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Physical, Chemical, and Sensory Properties of Ice Cream with the Substitution of Stabilizer with Gelatin from Various Sources

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Abstract: Bovine and porcine gelatin are usually used as ice cream stabilizer. However, Muslims are forbidden to consume foods that contain porcine or its derivatives product. Hence, in our previous study, we developed a technique to produce gelatin from local sources such as fish, buffalo, and bovine. This study aimed to determine the effect of various gelatin on the physical, chemical, and sensory properties of ice cream. Bovine, fish, and buffalo gelatin with the same concentration of 0.3% are added as ice cream stabilizer. We evaluated the overrun, melting rate, viscosity, as well as the nutrient content. The sensory properties were tested using a hedonic test using a 7-point scale. The substitution of carboxymethyl cellulose (CMC) with various gelatin did not affect the overrun, the melting rate, ash and protein content as well as sensory attributes ($p>0.05$). On the other hand, ice cream with various gelatin significantly affected the viscosity, moisture, fat, and carbohydrate content ($p<0.05$).

Keywords: bovine gelatin; fish gelatin; buffalo gelatin; ice cream stabilizer

1. INTRODUCTION

Stabilizers are water binder substances that added to food as food additives. It can be added during the food processing to get favorable texture or viscosity. The stabilizer that available in the market are those of polysaccharides such as Carboxymethyl Cellulose (CMC), gum arabic, carrageenan, and pectin. In addition to the polysaccharide stabilizer, there is also stabilizer from protein compounds such as gelatin. There are several kinds of gelatin found in the market namely bovine, fish, and porcine gelatin. Since more than 80% of the Indonesian population embracing Islam, hence consumption to non-halal substances such as porcine gelatine is forbidden. In our previous study, we conducted a research to produce halal gelatin from local sources such as from buffalo, bovine, goat, and fish [1,2]. The gelatin from those animal sources can be used as an alternative stabilizer.

Gelatin can be obtained from partial hydrolysis of protein from the skin, bone, and animal

connective tissue [3]. Gelatin can act as a gelling agent, water binder, thickener, and emulsifier. Gelatin has a melting point between 27^0 to 34^0C. This is a characteristic of gelatin that makes it able to melt in the mouth. According to Agustin [4], the results of protein hydrolysis from bone and skin of tuna fish have some properties which can be easily digested by the body and contain high protein. According to Mafazah [5], fish gelatin tends to be safer and its raw materials are abundant. The use of gelatin as a stabilizer in the making of ice cream can result in higher overrun value, texture, taste, aroma, and overall acceptance compared to the use of CMC stabilizer [6].

Ice cream is a product of frozen or semi-solid food made from a mixture of ingredients such as fat, stabilizers, sweeteners, and emulsifiers. The ingredients used in the making of ice cream will affect the characteristics and sensory properties of the ice cream. The process of making ice cream requires a stable material to prevent large ice crystals from forming, to produce a good texture, to maintain emulsion stability, to improve product properties as well as to reduce melt rate. In addition, the stabilizer can keep water and fat from crystallizing [7]. The addition of gelatin in ice cream is expected to enrich its nutritional value of protein compared to that use polysaccharide stabilizers. According to Yahdiyani [8], chili cream cheese products using fish gelatin contain higher protein than using CMC stabilizers. This is because gelatin contains 35% protein, whereas CMC does not contain any protein [9].

The quality of the ice cream products can be assessed from its physical, chemical, and sensory properties. This study aimed to determine the effect of bovine, fish, and buffalo gelatin on the physical, chemical, and sensory properties of ice cream.

2. MATERIALS AND METHODS

2.1. Material and ice cream formulation

The ice cream ingredients were skim milk, sugar, gelatin from various animal skin sources (bovine, fish, and buffalo gelatin), CMC as control stabilizer, ovalett, vanilla essence, water, and whipping cream. All ingredients were bought from local, except the bovine, fish, and buffalo gelatin which were obtained from Laboratory of Animal Products Technology, Universitas Gadjah Mada.

The first step in making ice cream was to mix stabilizer (CMC or gelatin) into hot water. This step was done so that the gelatin could be mixed perfectly with the other ingredients. After that, dry ingredients such as sugar, skim milk, and pre-prepared gelatin were mixed by adding water and then stirred until the mixture became evenly distributed. After that, ovalette, vanilla essence and whipping cream were added to the mixture and then stirred until they mixed thoroughly.

The mixture is then pasteurized using a temperature of 80 ^{o}C for 25 seconds. Then the mixture was cooled at room temperature after which the mixture is homogenized by using a blender for 10 minutes. The mixture was cooled back at room temperature. The next step was aging in which the mixture was put into the refrigerator with a temperature of 4 ^{o}C for 4 - 24 hours. Next, the mixture was frozen with an Ice Cream Maker for 45-60 minutes. The formulations of the ingredients for ice cream making can be seen in Table 1.

