Physicochemical characteristics of alkali treated cottonii (ATC) flour of Kappaphycusalvarezii seaweed from Morotai Island in North Maluku

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Abstract. The utilization of Eucheumacottonii or Kappaphycusalvarezii to become alkali treated cottonii (ATC) flour or semi refined carrageenan (SRC) is one effort to improve the quality and economic value of seaweed. ATC flour is a polysaccharide extracted from Kappaphycusalvarezii using hot alkali solution which can be used as raw material for the manufacture of refined carrageenan. The utilization of carrageenan in the food processing industry and other industries is very important, so it is necessary to study the processing of ATC flour using the optimal type and concentration of alkali solution. The research aim is to know the characteristic of ATC flour of Kappaphycusalvarezii seaweed from Morotai Island based on the type and concentration of alkali solution, while the research benefit as information resources in ATC flour processing and manufacture technique so that it can be applied by the community and seaweed processing industry. The research stages include sample preparation, the extraction using hot alkali solution with the treatment: A1 (KOH 6%), A2 (KOH 8%), A3 (NaOH 6%) and A4 (NaOH 8%), and ATC flour quality characterization includes: yield, gel strength, bulk density, whiteness, moisture content and ash content. ATC flour extracted using KOH 8% has the best characteristic with 24.03% yield value; gel strength 28774.88 g.cm⁻²; bulk density 0.12 g/mL; whiteness 58.27%; moisture content 15.97% and ash content 18.32%.

Keywords: physicochemical characteristics, ATC, Kappaphycusalvarezii
1. Introduction

Seaweed is an important commodity in Indonesia in general and North Maluku in particular because it has export potential. Good raw materials supported by appropriate postharvest technology will produce seaweed processed products with commercial quality standards, but until now most of seaweed is still exported in dried seaweed with low selling price, while processed products such as agar flour, carrageenan, and alginate, and other derivative products are still imported in bulk at high prices.

Morotai Island district is one of the areas in North Maluku Province which has a large and bulk Kappaphycus alvarezii seaweed cultivation center, but only sold in the form of dried seaweed. There are no many reports and information about the physicochemical characteristics and derivative products of seaweed from Morotai Island. ATC flour is one derivative products of Eucheuma cottonii or Kappaphycus alvarezii which is processed using hot alkali solution. This product has high economic value and many benefits and plays an important role in the food processing industry and other industries.

ATC flour can be used as raw material for the manufacture of refined carrageenan. Carrageenan is a hydrocolloid compound of straight polysaccharide and galactan molecule with galactose main unit. Carrageen is seaweed sap extracted with an alkali solution in some species of Rhodophyceae class (red algae). Utilization of carrageenan is widely used as a stabilizer, gelling agent, thickener and emulsifier (Ortiz & Aguilera., 2004; Aritoft et al., 2007).

Based on the background, it is necessary to conduct research on the technical processing and extraction of Kappaphycus alvarezii seaweed into ATC flour. The research’s aim is to know the characteristic of alkali treated cottonii (ATC) flour of Kappaphycus alvarezii from Morotai Island based on the type and concentration of alkali solution.

2. Research Methods

2.1. Samples Preparation

Dried seaweed obtained from Morotai Island, washed and soaked using clean water as much as 10 times the weight of dry seaweed for ± 8 hours, then drying up and cut to size ± 2-3 cm, and then do the extraction process using hot alkali solution with treated A1 (KOH 6%), A2 (KOH 8%), A3 (NaOH 6%) and A4 (NaOH 8%), the ratio of seaweed and alkali solution is 1: 5, for ± 2 hours. The results subsequently neutralized by washing extraction repeated 7 times and dried using an oven at temperature of 50 °C for 48 hours to dry and then milled into flour using a disc mill ATC.

