Characteristic of physicochemical ATC *Kappaphycus alvarezii* from Kolorai Village South Morotai District on different harvesting time

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Abstract. *Kappaphycus alvarezii* is kind of red seaweeds that can be cultivated to produce carrageenan. Fishermen in Kolorai Island of South Morotai are cultivated this seaweed. A number of studies show that the quality of carrageenan was determined by the length times of cultivation and coastal chemical physics parameter. The purpose of this study was to determine the influence of harvesting *Kappaphycus alvarezii* on different time to characteristic ATC flour. Random design complete one factor used to know the influence of treatment at the different harvesting time (30, 40 and 50 days) and used the extraction of 8% NaOH solution. The parameters observed included yield, whiteness degree, moisture content, ash content, viscosity and gel strength. Result showed that ATC flour at harvest time 40 days was the best with gel strength 630.77g/cm²; yield harvest 10.20%; whiteness degree 57.88 at physical test. The chemical test showed that moisture content and ash content is low 12.70 % and 37.40 %. Eight percent of NaOH extraction did not give significant influence of harvest yield, whiteness degree, ash content and moisture content, but give significant influence of gel strength of ATC flour.

1. Introduction

Seaweed is a commodity that plays a major role in the production of aquaculture sector in Indonesia. Every year, seaweed production continues to increase, from 2,963 million tons in 2009 to 3,915 million tons in 2010 and 9,298 million tons in 2013 [1]. Indonesia is one of the world's largest producers and exporters of seaweed, which contains carrageenan and controls the world market for about 90%. The total production of Indonesian seaweed in 2015 was 10,456,000 tons consisting of *Eucheuma cottonii* type or known by its scientific name *Kappaphycus alvarezii* 2,828,493 tons and *Glaucilla* sp with 253,691 tons. The Ministry of Trade noted that the export value of seaweed in 2010 reached US $135,939 million. In January - June 2011, it reached US $83,283 million or an increase of 14% from the same period in 2010. Furthermore, in 2010 the seaweed production in North Maluku Province was 529 tons, consisting of 472 tons of *Eucheuma cottonii* and 57 tons of *Glaucilla* [2].

Since seaweed was declared as one of the revitalized commodities, the orientation of its utilization as an export commodity in the form of raw material has begun to shift to a product with added value, especially in the form of Alkali Treated Cottonii (ATC). ATC products are processed from seaweed *Kappaphycus alvarezii* type which can be used as raw material for the manufacture of pure carrageenan. ATC is also exported in order to improve Indonesia's economy because its further processing can be used as a binder and stabilizer in the animal feed industry for the European, American and Asia Pacific markets. As the ATC has high benefits and important roles in Indonesia’s economy, it is necessary to study the process of making and processing ATC.

The use of ATC and carrageenan in Indonesia continues to experience developments in various fields, especially the food processing industry. An obstacle in the development of seaweed processing industry in Indonesia is the quality of raw materials and processing technology is not optimal, and therefore it is difficult to increase the economic value of ATC and carrageenan. In the upstream sector,
the different time of harvesting seaweed causes the declining of its quality. [3] stated that the chemical compound content in seaweed plants is influenced by factors of season, habitat and plant time.

Seaweed harvesting time generally ranges from 45–60 days after planting. If harvested less than those days, the production of it will result low quality due to its low content of agar, carrageenan and gelling ability. Therefore, such seaweed is not favored by the processing industry and appreciated in low selling prices and even unsold [4]. To produce seaweed with good quality characteristics, it is necessary to harvest it at an optimal time. Seaweed farmers in Indonesia have different perceptions of the harvesting time, depend on their habits and experiences so the quality of it and its application product is different in each region.

The purpose of this study is to determine the effect of different harvesting time on ATC characteristics of Kappaphycus alvarezii seaweed flour. The benefits of it are expected to provide optimal information on the time of harvest, and to obtain the best physicochemical characteristics of the ATC flour of Kappaphycus alvarezii seaweed.

2. Materials and Method

2.1. Materials
The raw material used is Kappaphycus alvarezii seaweed obtained from Kolorai Island, Morotai Island Regency. It is harvested in several different times 30 (A1), 40 (A2) and 50 (A3) days and dried. Some materials also used are distilled water, absolute ethanol, NaOH and pH paper.

2.2. Method
This research is divided into two steps: the first is field data collection to observe the characteristics of physical seaweed Kappaphycus alvarezii at the different harvesting time, and the second is processing of ATC which refers to the method applied by the Research Center for Marine and Fisheries Product Processing and Socio-Economic BRKP DKP at 2003.

