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The Effect of KOH and CaCO3 Solution Concentration on the Quality of Alkali Treated Cottonii Chips (ATCC) Produced

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ABSTRACT

The alkali treatment process typically employs KOH (potassium hydroxide) and CaCO3 (calcium carbonate) to modify Cottonii's cellular structure, facilitating carrageenan extraction and enhancing the final product's quality. The concentration of these solutions significantly impacts the quality of Alkali Treated Cottonii Chips (ATCC). This research aims to determine the effect of KOH and CaCO3 concentrations in the soaking and bleaching process on the quality of Alkali Treated Cottoni Chips (ATCC) produced. The ATCC processing was conducted by adding the concentration of KOH and CaCO3 solution in each treatment. Observations made in this research are water content and pH while for the analysis of the test is gel strength and carrageenan. This research is an experimental study using a Completely Randomized Design (CRD) with a factorial pattern consisting of 2 factors. The results of this research indicate the effect of the concentration of KOH and CaCO3 solutions on the processing of Alkali Treated Cottoni Chips (ATCC) is significantly influential on the quality of ATCC where KOH and CaCO3 contribute to the determination of the analysis of the physical and chemical properties of ATCC both from the ability of KOH to inhibit the rate of water content, pH, and the ability of KOH and CaCO3 in gel formation. The maximum standard of water content of ATCC is 12% in this research, the lowest water content is A3B3 with a value of 9.74%, the highest is A1B1 with a value of 11.72%, for the pH of ATCC, the value ranges between pH 8-11, the pH of A1B1 treatment with the lowest value of 8.66 and the highest is A3B3 with a value of 9.22, while for the highest gel strength is A3B3 treatment with a value of 150.70g and for carrageenan, the highest value is obtained in A2B2 treatment with a value of 65.98%.

Keywords: *ATCC Processing, CaCO3, Eucheuma Cottonii Seaweed, KOH, Quality*

INTRODUCTION

Seaweed is a valuable commodity nowadays. There are many daily products that use seaweed as the main ingredient. Seaweed is a versatile product that can be directly eaten or processed into food additives, livestock feed, fertilizers, biofuels, cosmetics, medicines, and others (Buschmann et al., 2017). Along with the development of technology, the usage of this product has become expansive, which has led to increased demand and production in various countries (Zainuddin, 2023).

Seaweeds contain phycocolloids, which are agar, alginate, and carrageenan (Lomartire & Gonçalves, 2023). Seaweed of the Eucheuma species contains carrageenan. There are three types of carrageenan which are iota carrageenan, kappa carrageenan and lambda carrageenan. Iota carrageenan is a soft and elastic jelly. Kappa carrageenan is a stiff and hard jelly. Lambda carrageenan is not a jelly, but a thick liquid (Frank, 2015). E.cottonii and E.spinosum seaweeds are very popular as raw materials for domestic and export industries. In Indonesia, commonly cultivated seaweeds are Eucheuma cottonii and Gracilaria sp (Sumule et al., 2021).

Eucheuma cottonii seaweed belongs to a group of red algae (Rhodophyceae) that produce carrageenan. Carrageenan is an important thickening agent because it is used in both the food and non-food industries. This type of seaweed was developed because of its good prospects, generates good profits, and has various benefits. Eucheuma cottonii belongs to carragaenophytes, a group of seaweeds that produce carrageenan in raw polysaccharide form. The carrageenan contained in this seaweed is rich in water-soluble fiber called gum fiber (Prajapati et al., 2014). Carrageenan is an ingredient produced from the seaweed Eucheuma cottonii. It is powdery and has many benefits, such as as a gelling agent, emulsifier, thickener, stabilizer, and binder in the food, ceramic, pharmaceutical, cosmetic, textile, and fertilizer industries (Desiana & Hendrawati, 2015). The main ingredient for producing carrageenan is alvarezii red seaweed, also known as Eucheuma cottonii (Nurani et al., 2024).