Table 1. The composition ice cream ingredients

Ingredients	Compostiton (g)
Skim Milk	8,5
Sugar	15
Gelatin or CMC	0,3
Ovalette	0,1
Water	45,54
Whipping Cream	30,56
Total of the ingredients	100 g
Total solids	36,4
Fat	11%
MSNF	10%

Source : Goff and Hartel [10]

Note: MSNF: milk solid non fat.

The composition of the ice cream ingredients was presented in 100g

2.2. Physical properties analysis (overrun, melting rate and viscosity)

Overrun was calculated by measuring the volume of ice cream mixture with a measuring cup before being stirred in an ice cream maker. After being processed, the volume was measured again to get the volume of the ice cream. Next, overrun was calculated by using the following formula:

$$Overrun\ (\%) = \frac{volume\ of\ processed\ ice\ cream - volume\ of\ ice\ cream\ mixture}{volume\ of\ ice\ cream\ mixture} x100\%$$

The melting rate was measured by putting 10 grams of ice cream sample on a filter that had a glass as its container underneath. The ice cream was let to melt at room temperature. Then, the time needed by the ice cream to melt completely was measured by using a stopwatch. The viscosity was measured using a 75 ml sample of ice cream which has been melted at room temperature which then was measured using a Viscometer Brookfield device.

2.3. Chemical properties analysis

Proximate analysis was conducted according to the methods of AOAC [11], whereas carbohydrate was determined by difference. The proximate analysis tested in this study included protein, fat, ash, and moisture content.

2.4. Sensory properties test

The hedonic test was conducted by involving 35 panelists. A 7-point scale was used to assess the aroma, taste, texture, and overall attributes subjectively. The 7-point scale anchored by: 1=”strongly disliked”; 2=”disliked”; 3=”slightly disliked”; 4=slightly liked”; 5=”liked”; 6=”strongly liked”; 7=”extremely liked”.

2.5. Statistical analysis

The normality of the data was analyzed using the Shapiro Wilk test. The physical and chemical properties of the ice cream were analyzed using One-way Anova test, while the sensory properties were analyzed using the Kruskal-Wallis test.

3. RESULTS AND DISCUSSION

3.1. Physical properties of ice cream

The physical properties of ice cream with different types of gelatin are shown in Table 2. The viscosity between the ice cream was significantly different ($p<0.05$), while the overrun and melting rate did not significantly different [$p> 0.05$]. Ice cream with bovine gelatin had the highest overrun score while the one with buffalo gelatin had the lowest overrun score. Ice cream with fish gelatin stabilizer had the longest melting rate, while ice cream with buffalo gelatin had the fastest melting rate. Ice cream with CMC stabilizer had the highest viscosity and ice cream with bovine gelatin had the lowest viscosity.

The use of various gelatin as stabilizers gave effects on the viscosity of the ice cream but did not give any effects to the overrun and melting rate of ice cream. The high or low overrun score is determined by the air trapped during the freezing process using the ice cream maker. One of the factors influencing the air trapped during the process was the stabilizer. According to Hartatie [6], ice cream with a higher viscosity will make it thicker and difficult to develop. It caused decreases in the ice cream overrun score. Hartatie [6] found that the ice cream with a gelatin stabilizer had a higher overrun score than ice cream with a CMC stabilizer. This is due to gelatin's characteristics which have a distinctive texture and resistant to sudden temperature changes. On the other hand, the ice cream melting rate is related to the amount of fat. Ice cream which contains low fat causes the ice cream to melt faster [12].

Ice cream viscosity can be affected by the material's viscosity, in this case, the gelatin stabilizer. The viscosity of buffalo gelatin ice cream was higher than the one of bovine gelatin ice cream. This was caused by the viscosity of buffalo gelatin that is higher i.e. 4.29 cP compared to bovine gelatin which is 3.82 cP [13]. Ice cream with CMC stabilizer had the highest viscosity compared to those using gelatin stabilizers. It might be correlated with the viscosity of CMC which is 10 cP [14]. According to Mulyani [15], the viscosity will affect the overrun score so that the higher the viscosity, the lower the overrun score. This happened because the high viscosity will make the ice cream mixture difficult to expand. This statement is in accordance with this study, that ice cream with bovine gelatin which had the lowest viscosity and the highest overrun score.

