Ice cream properties affected by carrageenan form seaweed deference type drying methods

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Abstract. This study was aimed to investigate on physical properties of ice cream samples prepared with combined κ-carrageenan from seaweed by using two methods of drying seaweed which is direct sun-drying and drying using sauna techniques, the results the highest overrun was in ice cream with κ-carrageenan with sauna system (59.54±0.55 %). The highest melting rate was ice cream with Sodium carboxymethyl cellulose (1.72±0.05 g/min). The highest of viscosity was κ-carrageenan with the sauna system (143.67±1.52 cP). The highest of hardness was κ-carrageenan with the Sodium carboxymethyl cellulose (405.20±0.26 g/cm²). The sauna technique good for overrun, viscosity and direct sun-drying good for hardness.

1. Introduction

Kappaphycus alvarezii type of seaweed is a non-fish fishery product which is currently one of the featured products that have various uses with advances in science and technology, the use of seaweed is very diverse, both for food and non-food products [1]. Seaweed food and pharmaceutical industry. One of factors the determinants of the high selling value of seaweed is post-harvest handling, namely the drying process [2]. The drying process which aims to reduce water content in K. alvarezii. The method of drying directly the sun and the sauna method are methods commonly used by the community so they need to be applied to food. K. alvarezii as a producer of carrageenan extracts. Carrageenan is an alternating copolymer of α-(1-3)-D-galactose and β-(1-4)-3,6- anhydro-D-galactose and is classified as kappa (κ), iota (ι), and lambda (λ) based on the number of sulfate based on the number of sulfate ester groups and presence of 3,6-anhydro-D-galacto. Carrageenan which a polysaccharide from red seaweed extracted the type Chondrus, Euchema, Gigartina, Hypnea, Iradea dan Phyllophora [3,4] Carrageenan use the food products serves as stabilizer, emulsifiers [4,5], in pharmaceuticals [6], red alga applied to cosmetic product [7].

In general, carrageenan is divided into 3 fractions based on its constituent units, namely kappa, iota, and lambda carrageenan. All three differ in the gel’s nature and its reaction to protein. Kappa carrageenan produces a strong gel, while iota forms a gel that is smooth and easily formed, and lambda cannot form a gel. All three is thermoreversible, which means it will melt when heated and becomes gel again if cooled.
Carrageenan and alginate have been widely used in various fields; carrageenan can be used as a gel or stabilizer, suspender, as well as the maker of emulsion textures. Therefore, carrageenan is widely used in the food industry, medicines manufacture of pills and tablets, cosmetics, and other industries. One of the food products that carrageenan use is ice cream which serves as a stabilizer to bind water and produce proper viscosity to limit the formation of ice crystals and lactose crystals, especially during storage temperature.

Stabilizers are one of the important ingredients in ice cream as a stabilizer, although in small amounts. The main role of stabilizers is to reduce the amount of free water in ice cream by binding it to the gel structure, absorbing and holding the amount of water that is bound, producing a soft ice cream texture, slow to melt, forming a solid ice cream. There are many formulations and processing factors that affect the texture and reception of ice cream [8]. A good stabilizer should be non-toxic, easily spread in the mixture, does not produce excessive viscosity or separation or foam in the mixture, making the texture of the cream cream soft, economical and does not add flavor to the ice cream mixture [9]. To get a good ice cream you need to pay attention to the composition of the dough and the making technique. The percentage of stabilizers greatly affects the texture results of the ice cream. The stabilizer material used is 0.1-0.5% of the total ice cream mixture. The percentage of stabilizer depends on the mixture used, for example, a mixture of high fat or total solids (40%) and a mixture of chocolate or ultra-high temperatures use fewer stabilizers compared to mixtures with a lower total density of around 37% [8].

The amount and type of stabilizer needed in ice cream depends on its properties, mixtures of ingredients, materials used; processing time, temperature, and pressure; temperature and time storage; and many other factors. Stabilizers must also be clean, neutral, not tied to other ice cream flavors, contribute to the destruction of ice cream, and provide the desired texture for consumption [8]. Carrageenan is used special stabilizing substances on ice cream ranges from 0.01-0.03% [10,11,12].