There are three different types of products made from dried Eucheuma cottonii seaweed. First, Alkali Treated Cottonii (ATC) is made by boiling the seaweed in an alkaline solution (KOH). This product is usually in the form of chips and is used as a raw material to make pure carrageenan. In addition, ATC can serve as a binder and stabilizer in the non-food industry, particularly animal feed in the European, American and Asia Pacific markets. The carrageenan industry has great investment potential. The added value of carrageenan products is very high, which is 4-12 times higher than the raw material of Eucheuma cottonii seaweed. Indonesia has abundant production of raw materials. Indonesia was the largest producer of Eucheuma cottonii in the world in 2015 with a production of 1.04 million tons. However, only 5 percent of Eucheuma cottonii in

the country is processed into carrageenan. Meanwhile, there has been an increasing demand for carrageenan products in the domestic and global markets (Desiana & Hendrawati, 2015).

The price of processed Karaginan products is constantly increasing and has a tendency to stabilize. Stabilized prices allow investors to plan medium and long-term investments with confidence. Carrageenan has high economic value, coupled with the potential of Eucheuma cottoni seaweed in South Sulawesi. This product is expected to increase community income and create jobs.

In order to produce quality ATCC, the production process must follow certain standards so that ATCC products meet national and international market standards. Since there is still limited research on the best concentration combination in the ATCC production process, especially in the soaking stage with KOH and bleaching process with CaCO3, this research aims to inform the best concentration of KOH and CaCO3 solution. This information is expected to help produce quality ATCC products from E. Cottoni in accordance with ATCC standards.

LITERATURE REVIEW

Seaweeds

Seaweeds, scientifically called algae, are plants that have chlorophyll. There are two types of seaweed based on their size that are microscopic and macroscopic. The macroscopic type is commonly known as seaweed in everyday life (Surni, 2014).

Figure 1. Seaweeds
Source: Google Images

The classification of Eucheuma cottonii based on Doty (1985) is classified as follows:

Division: Rhodophyta (a kind of red algae)
Class: Rhodophyceae
Order: Gigartinales
Family: Solieriaceae
Genus: Euecheuma
Species: E. spinosum and E. cottonii

E.cottonii species are characterized as follows: cylindrical stem, smooth surface and similar to young cartilage. The color can be bright green, olive green, or reddish brown. The stem is branched with pointed or blunt ends, and there are protrusions and blunt soft spines to protect the genital cells.

The branches of this seaweed grow alternately and irregularly. The branches can grow two-by-two (dichotomus) or three-by-three (trichotomus). This seaweed requires sunlight for photosynthesis, so it can only live in areas that still get sunlight, that is, at the photic layer. The growth of this seaweed is affected by strong currents and stable salinity levels, around 28-34 per mile. Therefore, this seaweed grows well away from river estuary (Sumule et al., 2021).

Figure 2. Eucheuma Cottonii Seaweed
Source: Google Images

Eucheuma cottonii seaweed contains carbohydrates, proteins, low amounts of fats, and ash. Additionally, it serves as a source of vitamins such as vitamin A, B1, B2, B6, B12, and vitamin C, and contains minerals such as K, Ca, P, Na, Fe, and iodine (Baghel et al., 2023).

ATCC (Alkali Treated Cottoni Chips)

ATCC is a seaweed preservation process that produces carrageenan using alkaline solutions, either cold or hot alkali. The product is produced as pieces or flour with significant added value. The process of making ATCC is simple, by boiling seaweed in KOH solution. Afterwards, the seaweed is neutralized by repeated washing, cut, and dried to produce chip-shaped carrageenan. Alkaline boiling aims to increase the melting temperature of the carrageenan to keep it from dissolving into paste, and to increase the gel strength of the carrageenan (Pumpente et al., 2019). The steps of processing seaweed in ATCC are described below:

1. Dried seaweed is cleaned to remove contaminants from the sea.
2. Then, soaking 500g of seaweed is done for 14 hours with the addition of 4 grams of KOH per 400 liters of water at pH 11-12.
3. After soaking, extraction is carried out for 1 hour with the addition of 4 grams of KOH per 400 liters of water at pH 11-12.

