Effect of different types of base solution on physico-chemical characteristics of *Eucheuma cottonii* carrageenan flour

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Abstract. *Eucheuma cottonii* is red seaweed (Rhodophyceae) producing carrageenan which is widely cultivated to be utilized for its products, one of which is the basic material for making edible films. The purpose of this study was to determine the effect of different types of base solution on the physico-chemical characteristics of carrageenan flour produced. This study used *E. cottonii* from Karimun Regency, Riau Islands which was extracted using different base solutions namely KOH, NaOH, and $Ca(OH)_2$. The parameters tested from this study were the value of CAW (Clean Anhydrous Weed) and impurities value of seaweed raw materials and analysis of yield, viscosity, water content, and ash content of carrageenan flour. The results of the analysis of *E. cottonii* seaweed raw materials have met Indonesian national standards with a CAW value of 31.9% (SNI 8168:2015) and an impurities value of 0.09% (SNI 8169:2015). The best result for physico-chemical characteristic of carrageenan flour is the KOH treatment which is close to the standard of carrageenan based on FAO in 2007, namely yield of 25%, viscosity of 2077.20±435.66 cP, moisture content of 12.37±0.20%, and ash content of 36.08±2.79%. The carrageenan from this study can be used as a basic material for making edible films.

1 Introduction

Seaweed is one of the largest marine resources in Indonesia [1]. Seaweed is a multicellular plant consisting of complex differentiated talus, does not have true roots and leaves, and is macrobenthic [2] [3]. Seaweed consists of Phaeophyta, Rhodophyta, Chlorophyta, and Cyanophyta [4]. Seaweed lives attached to two types of substrates, namely soft and hard, such as sand, mud, a mixture of sand, gravel, rocks, dead coral, shells, live coral, and other hard objects [5] [6]. One type of red seaweed that is widely cultivated in Indonesia is *Eucheuma cottonii* [7].

Eucheuma cottonii is a potential food ingredient in producing carrageenan. Carrageenan is a seaweed gum extracted with water or base solution [8]. Carrageenan is a type of galactan that has high water binding characteristics. Carrageenan is categorised into three types namely kappa, iota and lambda carrageenan, all three of which are divided based on

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differences in chemical structure. To extract carrageenan, a base solution is required [9]. Base solutions commonly used to extract carrageenan are NaOH (Sodium Hydroxide), $Ca(OH)_2$ (Calcium Hydroxide) and KOH (Potassium Hydroxide). Research [7] explains that in the processing process, seaweed can be an export commodity in the future, if the processing is good and guaranteed. Therefore, this study aims to determine the effect of various types of base solution on the physico-chemical characteristics of *Eucheuma cottonii* carrageenan flour produced.

2 Materials and methods of research

2.1 Materials and Equipment

The main materials used in this research as a source of carrageenan flour were *Eucheuma cottonii* obtained from Karimun Regency, Riau Island. The chemical used in carrageenan extraction process include technical base solution (KOH, NaOH, $Ca(OH)_2$), KCl and other chemicals used for analysis.

The equipment that used for raw material preparation and carrageenan extraction are basin, waterbath, pot, stove, beaker glass, drying oven, calico cloth, thermometer, pH meter and stopwatch. While the equipment to analyse the quality of carrageenan consisted of desiccators, Erlenmeyer flasks, beakers, beakers, stirrers, porcelain cups, funnels, ovens, furnaces, Brookfield viscometers, and filter paper.

2.2 Research procedure

This study consisted of two main stages, namely raw material preparation and carrageenan flour extraction. In the raw material preparation stage, *E. cottonii* seaweed was washed with running water and cleaned from dirt such as sand, rope, coral and other objects until clean and drained. After that, it is dried evenly by aerating or without direct sunlight. The dried *E. cottonii* was utilized as raw material in carrageenan extraction.

Extraction of *E. cottonii* carrageenan flour refers to research [10] with modification of base solvents (KOH, NaOH, and $(CaOH)_2$). Dried seaweed (100 g) was added with base solution (12%) at 80°C for 2 hours. Then the seaweed was soaked in water to remove excess base solution residue and lower the pH of the seaweed to 8-9. Then dissolved in water in a ratio of 1:20 at 80°C for 30 minutes or until the seaweed was crushed. After the extraction process is complete, the seaweed is filtered with calico cloth. The resulting filtrate was collected, then added with 2% KCl (1:2) solution at 30°C. Finally, the carrageenan fibres were dried at room temperature and then ground to a fine powder that passed 60 mesh.

2.3 Methods of analyses

The result analysis of seaweed raw materials consisted of the value of CAW (Clean Anhydrous Weed) [11] and the impurities value [12] refer to the Indonesian national standard SNI 8168:2015 and SNI 8169:2015. The result analysis of the physico-chemical characteristics of carrageenan flour consisting of yield [13], viscosity [13], moisture content [14], and ash content [14] of seaweed carrageenan flour refer to the standard of FAO in 2007 [15].

3 Results and Discussion

3.1 Characteristics of *Eucheuma cottonii* raw materials

Eucheuma cottonii is a type of macroalgae that can be found at the bottom of the water and attached to the substrate or floating on the surface of the water [16]. *Eucheuma cottonii* is usually green or reddish brown in colour [17]. This study used *E. cottonii* seaweed from Karimun Regency, Riau Islands (Figure 1) and characteristics of *E. cottonii* as raw materials are presented in Table 1.

Fig.1. *Eucheuma cottonii* from Karimun Regency, Riau Island

Table 1. Characteristics of *E. cottonii* as raw materials.