2.2.1. ATC Production. Processing of ATC flour was started by washed the seaweed with fresh water until clean, then cut into small pieces, drying under the sun and stored in plastic packaging for use as research material. The dry seaweed was washed aimed at removing sand, salt, lime, coral, rope pieces and other unwanted types of seaweed. Then it soaked for ± 6 hours with the ratio of water and seaweed (5:1). The extraction process is carried out on clean seaweed in 8% NaOH solution (1: 3) for two hours at 80-85°C. In order to achieve the neutral pH (pH 7), it washed repeatedly by using distilled water. After that, the seaweed was cut into a size of 4-5cm, and dried in the sun. The dried seaweed is then mashed to get ATC flour. The ATC flour processing shows in Figure 1.
Quality parameters of ATC being evaluated were yield [4], gel strength [4], moisture content (Oven method, SNI 3547.2-2008), ash content (SNI 3547.2-2008), and whiteness degree analysis [5].

2.2.2. Data Analysis. The analysis was done in 3 replicates and the data were statistically analyzed by using a single factor analysis of variance (ANOVA). A further test will be followed if the value of f calculation is greater than f table. The following testing process is carried out after first calculating the coefficient of diversity to show the degree of accuracy and reliability of the conclusions or results obtained from the experiment [6]. The data visualization process was used Excel 2007, while analysis of variance and advanced testing used SPSS software version 20.

3. Results and Discussion

3.1. Yield

Yield is one of the determining factors of economic value of processing and producing materials. Its value describes the net of it from production. The yield value of ATC flour was calculated based on the percent time of dry ATC flour compared to dry seaweed. The yield of ATC flour in this study is shown in Figure 2.
As seen on Figure 2, the average yield value of ATC flour at the 30 days of harvest was 10.9%, decreased at the time of 40 days of harvest by 10.2% and increase in the 50 days of harvest by 11.0%. The resulting of high and low yield can be affected by the extraction process, the raw material and the type of solution used at the time of extraction. In this study, the type of solvent used was 8% NaOH, which is known as a strong base (alkali) and a strong reducing agent. The use of NaOH in the extraction process will cause the opening of the cell wall so that it facilitates the process of extracting ATC extract and will affect the yield produced. According to [7], the yield value is influenced by the presence of NaOH concentration, as a result, the cell wall damaged and the ATC that accumulates on the cell wall can be easily withdrawn when extracted by using acetic acid. [8] found yield of ATC *Kappaphycus alvarezii* using 1% NaOH produced the highest average yield value at 50 days of harvest time, which is 61.87%, compared to other harvest time.

The quality of raw materials used is a factor that affect the yield production. Carrageenan content found at optimal harvesting time will produce high yields, however, the mechanical process that occurs in the processing and extraction process is also another factor that affects the yield value. The extraction process carried out can affect the yield of the ATC flour produced. The longer the extraction process takes, the more ATC content increase the yield produced.

3.2. White degree

Degree of whiteness or color is an important physical quality parameter for ATC flour products. The L symbol is a brightness value with a scale from black to white. In general, consumers demand the high degrees of brightness, low yellowness and high degree of whiteness of flour products [8]. Degree of whiteness is important to determine the quality of food ingredients, especially flour products because the white color of flour affects the product produced.

Figure 3 shows that the mean value of white degree of ATC flour. As can be seen, the highest value occurs in ATC flour at 50 days of harvesting time treatment (60.98) and the lowest is at 30 days of harvest (55.09). It also shows that the longer the seaweed harvested, the higher the whiteness of ATC flour produced. The whiteness of ATC flour produced in this experiment still needs to be improved, in order to be able to compete with carrageenan products on the market.
The results of variance analysis in Table 1 show that the value of $F$-count is 2.17 and it is less than $F$-table at $\alpha= 0.05$ (5.14) and $\alpha= 0.01$ (10.92). It means that seaweed harvesting time has no significant effect on the characteristics of ATC flour. In other words, the different time of harvesting 30, 40 and 50 days had no effect on the whiteness of ATC flour produced. However, according to [9], white degrees values of *Kappaphycus alvarezii* seaweed from Kota Baru, South Kalimantan and Karimun Island at 45 days of harvest with 0.1% NaOH extraction was 39.13% and 31.00%, which means that this study still higher in the short harvest life.