2. Material and methods
2.1. Material
This section describes the use of carrageenan in ice cream with different methods of drying seaweed. Drying was done in two methods, using a direct sun-drying system and drying using a sauna system. The carrageenan was used as a stabilizer in ice cream with a composition of 0.3% in ice cream. For the purpose of comparison in this research, the derived from sodium carboxymethyl cellulose (CMC) was used to control.

| Table 1. Ice cream formulation

| Formulation                        | Amount (g) |
|-----------------------------------|------------|
|                                   | Control    | Sample   |
| Whole milk                        | 43         | 43       |
| Skimmed milk powder               | 4.6        | 4.6      |
| Whipping cream                    | 39         | 39       |
| Sugar                             | 13         | 13       |
| Vanilla                           | 0.1        | 0.1      |
| Sodium carboxymethyl cellulose (CMC) | 0.3    | 0.03     |

Source: [10,11,12].

2.2. Preparation of ice cream
The stages of making ice cream were as follows: The first step was the standardization and formulation making. The whole milk, whipping cream, emulsifier (carrageenan) and water. Then, the ice cream mixture...
was homogenized using a mixer for 10 minutes at a speed of 1500 rpm. heated to approximately 40-50°C, was mixed. Next, the mixture of ice cream dough was pasteurized at 60°C for 5 minutes while being continuously stirred. Afterwards, the ice cream mixture was transferred into a plastic container to cool (aging process) until the temperature reached 4°C in the refrigerator for 24 hours. Then, the ice cream was made by using an ice cream maker for 35 minutes which was referred to as the process of freezing and frothing. This process was carried out continuously at -10°C. Finally, the finished ice cream was transferred to a plastic container and placed in the freezer for the hardening process at -25°C for 24 hours. Analysis of the ice cream’s physical quality was carried out through the measurements of:

1. Overrun value [13]. Overrun calculation was done by calculating the difference in volume of ice cream products with the initial volume of dough at the same weight or based on differences in product weight with the weight of the original dough at the same volume.

2. Melting speed of ice cream. The measurement of melting speed was carried out on ice cream that had been hardened for 24 hours. The melting time was measured in the following way: a total of 10 g of ice cream was placed in a filter and stored in a glass and allowed to melt completely at room temperature.

3. The viscosity was measured by using Brookfield Viscometer. A 100 ml sample was placed into a cup of 100 ml. By using spindle 2 and the speed of 30 rpm, the sample’s viscosity was measured. The measurement was done in 2 minutes till the needle readings reached a stable position. The rotor span and the needle would move until the sample’s viscosity was obtained.

4. Hardness of ice cream [14,15]. A texture analyser can be used to measure the hardness of the hardened ice cream, which was conditioned at room temperature for 5 minutes before the experiment (CNS Farnell Com, UK). The temperatures at the geometric centre of the sample were -16±1ºC, immediately before starting the test. Three measurements were done for each sample using a 6-mm stainless steel cylindrical probe. The penetration depth was 15 mm and the penetration speed was set at 2.0 mm s⁻¹. Hardness (g) of the sample was determined as the peak compression force during the penetration.

5. pH value. The measurement of pH analysis was done using pH meter. Before it was used, the pH meter was calibrated using buffer solution with pH 4 and pH 7. As much as 10 ml of the ice cream sample was prepared in a measuring cup, then the electrode of pH meter was dipped into the sample.

3. Result and discussion

3.1. Overrun

The overrun measurement showed average ice cream with stabilizer was 54.12±0.75. The lowest value was in control (47.85±0.98 %) ice cream with stabilizer the sodium carboxymethyl cellulose (CMC). The highest average value was in ice cream with k-carrageenan from seaweed drying sauna system (59.54±0.55 %). But the overrun of control showed lower value than treatment thus, it can be said that the stabilizer using carrageenan provided a high overrun value. Ice cream volume increases before the freezing process, when air trapped in ice cream causes ice cream volume to increase. The more stabilizer used, the lower the overrun. k-carrageenan addition in ice cream making makes ice cream dough thick because alginate binds water molecule to dough, ice cream with high overrun are softer. Thick dough makes surface tension greater, so air has difficulty penetrating dough surface and the ice cream growth will be small [16]. The degree of development (overrun) is one of the most important parameters in the ice cream production since it can determine the level of profits economically. The greater the value of overrun, the higher the level of profits.