Parameter	Value (%)
CAW	31.9
Impurities	0.09

CAW analysis was conducted to show the purity of the seaweed, namely the cleanliness of the seaweed from embedded impurities such as sand, coral, or other seaweed mixtures [18]. The CAW value of *E. cottonii* (Table 1) obtained was 31.9%. The CAW value obtained in this study is in accordance with Indonesian national standards (SNI 8168:2015) which is minimum 40% [11].

The impurities content of *E. cottonii* (Table 1) was 0.09%, where the results in this study was lower than those conducted by [19] stating that impurities of *E. cottonii* with different drying treatments are obtained ranging from 0.47% - 1.53%. The value of impurities content meets the requirements of handling on good seaweed can improve the quality of seaweed produced. The value of impurities levels in this study is in accordance with Indonesian national standards (SNI 8169:2015) which is below 3% [12].

3.2 Physico-chemical characteristics of *Eucheuma cottonii* carrageenan flour

Carrageenan is a sulfate group polysaccharide present in the intercellular matrix of red algae cell walls [20]. The carrageenan flour that has been extracted using base solution can be seen in Figure 2 and physico-chemical characteristics of *E. cottonii* carrageenan flour are presented in Table 2.

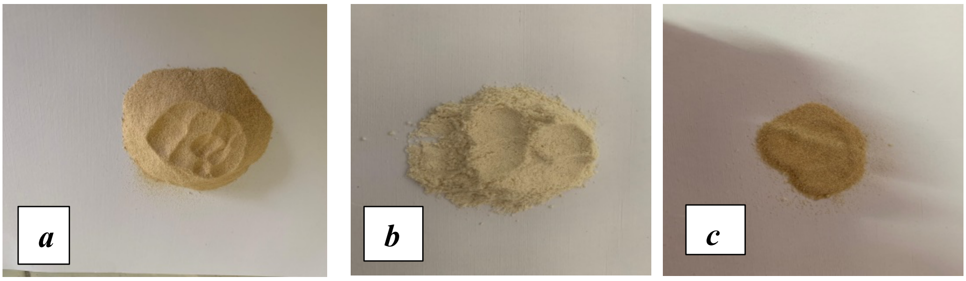

Fig.2. *Eucheuma cottonii* carrageenan flour that has been extracted using (a) KOH, (b) NaOH, and (c) $Ca(OH)_2$

Table 2. Physico-chemical characteristics of *E. cottonii* carrageenan flour.

Parameter	KOH	NaOH	$Ca(OH)_2$
Yield (%)	25	27	22.5
Viscosity (cP)	2077.20±435.66	43.30±2.61	887.27±29.02
Moisture content (%)	12.37±0.20	15.63±0.58	20.39±0.80
Ash content (%)	36.08±2.79	36.63±5.58	30.37±4.58

3.1.1 Yield

Yield is an important parameter in determining whether or not the carrageenan extraction process is effective. Table 2 showed a difference in the yield of carrageenan flour produced using different types of base solution where the yield using NaOH solvent treatment was 27% and KOH solvent was 25%. The requirement for carrageenan yield stated by FAO is 25% [15] so that NaOH and KOH treatments have met the standard.

The $Ca(OH)_2$ treatment resulted in a yield of 22.5% that did not meet FAO standards [15]. The low yield when extraction using base solution may be due to the release of sulfate ions (hydrophilic). The reduction of sulfate groups causes carrageenan to tend to be more hydrophobic, so carrageenan in seaweed will be more difficult to dissolve in solvents containing water [21].

3.1.2 Viscosity

Viscosity is the flowability of molecules in a solution system. Table 2 showed that all treatment using different types of base solution have met the standard stated by FAO which is is ≥5 cP [15]. The viscosity of the carrageenan solution is mainly due to the nature of carrageenan as a polyelectrolyte. The repulsion force between negative charges along the polymer chain, namely the sulfate group, causes the molecular chain to stiffen. Due to its hydrophilic nature, the polymer is surrounded by immobilised water molecules, causing the carrageenan solution to be viscous [22].

3.1.2 Moisture content

This moisture content test is conducted to determine how much water content is in carrageenan. Moisture content in carrageenan can trigger microbiological activity which can affect the storage time of carrageenan. Table 2 showed that that all treatment using different types of base solution have not met the standard stated by FAO which is maximal 12% [15].

It is necessary to increase the drying time of carrageenan so that it can reach the FAO standard. Drying will remove some moisture from the seaweed [23]. The lower the moisture content, the higher the quality of the material [24]. The moisture content that is closest to the FAO standard is KOH with a value of 12.37±0.20 %.

3.1.2 Ash content

Ash content testing aims to determine the amount of mineral content contained in carrageenan. Table 2 showed that all treatment using different types of base solution have met the standard stated by FAO which is 15-40% [15]. The ash content of the carrageenan obtained is mainly composed of potassium, sodium, magnesium and calcium, because carrageenan is a hydrocolloid consisting mainly of sulfate esters, potassium, sodium, magnesium, calcium and ammonium of galactose, and 3,6 anhydro-D-galactose. [25, 26].

4 Conclusions

The results of the analysis of *Eucheuma cottonii* seaweed raw materials have met Indonesian national standards with a CAW value of 31.9% (SNI 8168:2015) and an impurities value of 0.09% (SNI 8169:2015). The best result for physico-chemical properties of carrageenan flour is the KOH treatment which is close to the standard of carrageenan based on FAO in 2007, namely yield of 25%, viscosity of 2077.20 cP, moisture content of 12.37±0.20%, and ash content of 36.08±2.79%. The carrageenan from this study can be used as a basic material for making edible films.

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