive Test

Table 6. Average Descriptive Test of Cilembu Sweet Potato Ice Cream

Treatment	Parameter				
	Color	Aroma of sweet potato	Flavor of sweet potato	Stickiness	*Scoopability*
Carragenan	4,49±2,35[a]	1,64±1,67[a]	3,94±2,19[a]	4,02±2,38[a]	4,48±2,21[a]
CMC	4,5±2,61[a]	1,73±1,92[a]	3,21±2,00[a]	4,22±1,85[a]	4,00±1,84[a]
Gelatin	4,33±2,54[a]	1,68±1,71[a]	3,20±1,72[a]	3,47±1,77[a]	3,87±2,24[a]
Guar gum	4,56±2,50[a]	1,70±1,33[a]	8,09±13,75[a]	4,36±1,89[a]	5,36±1,91[a]

Notes: The same notation in the same column indicates values that are not significantly different at the 5% significance level using the Duncan test.

Based on descriptive tests that have been carried out on 10 panelists, the results are not significantly different in all types of stabilizers, namely carrageenan, CMC, gelatin, and guar gum. In the color parameter, the average score ranged from 4.33 - 4.56. The aroma parameter of cilembu sweet potato average score ranged from 1.64 - 1.73 which shows the aroma of cilembu sweet potato is less aromatic. Then, in the cilembu sweet potato flavor parameter, the average score ranged from 3.20 - 8.09 which showed that guar gum had a stronger flavor than other types of stabilizers. In the melting parameter, the average score ranges from 3.47 - 4.36, which shows that gelatin has the longest melting power compared to other types of stabilizer. In the scoopability parameter, the average score ranged from 3.87 - 5.36, indicating that guar gum produces ice cream that is easily scooped.

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3.5.2. Hedonic Test

Table 7. Averaged Hedonic Test of Cilembu Sweet Potato Ice Cream

Treatment	Parameter					
	Color	Taste	Aroma	Texture	Appearance	*Overall*
Carrageenan	3,94±0,61[a]	4,04±0,85[a]	3,64±0,72[a]	3,84±0,81[a]	4,00±0,69[a]	4,00±0,67 [a]
CMC	4,06±0,65[a]	4,46±0,73[b]	3,96±0,80[a]	3,96±1,00[a]	4,06±0,71[a]	4,34±0,62 [b]
Gelatin	4,04±0,66[a]	4,22±0,70[ab]	3,88±0,77[a]	4,02±0,82[a]	4,18±0,66[a]	4,24±0,68 [ab]
Guar gum	3,94±0,61[a]	4,14±0,83[ab]	3,82±0,76[a]	3,88±0,87[a]	4,02±0,79[a]	4,06±0,73 [ab]

Notes: The same notation in the same column indicates values that are not significantly different at the 5% significance level using the Duncan test.

The hedonic test table in the Cilembu sweet potato ice cream research displays the level of panelist preference for several sensory attributes, namely color, taste, aroma, texture, appearance, and overall. The assessment was conducted by 50 panelists using a scale of 1-5, where a score of 1 means very dislike and a score of 5 means very like. The average results showed that all stabilizer types (carrageenan, CMC, gelatin, and guar gum) produced ice cream with a good level of acceptance, with scores ranging from neutral to very like on all parameters tested.

In particular, ice cream with the addition of CMC obtained the highest hedonic scores in the taste and overall categories, indicating the highest level of panelist liking compared to other stabilizers. Meanwhile, there were no significant differences between stabilizers in color, aroma, texture, and appearance attributes, which means that all types of stabilizers were well accepted by the panelists. This study shows that the use of various types of stabilizers still produces cilembu sweet potato ice cream that consumers like.

4. CONCLUSION

Based on the results of the study, it can be concluded that the use of different types of stabilizer gives a real influence on the quality of Cilembu yam ice cream, both physicochemically and sensorially. From the results of physicochemical analysis, CMC stabilizer produced the highest viscosity and overrun, indicating a thicker texture and more fluffy ice cream volume. Meanwhile, carrageenan gave the longest melting rate, but not as good as CMC in terms of texture and consumer acceptance. In color analysis using the parameters L* (brightness), a* (green-red), and b* (blue-yellow), ice cream with CMC showed a brighter color (high L* value), attractive yellowness (high b* value), and a slight tendency towards red (positive a* value). The hedonic test results also showed that all stabilizer types were well accepted by the panelists, but CMC scored the highest in several aspects, especially in the overall category. Thus, it can be concluded that the use of stabilizer greatly affects the quality of Cilembu yam ice cream, and CMC is recommended as the main choice because it can improve texture, stability, color appearance, and overall consumer acceptance.

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