3.2. Melting rate

Ice cream melting rate measurement showed that ice cream with increased k-carrageenan concentration has average melting time of 19.71 to 21.23 minutes. Histogram of average melting rate of ice cream can be seen in Table 1. The average value of melting power tests of ice cream from 3 (three) treatments produced were
ranged from 0.97±0.05 g/min. The highest average value was at treatment Sodium carboxymethyl cellulose (1.72±0.05 g/min), the ice cream with k-carrageenan from seaweed drying sauna system) showed the lower value of melting rate (0.72±0.01 g/min). Overall, the times of the melting rate of treatment and control were not much different. It was due to the amount of carrageenan and CMC used were similar so it has the ability to bind the ice particles which are not much different in the ice cream dough. This result was lower than the commercial ice cream on the market which has the melting speed of 2.017 min/g. It was because the ice cream in this study used milk with 3.5% fat content in 100 ml or a low fat content made the ability to form three-dimensional structures which can trap air low. This hydrocolloid its ability to control recrystallization the presence of milk proteins [15]. Besides the stabilizer, a low fat content made the ice cream melted faster. Milk fat is functioned to improve the nutritional value of ice cream, add flavor, produce soft texture characteristic, give shape and density as well as give good properties of ice cream melting. The speed of ice cream melting is affected by the amount of air trapped in the ice cream mixture, ice crystals formed [17].

Table 2. Physicochemical characteristics of ice cream containing k-carrageenan with different methods of drying seaweed

| Parameter      | Treatments                         |
|----------------|------------------------------------|
|                | Direct dry with the sun | Sauna | CMC               |
| Overrun (%)    | 54.95±0.72                      | 59.54±0.55 | 47.85±0.98        |
| Melting Rate (g/min) | 1.10±0.08                   | 0.72±0.01    | 1.72±0.05         |
| Viscosity (cP) | 104.00±2.00                     | 143.67±1.52  | 132.33±2.75       |
| pH             | 7.79±0.02                       | 7.86±0.02    | 7.92±0.02         |
| Hardness (g/M²) | 398.27±1.19                    | 211.88±1.19  | 405.20±0.26       |

3.3. Viscosity
Viscosity is one of the most important properties of an ice-cream mixture since it can result in a desirable body and texture in ice creams, the results of the average viscosity of ice cream of 126.67±1.96 cP, The highest average value was at treatment k-carrageenan with the sauna system (143.67±1.52 cP) and the lowest ice cream with k-carrageenan with seaweed direct sun-drying system (104.00±2.00 cP). Measurement of viscosity on ice cream is important because viscosity can affect the mobility of water molecules in the space between particles in the ice cream to become increasingly narrow or wide which will affect the process of developing or overrun and the texture of ice cream. Each stabilizer has different characteristic, so it will produce different products viscosity along with the increase of concentration [5].

3.4. pH
Concentration of pH on ice cream is very important to maintain the stability of the mixture, based on Table 1 overall, the pH between treatment and control did not differ significantly (7.79±0.02, 7.86±0.02 and 7.92±0.02). Because the one that plays a large role in the pH concentration of ice cream is milk, therefore selection of milk is very important in the process of making ice cream. Carrageenan serves as a stabilizer in the process of making ice cream, and has no effect on pH concentration in ice cream. The use of carrageenan in ice cream serves as a stabilizer [18]. The acidity of ice cream depends on the ingredients used in the ice cream mixture. The pH value is determined by milk protein, mineral salts and dissolved CO₂ [13]. Too high acidity is not desirable because it will reduce the development, the texture of the ice cream becomes thicker and gives rise to unpleasant tastes. The pH value that is too high is also not good, because at high pH, the protein will be soluble which reduces the stability of the emulsion.

3.5. Hardness
The results of hardness measurement showed the average hardness of ice cream that used carrageenan as the stabilizer was 338.45±0.57 g/cm². The highest average value was at treatment k-carrageenan with the CMC (405.20±0.26 g/cm²) and the lowest hardness of ice cream was of carrageenan from seaweed that used the sauna system (211.88±1.19 g/cm²). The hardness of ice cream is influenced by many factors such as the overrun, size of ice crystals, volume of ice phase, and destabilization level of fat. While the stabilizer functions to keep the water in the ice cream to make it not too frozen and to reduce crystallization of ice. The hardness is one of the characteristics of ice cream which is important related to the ability of ice cream[18]. Hydrocolloids or stabilizers had an effect on free water, preventing the growth of ice crystals [10]. The results showed an inverse comparison between the hardness value and overrun value where the ice cream with high overrun value will produce a soft texture. Therefore, the higher the overrun value the hardness of the ice cream will decrease, which shows that the hardness of ice cream is influenced by several things, like the overrun and viscosity.

4. Conclusion
Ice cream used k-carrageenan with seaweed direct sun-drying system the highest for hardness and ice cream was of carrageenan from seaweed that used the sauna system the highest for overrun, melting rate, viscosity. The comparison between the hardness value and overrun value where the ice cream with high overrun value will produce a soft texture. Therefore, the higher the overrun value the hardness of the ice cream will decrease.

5. References
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