**Table 1.** Anova value of white degree of ATC Flour

| Source of Variation | Sum of Square | Degree of Freedom | Mean Square | $F$-count | $F$-table 0.05 | $F$-table 0.01 |
|---------------------|---------------|-------------------|-------------|-----------|----------------|----------------|
| Treatment           | 52.15         | 2                 | 26.07       | 2.17      | 5.14           | 10.92          |
| Error               | 71.82         | 6                 | 11.97       |           |                |                |
| Total               | 123.96        | 8                 |             |           |                |                |

3.3. Gel strength

Another important property of ATC flour is formation and strength of the resulting gel. Gel strength is the ability to turn liquid into solid or change the form of sol to gel which is irreversible. The ability to make gel causes ATC and carrageenan are used widely, both in food and non-food fields.

The highest value of ATC flour gel strength in this study was found at 40 days of harvest with a magnitude 630.77g/cm² and the lowest was at 30 days of harvest with a value 176.63g/cm² (Figure 4). The strength of gel produced in this study are way down by the FAO standard, that is 900-1200g/cm² but still within the quality standards Japanese jelly products, the thirdquality ranges from 100-150g/cm², the secondquality ranges from 200-250g/cm² and the firstquality I is 300-350g/cm².
The average gel strength of ATC flour can be seen in Figure 4. It shows that the strength of ATC flour gel increased from 30 to 40 days of harvest and then decreased at 50 days of harvest. [10] states that the longtime harvesting will increase 3,6-anhydrogalactose and results to the increasing of double helix formation. By that means, the gel formation is achieved more quickly. Table 2 shows the results of variance analysis of ATC flour gel strength. As can be seen, the F-count value is 5.240 and greater than F-table at $\alpha = 0.05$ (5.14). This condition indicates that harvesting time influences the strength of ATC gel. However, at $\alpha = 0.01$, the F-count value is less than F-table 10.92. The results indicate that the precise harvesting time could increase strength of gel produced, and decrease after reaching the peak growth. [11] states that K. alvarezi from waters of Seram District Maluku which was harvested in 45 days has the highest gel strength 909 g/cm.

![Figure 4. The gel strength values of ATC flour](image)

| Source of Variation | Sum of Square | Degree of Freedom | Mean Square | F-count | $F_{table}$ 0.05 | $F_{table}$ 0.01 |
|---------------------|--------------|------------------|-------------|---------|-----------------|-----------------|
| Treatment           | 371767.5     | 2                | 185883.8    | 5.240   | 5.14            | 10.92           |
| Error               | 212807.3     | 6                | 35467.9     |         |                 |                 |
| Total               | 584574.9     | 8                |             |         |                 |                 |

Then the results of the analysis of the coefficient of diversity get a value of 54-615%, so that further was carried out by using the Duncan test and it was found that the treatment of 40 days harvesting time giving the best result of 630.7750 compare to other treatment.

In particular, *Kappaphycus alvarezi* seaweed cultivated in Kolorai Village, South Morotai Island, reached its peak growth at 40 days and where there was a decrease in gel strength at 50 days of harvest. It is suspected that the 50 days of harvest can increase sulphate levels and reduce the polysaccharide content in seaweed, thereby reducing the ability to form gels. This is supported by [12] that the increasing of gel strength is directly proportional to 3,6-anhydrgalactose and inversely proportional to its sulphate content.

The highest gel strength of 40 days harvest time sample, presumably caused by highest production of polysaccharide in seaweed. The polysaccharide content in seaweed influences the strength of ATC powder gel produced. The content of polysaccharide in seaweed is influenced by the conditions, substrate and location of cultivation. Therefore, the polysaccharide content of seaweed cultivated in ponds and in the sea is different.
Habitat, season, cultivation method, harvest time, extraction method also influences the formation of polysaccharides and the gel strength resulted. The process of gel formation is a phenomenon of joining or bonding polymer chains to form a continuous three-dimensional mesh, and the mesh formed is able to mobilize water on it and form a strong and rigid structure [13].

3.4. Water content
Food water content is one of the main requirements for the safety of food products. It is because the water content of a product related to its shelf life and durability when stored for a long time [14], and microbial activity during the short time process of ATC flour. Analysis of moisture content of ATC flour aims to determine the free moisture content on it, because the moisture content in flour products greatly affects its shelf life.