Characterisation of ATC flour produced include: yield (AOAC, 2015), gel strength (Tuazon, 1996), bulk density (Falate & Okafor, 2013), whiteness (Lanier et al. 1991), moisture content (SNI 01.2354.2-2006) and ash content (SNI 01.2354.1-2006).

2.2. Statistics

Analysis of data from the ATC flour quality tests in this study using Random Block Design (RBD) with three replications in each treatment is using SPSS 22 and if a significant influence further test of Duncan.

3. Results and Discussion

ATC flour characteristics influenced by raw materials quality, type of alkali solution and harvesting seaweed used. Research on the physicochemical characteristics of ATC flour, made using Kappaphycus alvarezii seaweed cultivated on the Morotai island by harvesting 45 days are extracted using 2 types of alkali solution (NaOH and KOH) with 2 concentration (6% and 8%). ATC flour characteristics value generated as in Table 1.
Table 1. Characteristics of Quality of ATC Flour

| Quality Parameters       | A1 KOH 6% | A2 KOH 8% | A3 NaOH 6% | A4 NaOH 8% |
|--------------------------|-----------|-----------|------------|------------|
| Yield (%)                | 28.57b    | 24.03a    | 20.73a     | 20.73a     |
| Gel strength (g.cm⁻²)    | 24489.88b | 28774.16c | 1886.78a   | 1640.68a   |
| Bulk density (g.mL⁻¹)    | 0.12a     | 0.12a     | 0.09a      | 0.11a      |
| Whiteness (%)            | 55.38a    | 58.27b    | 63.57c     | 64.71c     |
| Moisture content (%)     | 15.75a    | 15.97a    | 19.04b     | 22.38c     |
| Ash content (%)          | 21.27bc   | 18.32a    | 20.36b     | 22.34c     |

Remarks: The number followed by the same letter on the same line is not significantly different at α 0.05

3.1. Yield

The yield is determinants of the economic value of the processing and production of materials. Describe the yield value of the net proceeds of production. ATC flour yield value is calculated based on a percentage of dry ATC flour compared with dried seaweed. Yield value is an important factor because it shows the quality of the raw materials of seaweed used in the production of ATC (Darmawan et al., 2013).

Yield value of ATC flour (Figure 1), shows that the extracted using KOH solution has higher yield value than the result of extraction using NaOH solution. KOH and NaOH are compounds that are strong alkali reduction. Extraction using hot alkali solution will open the cell walls of seaweed so as to facilitate the withdrawal process extracts ATC when added acid solvent that will affect the yield generated. This is in accordance with the opinion of Kusuma et al., (2012), which states that the value of the yield is affected due to the provision of alkali concentration that causes the hydrolysis of cell walls and ATC that accumulates in the cell wall can be pulled easily when extracted using acetic acid.

ATC flour yield value range between 20.73-28.57% (Figure 1), this value is equal to the results of research Tunggal and Hendrawati, (2015) which ranged from 17.33-28.80% and smaller than the ATC produced from Eucheumacottonii collected from several regions, which ranged from 1.30-41.33% (Darmawan et al., 2013). Analysis variance result showed that type and concentration of alkali solution gives the significant effect on the yield value of ATC flour. The yield of the extraction using KOH 6% have significantly different values compared to the yield using other treatments (Table 1).

3.2. Gel strength

Gel strength is the property of an object or food product in terms of its resistance to breaking due to a non-deforming force (Soekarto, 1990), whereas violence is the amount of force to break food.
products. One of the important properties of ATC flour is its gel forming properties and strength. Gel strength is the ability to change a liquid to a solid or changing the shape of the sol to a gel which is irreversible. The ability of gelling carrageenam is causing very extensive ATC and its use, both in food and non-food.

