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Kappa and iota carrageenan combination of *Kappaphycus alvarezii* and *Eucheuma spinosum* as a gelatin substitute in ice cream raw material product

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Abstract. Carrageenan can generally be used as a substitute for gelatin presented in ice cream raw material. Various types of carrageenan may influence the organoleptic and phytochemical characteristics generated by the ice cream product. The purpose of this research was to observe the effect of different carrageenan concentrations on the ice cream's characteristics. This research used a complete randomized design experimental method with four treatments and five replications, which were ice cream with kappa carrageenan substitute, ice cream with iota carrageenan substitute, ice cream with kappa and iota carrageenan substitutes, and a control treatment containing ice cream with gelatin. The results showed that ice cream with the kappa and iota carrageenan substitutes had the following nutritional value: carbohydrate 11.3%, protein 9.585%, fat 6.995%, fiber 17.695%, water 51.525%, ash 2.9%, and 0.85 viscosity. The results using gelatin had the following nutritional values: carbohydrate 12.72 %, protein 9.225%, fat 8.65%, fiber 14.08%, water 52.01%, ash 3.315% and 0.745 viscosity. The results indicate that the kappa and iota carrageenan combination is low fat, high protein, and high fiber ice cream, which means that the kappa and iota carrageenan combination can substitute gelatin as a stabilizer in ice cream.

1. Introduction

Indonesia has a sea whose coastline is rich in various biological and potential environments. This situation is one of the factors that can support the success of the fisheries sector. Nowadays, natural resource processing efforts- in this case, seaweed - have shown significant progress when it comes to improving the lives of human beings [1].

Most of the buyers of Indonesian seaweed are in Singapore and Hong Kong. After being processed in these countries, it is often sent to the United States, France, and Denmark. The world market prices for products from Indonesia are still low. This is because the quality of processed seaweed is still often not by international quality standards. Indonesian seaweed water content is still high, and it is still mixed with impurities such as sand, coral, and small twigs [2]. The seaweed values would be higher if it were not in the form of dried seaweed as the raw material, but in a processed form, for example, carrageenan.

Carrageenan is an essential seaweed extract. Carrageenan is a substance produced by seaweed from the Rhodophyceae class and is generally in the form of flour. Seaweed, also known as algae, based on its size, is divided into two classes; microalgae and macroalgae [3].

One form of carrageenan itself is kappa and carrageenan. Kappa and carrageenan are fractions that can form gels in water and are thermoreversible. This means that they melt when heated and form a gel again when cooled. The gel formed from kappa carrageenan is rather dark and has a texture that is



easily cracked, while the gel formed from the iota type is more transparent than kappa and has a soft and elastic texture [4]. The difference in the content is that the 3,6-anhydrogalactose and sulfate ester in carrageenan causes differences such as gel strength, texture, syneresis, and synergy. Kappa has a rigid or easily broken gel type which is characterized by high syneresis, which is the flow of liquid on the surface of the gel, while iota has a gel that is elastic, free of synergy and reversible.

In addition, the rigid properties produced in the gel of kappa carrageenan increases according to the increase in potassium ion concentration, while the addition of calcium ions will make the gel from kappa carrageenan have more rigid but brittle properties, becoming easily broken. This can be controlled or eliminated by mixing in non-synergetic materials such as carrageenan. The combination of carrageenan and kappa carrageenan can increase gel elasticity and prevent syneresis [5].

In this case, the combination of kappa and carrageenan as a substitute for gelatin in the ice cream raw material becomes a new innovation for the manufacture of ice cream that can equalize the composition of gelatin. This study aimed to determine the combination of kappa and carrageenan as a substitute for gelatin as a raw material for making ice cream determined through organoleptic tests, viscosity, and gel strength.

2. Material and methods

2.1. Material

The materials used in this study were carrageenan flour from seaweed types *Kappaphycus alvarezii* and dried *Eucheuma spinosum*, full cream milk, skimmed milk, sugar, gelatin, water, cornstarch, and developer ingredients. The tools used in this study included the tools used in the carrageenan extraction, namely work tables, scales, glasses, stainless basins, wooden spatulas, mixers, freezers, ice cream containers, packaging, ice cream spoons, pans, and stirrers.

2.2. Variables

This research had three variables: a) the independent variable in this study was the treatment of the use of kappa, iota, and kappa + iota materials in the manufacture of ice cream; b) the dependent Variables: the indicator of the color, taste, aroma, and viscosity of the ice cream and c) the controlled Variables: in this study, the control variables were the materials used, the tools used and the manufacturing process conducted using the same treatment of mixing, printing, and freezing.

2.3. Research design

This study used a completely randomized design (CRD) with 4 treatments and 5 replications, namely: F0 = Ice cream with the addition of 0.6% gelatin, F1 = Ice cream with the addition of 0.6% kappa, F2 = Ice cream with the addition of 0% iota and F3 = Ice cream with the addition of kappa 0.3% and iota 0.3%.

2.4. Data analysis

The data obtained from the research results were analyzed using ANOVA (Analysis of Variance) in order to determine whether or not there were any differences in the results of the test rooting. The data analysis results were continued with Duncan's multiple distance test to find out which treatment produced the best results, and if there were any significant differences between the treatments.