Figure 5 shows the mean of water content of ATC flour which is ranged from 12.70-14.79%. The highest value of it at 30 days of harvest at 14.79% and the lowest at 40 days of harvest at 12.70%. The water content of ATC flour in this study meets the SNI requirements with the maximum moisture content of ATC flour is 17%, while the export quality standard for ATC flour according to FAO is 15-21%. This result is not different from [3], stated that the longer the harvest time, the lower the moisture content. In other words, the longer of the harvesting times of seaweed is, the more of free water content, so that evaporation during drying is greater and consequently the water content is less [10]. According to research [15], states that the best water content value was found at the harvest time of *K. alvarezii* 30 days of 13.17% in the waters of Arakan Village, South Minahasa.

The results of water content analysis of ATC flour shows that F-count value is 3.66 and less than F-table at $\alpha = 0.05$ (5.14) and $\alpha = 0.01$ (10.92) (Table 3). Thus, the harvesting time at 30, 40 and 50 days did not collectively influence the moisture content of ATC flour.

![Figure 5. The water content of ATC flour.](image)

| Source of Variation | Sum of Square | Degree of Freedom | Mean Square | E-Count | F table $0.05$ | F table $0.01$ |
|---------------------|--------------|------------------|-------------|---------|----------------|----------------|
| Treatment           | 6.70         | 2                | 3.35        | 3.66    | 5.14           | 10.92          |
| Error               | 5.49         | 6                | 0.92        |         |                |                |
| Total               | 12.19        | 8                |             |         |                |                |
The water content of ATC flour measured was bound water, especially chemically bonded, while free water may have evaporated. Longer harvest time tends to increase the moisture content of the flour. This is probably due to its hydrophilic nature so that the seaweed will absorb a lot of water the longer it stays in the water.

3.5. Ash content

Ash content analysis was carried out to determine in general the mineral content contained in carrageenan. The value of food ash content shows the amount of minerals contained in the foodstuff [16]. The value of ash content is based on weighing the remaining minerals from the combustion of organic matter. This research shows that the higher the water content, the lower the ash content of the ATC flour.

The analysis results of the ash content of ATC flour ranged from 37.41 to 44.99%. The highest value of ash content was at the 30 days of harvest (44.99%) and the lowest was at 40 days of harvest (37.41%) (Figure 6). This value of the ash content is still better according to SNI (15-40% ash content) when compared to the research of [17], who found the best ash content of carrageenan from K. alvarezii harvested in 30 days was 45.95 of Maumere Bay in Kojadoi Village, East Alok District, Sikka Regency, East Nusa Tenggara.

The value of ash content obtained in this study was quite high and far from the export quality standards for carrageenan and ATC set by FAO, namely a maximum of 4%. This was also said by [18], that the maximum ash content of seaweed flour is 4%. Ash content value greater than 4%, will have negative correlation with the level of flour purity. The higher the ash content, the higher the mineral content. This indicates the low purity of the flour. This may be caused by unclean washing and incomplete filtering so that the dirt is not filtered out and carried away by current.

The results of the analysis of variance in Table 4 show that F-count value is 3.74 and lower than F-table value 5.14 at α = 0.05 and 10.92 at α = 0.01. This illustrates that the harvest time has no significant effect on carrageenan ash content.

The increasing of harvest time tends to reduce the ash content of ATC. Seaweed contains high enough minerals because of its ability to absorb minerals from the environment.

The mineral content is also influenced by the waters condition where the seaweed is cultivated. Therefore, the longer the seaweed is cultivated, the higher the ash content, because lots of minerals will be absorbed. According to [19], increasing harvest time tends to increase the ash content. Seaweed is a kind of food that contains high enough minerals because of its ability to absorb minerals from the environment.
Table 4. Anova ash content of ATC

| Source of Variation | Sum of Square | Degree of Freedom | Mean Square | F-Count | F table |
|---------------------|---------------|-------------------|-------------|---------|---------|
| Treatment           | 95.29         | 2                 | 47.64       | 3.74    | 5.14    |
| Error               | 76.49         | 6                 | 12.75       |         | 10.92   |
| Total               | 171.78        | 8                 |             |         |         |

4. Conclusions

The psychochemical characteristics of *Kappaphycus alvarezzi* ATC flour cultivated in South Morotai Village waters with NaOH solution treatment at different harvesting time had a significant effect on moisture content, ash content, gel strength and color. ATC flour made of *Kappaphycus alvarezzi* seaweed at harvest time 40 has the best physical and chemical characteristics. The physical characteristics are gel strength 630.77 g/cm²; yield 10.20%; white degree 57.88; while the chemical characteristics such water and ash content are low with a value of 12.70% and 37.40%.

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