The gel strength of ATC flour were in the range of 1640.68-28774.16 g.cm\(^{-2}\) (Figure 2) with the highest was found in ATC flour treated using KOH 8% (A\(_2\)) and the lowest was that treated using NaOH 8% (A\(_4\)). This result exceeds the value of gel strength standards set by the FAO (2007) is 900-1200 g.cm\(^{-2}\) and the results of Sedayu et al., (2008), which ranged from 783-828 g.cm\(^{-2}\). The high gel strength values caused by the extraction process using hot alkali solution thus opening the cell walls that increase 3,6-anhydrogalaktosa cause increased potential double helix formation so much faster gel formation is achieved (Moirano, 1977 in Syamsuar, 2006).

Analysis variance result of gel strength of ATC flour indicated the type and concentration of alkali solution significantly influence the gel strength value of ATC flour. ATC flour extracted using NaOH solution at different concentrations that do not generate different in gel strength values, whereas the extraction using KOH at different concentrations have different gel strength values (Table 1). The ratio gel strength of ATC flour extraction results using KOH and NaOH was 12:1, meaning extracted using KOH solution produced the gel strength of ATC flour was 12 times higher than using NaOH solution.

### 3.3. Bulk Density

Bulk density is the parameter that indicates about the characterization of particle material. Characteristics of particles of powder have important influence on the nature of products such as particle size, shape, surface, density, hardness and adsorption properties. Bulk density of powdered food product is very dependent on particle size and distribution (Singh et al., 2005).
Bulk density values ranged between 0.093-0.124 g.mL⁻¹(Figure 3) with the highest bulk density was found in ATC flour extracted using KOH 6% (A₁) and the lowest was that extracted using NaOH 6%(A₃). Analysis variance results showed that treatment with different of type and concentration of alkali solution have no significant effect on the bulk density of ATC flour produced.

A very small change in bulk density of powder products can cause large of flow ability (Levy & Kalman, 2001). Bulk density parameter can be used to see the perfection of the drying process or the uniformity of the shape and size of flour particle (material). The powdered product by means of slow drying will have higher bulk density than fast drying.

### 3.4. Whiteness

Whiteness is common measurement to determine the color of flour which having different brightness levels (Hutching, 1999). Measurement of whiteness on a scale of 0-100% ranged from black (0%) to white (100%).

![Figure 4 Histogram of ATC flour whiteness](https://via.placeholder.com/150)

Whiteness of ATC flour ranged from 55.38-64.71% (Figure 4) with the highest value in the treatment using NaOH 8% (A₄), the lowest in treatment using KOH 6% (A₁). Whiteness in this study was similar to the value of the whiteness flour semi refined carrageenan research results Sedayu et al., (2008), which 55.5-64.3%. Analysis variance of whiteness of ATC flour indicate that the type and concentration of alkali solution used in the extraction process ATC flour influenced to the whiteness of ATC flour.

Whiteness of ATC flour as in Figure 4 shows that extraction using NaOH solution produces the ATC flour is more white than the ATC flour extraction using KOH solution. This figure also shows that the higher the concentration of alkali solution is used to produce higher whiteness values.

### 3.5. Moisture content

The moisture content of food is an important factor in quality, preservation and resistance to deterioration (Nielsen, 2009) and became one of the main requirements for the safety of food products because its relate to shelf life and durable of product at the time stored in a long time, because it is related to microbial activity during ATC flour storage process. Analysis of moisture content on ATC flour aims to determine the free water content in the flour, because the moisture content in the flour product is very influential on its shelf life.
Moisture content of ATC flour ranged between 15.97-22.38% (Figure 5), with the highest value in moisture content was found in ATC flour treated using NaOH 8% (A4) and the lowest was that treated using KOH 6% (A1). Analysis variance results showed that type and concentration of alkali solution significantly influence the moisture content of ATC flour. ATC flour extraction process using KOH solution produces a lower moisture content compared to ATC flour extraction using NaOH. Same type of solution (KOH) in different concentrations did not give different effect on the value of moisture content, but different things happen on moisture content of ATC flour extracted using NaOH solution (Table 1).