Table 2. Physical properties of ice cream with the substitution of stabilizer with various gelatin

Type of Stabilizer	Overrun (%)	Melting Rate (minutes)	Viscocity (Cp)
CMC	36.05±4.88	20.05±2.75	4134.00±98.15
Bov-G	37.27±0.33	20.74±3.46	50.38±0.75
Fi-G	36.90±2.69	23.76±1.00	299.68±110.26
Buf-G	34.80±3.82	18.86±2.18	461.40±37.47
p value	0.885	0.371	0.001

Note: CMC: carboxymethyl cellulose; Bov-G: bovine gelatin; Fi-G: fish gelatin; Buf-G: buffalo gelatin

3.2. Chemical properties of ice cream

The chemical properties of ice cream with different types of stabilizers are shown in Table 3. The moisture, fat, and carbohydrate content were significantly different. On the other hand, ash and protein content were not significantly different. Ice cream with bovine gelatin had the highest amount of moisture content, while ice cream with fish gelatin had the lowest. This was caused by

amino acid proline and hydroxyproline of bovine gelatin which is higher than that of fish gelatin. According to Leward [16], the ability of gelatin in binding water is influenced by amino acid composition in the gelatin namely proline and hydroxyproline.

According to Alkali et al. [9], the protein content of gelatin is 35%, hence the ice cream with gelatin stabilizer will have a higher protein content than the one with the CMC stabilizer. However, in our study, we found that the protein content between the ice cream was not significantly different ($p>0.05$). This was caused by the concentration of gelatin used in the ice cream formulae was only 0.3%. According to Yahdiyani [8], by using the same concentration of gelatin and CMC that was 0.4%, the difference in protein content of the product was only ± 1%. Consequently, if the concentration of the stabilizer only 0.3%, it couldn't show the difference in protein content significantly

The highest fat content was found in the ice cream with fish gelatin, followed by ice cream with bovine gelatin and buffalo gelatin. As stated by Violisa [17], ice cream fat content is associated with overrun. The higher the fat content of the ice cream the higher the overrun score. The low-fat content caused the ability to form three-dimensional structures that can trap air to be low. Ice cream with various gelatin stabilizer did not have a significant difference in carbohydrate content because gelatin does not contain carbohydrates as it comes from skin collagen, so it contains more protein [9].

Table 3. Results of Chemical Properties Analysis of Ice Cream with Various Gelatin

Type of Stabilizer	**Nutrition Composition (%)**				
	Moisture	**Ash**	**Protein**	**Fats**	**Carbohydrate**
CMC	57.86±0.08	0.79±0.05	4.25±0.35	9.38±0.31	27.71±0.53
Bov-G	59.89±0.58	0.73±0.44	3.83±0.25	10.64±0.33	24.91±0.42
Fi-G	59.22±0.24	0.76±0.43	4.05±0.22	10.85±0.42	25.12±0.13
Buf-G	59.66±0.11	0.74±0.29	4.04±0.26	10.51±0.65	25.06±0.48
P	**0.001**	**0.274**	**0.247**	**0.003**	**0.001**

Note: CMC: carboxymethyl cellulose; Bov-G: bovine gelatin; Fi-G: fish gelatin; Buf-G: buffalo gelatin

3.3. Sensory properties

The result of the hedonic test can be seen in Table 4. The hedonic test was conducted to determine the preference level of ice cream products. In terms of sensory property, there were no differences between the ice cream made with various stabilizers ($p>0.05$). Since most of the ingredients for the making of ice cream are the same, then the color, aroma, and taste of ice cream did not differ among variant of ice cream. The stabilizers improved the texture because the stabilizer serves to keep the water in the ice cream from over freezing and to reduce the formation of large ice crystal. According to the overall attribute, ice cream with buffalo gelatin is the most preferred ice cream among panelists. In line with the melting rate analysis, ice cream with buffalo gelatin has the lowest melting rate, hence the panelist seemed to prefer soft ice cream that easy to melt in the mouth. Hartatie [6] found that ice cream with the addition of gelatin had better taste compare to the ice cream with CMC as a stabilizer.

Table 4. Hedonic test of ice cream with various gelatin

Type of Stabilizer	Sensory Attributes				
	Color	**Aroma**	**Taste**	**Texture**	**Overall**
CMC	4.86±0.91	5.09±0.70	4.86±1.06	4.91±1.36	4.74±1.20
Bov-G	5.11±0.63	4.89±0.87	5.11±1.16	5.00±1.00	4.97±1.07
Fi-G	5.03±0.57	4.86±0.77	5.46±0.95	5.43±0.78	4.86±1.00
Buf-G	5.11±0.90	4.71±0.96	5.23±1.14	4.80±0.96	5.37±0.84
P	**0.470**	**0.455**	**0.104**	**0.105**	**0.056**

Note: CMC: carboxymethyl cellulose; Bov-G: bovine gelatin; Fi-G: fish gelatin; Buf-G: buffalo gelatin
The data was analyzed using Kruskal-Wallis test with the significancy level 0.05

4. CONCLUSION

The substitution of CMC with various kinds of gelatin as a stabilizer resulted in the same overrun and melting rate, while the viscosity of the ice cream was significantly different. In terms of nutrient content, the ash and protein content was similar, while moisture, fat, and carbohydrates were different. The preference of the ice cream among different variants revealed that the panelist gave a "5" score on average, hence it can be concluded that the panelist "liked" the color, aroma, taste, texture, and the overall characteristic of the ice cream.

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