3. Results and discussion

3.1. Proximate analysis

The results showed that ice cream with kappa and carrageenan showed carbohydrate, fat, water and ash content levels that were lower than gelatin. The protein levels were no different after the addition of kappa carrageenan and carrageenan iota compared to the addition of gelatin. The crude fiber levels showed higher levels of ice cream added with kappa carrageenan and iota carrageenan compared to gelatin. The proximate test results can be seen in Table 1.

Table 1. Proximate analysis.

Treatment	Mean (%)					
	Carbohydrate	Protein	Lipid	Water	Ash	Fiber
Kappa + Iota	11.3	9.585	6.995	51.525	2.9	17.695
Gelatin	12.72	9.225	8.65	52.01	3.315	14.08

The nature of kappa and iota, which they have in common, is that they are able to form a gel in water and are thermoreversible. This means that they melt if heated and form a gel again when cooled. Carrageenan iota solution is reversible, meaning that if the solution is reheated, then the gel will re-melt [2]. In this case, it can be used as an emulsifier for food, especially ice cream, which will affect the quality of the ice cream produced. Carrageenan has also been widely used as a stabilizer. Stabilizers are very important when making quality ice cream. The quality of ice cream produced is strongly influenced by the processing methods and raw materials used, including the stabilizer [6]. From the research, it was found that the nutrient content of carrageenan as a substitute for gelatin was better. The results obtained from the addition of a combination of kappa and carrageenan iota indicated that the combination produced ice cream that was low in energy, low in fat and high in fiber compared to gelatin. The energy was extracted from the number of carbohydrates contained in the food. If the foods containing carbohydrates were higher, then the energy produced will be higher in turn. The use of carrageenan as a stabilizer is recommended for use in ice cream that is to be consumed by people who are on a low-calorie diet [7].

The use of carrageenan which causes a decrease in fat to 6.9% does not have an impact on the quality of the ice cream itself. It has been reported that the addition of reduced-fat ingredients, such as whey protein isolate and inulin, does not reduce the quality of the ice cream and can even provide benefits to the structure and texture [8]. Fats in food are needed, but if consumed in excessive amounts, they can cause obesity. Several studies have shown that studies in mice given high glucose showed a link between the etiology of type 2 diabetes and obesity in humans under the condition of high-fat diets [9].

Ice cream with added carrageenan will show an increase in the amount of crude fiber. Crude fiber in many foods is reported to have rich benefits. Carrageenan incorporated in locally consumed foods, such as pan de sal, maja blanca, fish ball, and arroz, is found to have significantly reduced blood cholesterol and lipid levels in free-living human volunteers [10].

3.2. Viscosity

Addition of Kappa carrageenan and carrageenan Iiota produced a higher viscosity value compared to the addition of gelatin in ice cream. The viscosity values can be seen in Table 2.

Table 2. Viscosity.

Treatment	Viscosity (%)
Kappa +Iota	0.87
Gelatin	0.745

Viscosity will provide an idea of the thickness of the solution, which will make it easier to choose the type of hydrocolloid or a combination thereof that is suitable for food and non-food products [11]. From the viscosity test, the results of the combination of kappa and iota also have a higher level of viscosity than gelatin. Increased viscosity will affect the quality of ice cream. Several studies have reported the use of alginate which has an effect on viscosity. The ice cream structure will melt more quickly [12].

3.3. Hedonic test

The results of the hedonic tests on the ice cream conducted on the kappa carrageenan and carrageenan iota showed values of 5 - 6 in the parameters of aroma, taste, and texture.

Table 3. Hedonic test.

Parameter	Mean
Flavor	5.8
Taste	6.1
Texture	6

The hedonic test showed that the taste parameters were more significantly affected by the panelists' preference, so the combination of kappa and iota was preferred because the panelist's statement stated there to be a distinctive and softer taste. From some of the test parameters, it can be seen that the use of a combination of kappa and carrageenan can substitute gelatin and that this was what the panelists preferred.

The results of the panelist's value of the aroma of ice cream showed a value of 5.8. The panelists did not recognize the aroma of carrageenan. Carrageenan has no effect on the aroma of the ice cream [7]. The ice cream texture showed 6 degrees, which indicates that the panelists "like" the ice cream with the addition of carrageenan. The level of preference regarding the texture was influenced by the non-melting property [7]. The results of the hedonic test conducted on taste showed the highest degree of preference as the other hedonic indicators. A sense of taste of 6 showed that the panelists "liked" the ice cream.

4. Conclusion

From this study, it can be concluded that the addition of carrageenan in the manufacture of ice cream can be used as a substitute for gelatin as seen in the results from the proximate test and in the viscosity of carrageenan ice cream (kappa + iota); this is as it is similar to the results for gelatin. The proximate test results for the ice cream with a combination of kappa and carrageenan iota obtained 11.3% carbohydrate, 9.585% protein, 6.995% fat, 17.695% fiber, 51.525% water and 2.9% ash values. It can, therefore, be used as an alternative as the latest innovation emulsifier when making ice cream.

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