Moisture content of ATC flour in this study meets the requirements of SNI with maximum value is 17% whereas the export quality standards according to the FAO ranged from 15-21%. This result is similar to SRC moisture content of Sedayu et al., (2008) which ranged from 17.75-20.61% and higher than ATC moisture content from research results of Darmawan et al., (2015) which is 6.62-10.42%.

The measured moisture content of ATC flour was done to measure of chemically bonded water, whereas the free water may have evaporated, the longer the drying process tends to cause the moisture content of the flour to decline. High concentration of solution is used for the extraction resulted in the increase of ATC flour produced, it is suspected that the high concentration of alkali solution increases the hydrophilic nature of seaweed so that the seaweed can absorb sufficient water during the extraction process.

3.6. Ash content
Analysis of ash content in general performed to determine the mineral content contained in ATC flour. Ash content of a foodstuff indicates the amount of minerals contained in the foodstuff (Apriyantono et al., 1989). Values are based weighing the residual ash content of minerals as a result of burning organic material.

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**Figure 5.** Histogram of ATC flour moisture content

Moisture content (%)

| Research treatment | A1 | A2 | A3 | A4 |
|--------------------|----|----|----|----|
| Moisture content (%) | 15.75 | 15.97 | 19.04 | 22.38 |

**Figure 6.** Histogram of ATC flour ash content
ATC flour ash content ranged from 18.32-22.34% (Figure 6) with the highest value was found in ATC flour extracted using NaOH 8% (A1) and the lowest was extracted using KOH 8% (A2). The ash content result of this research were higher than ash content of the SRC that ranged from 16.73-18.50% (Sedayu et al., 2008), almost similar to ash content of the ATC which 19.82-24.33% (Darmawan et al., 2013) and lower than ash content of carrageenan were made using different KOH concentration which 26.3-37.2% (Tunggal & Hendrawati, 2015).

Analysis variance of ash content value indicated that type and concentration of alkali solution significantly influence the ash content of ATC flour generated. ATC flour extraction process using KOH has a lower ash content compared with the results of extraction using NaOH.

Ash content of ATC flour is natural mineral content contained in seaweed and minerals stick to the seaweed, so that during the process of mineral extraction and neutralization lot is wasted in the solution used for the extraction and leaching time of neutralization. Ash content of wet seaweed ranged between 24.9-36.4% (Kilinc et al., 2013), naturally seaweed used in the food processing industry has a high mineral content such as Na⁺, K⁺, Ca²⁺ and Mg²⁺ (Basmal et al., 2003). Meanwhile, Wenno et al., (2012) stated the longer the life of seaweed will produces carrageenan with high ash content. This research showed that high concentration of KOH, then decreased the ash content of ATC flour and in other way, high concentration of NaOH resulted ATC flour with high ash content.

The ash content obtained in this study was quite high and exceeds the quality standards of export carrageenan and ATC established by FAO with maximum value of 4%. The same was said by Dwi (2012), that the ash content of a maximum of seaweed flour ≥ 4%, if bigger than 4%, it is negatively correlated to the degree of purity of ATC flour because the higher the ash content showed high levels of minerals resulting in lower purity of carrageenan resulting. This is presumably due to factors that have not been clean washing and filtration were less than perfect so that there is no dirt filtered out and carried away.

4. Conclusions

The type and concentration of alkali solution used in ATC flour extraction process from Kappaphycus alvarezii seaweed had significant effect on yield, gel strength, whiteness, moisture and ash content, and had no significant effect on bulk density. ATC flour characteristic in this research were yield of 20.73-28.57%; gel strength 1640.68-28774.16 g.cm⁻²; bulk density 0.09-0.12 g.mL⁻¹; whiteness 55.38-64.71%; moisture content 15.75-22.38% and ash content 18.32-22.34%.

5. Suggestion

Further need a research on physicochemical characteristics of ATC flour from Kappaphycus alvarezii using another type of alkali solution with optimal concentration.

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