4. Bleaching of the seaweed is conducted for 1 hour with the addition of 12 grams of $CaCO_3$ per 400 liters of water.
5. Next, rinsing is done with 800 liters of clean water.
6. Drying takes place for 3-4 days until the desired moisture content of 12g is achieved (according to SNI 01-2690-2009).
7. After drying the seaweed, it undergoes chipping and packaging.

Research Hypotheses

The effect of KOH and CaCO3 solution concentration on the quality of Alkali Treated Cottoni Chips (ATCC) that are produced is the following:

1. It is assumed that there is no effect of KOH and CaCO3 solution concentration on the quality of the Alkali Treated Cottoni Chips (ATCC) produced (H_0).
2. It is suspected that there is an effect of the concentration of KOH and CaCO3 solutions on the quality of Alkali Treated Cottoni Chips (ATCC) produced (H_1).

RESEARCH METHODOLOGY

This research is an experimental study using a Completely Randomized Design (CRD) with a factorial pattern consisting of 2 factors. The first factor is the soaking process using KOH solution in 3 different concentrations, while the second factor is the bleaching process using CaCO3 solution in 3 different concentrations. In total, 27 experiments were conducted with a combination of 3 KOH concentrations and 3 CaCO3 concentrations, each repeated 3 times. This research starts from preparation to testing, which began on September 2020 to May 2021 with the research method used is experimental research method. ATCC processing was conducted at the Agricultural Technology Education Laboratory, Faculty of Engineering, Universitas Negeri Makassar and the analysis of carrageenan and gel strength was conducted at the Water Quality Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Hasanuddin. There are several procedures conducted in this research, including the following:

1. Seaweed is sorted to remove pollutants like paper, plastic, sand, and salt. Then, 250g of dried seaweed is soaked for 14 hours in a solution of KOH (potassium hydroxide) added at concentrations of 1.22g, 1.53g, and 1.83g per 2 liters of water, with a pH of 11-12 and at a standard temperature of ±28°C.
2. Measure the initial and final pH and water temperature during the soaking process.
3. After soaking, perform extraction for 1 hour using a KOH solution added at a concentration of 1.85g per 2 liters of water, at pH 11-12. Stir the mixture every 15 minutes, maintaining an extraction temperature between 60°C and 65°C.

4. Measure the initial and final pH and water temperature during the extraction process.
5. After extraction, bleach the seaweed for 1 hour using a CaCO3 (calcium carbonate) solution added at concentrations of 6.6g, 8.3g, and 9.9g per 2 liters of water.
6. Measure the initial and final pH and water temperature during the bleaching process.
7. Rinse the seaweed with 2 liters of clean water, repeating this rinsing process 3 times.
8. Dry the seaweed for 3-4 days until it reaches the desired moisture content of 12%. Use a drying room where the seaweed is placed on trays.
9. Once dried, chip and package the seaweed.

The data collection technique used in this research is the systematic observation and note-taking method of the research subject. Data collection was conducted by testing as follows:

1. Moisture Content
2. Carrageenan Content
3. Gel Strength
4. pH Value

RESULT AND DISCUSSION

Research Result

Moisture Content

Moisture content is a process to determine the quantity of water contained in a food item. When the material is dried, the water content is reduced. Moisture content is measured before and after the material is dried. During the drying process, the moisture content is identified by calculating the ratio of the weight loss of the material to its dry weight (Zambrano et al., 2019).

Analysis of ATCC moisture content in Chart 1 indicates that the highest average moisture content occurred in treatment A1B1, where 1.22g KOH solution was used in the soaking process, and 6.6g CaCO3 was used in the bleaching process, with a value reaching 11.72%. On the other hand, the lowest average moisture content was reported for treatment A3B3, where 1.83g KOH solution was used for soaking and 9.9g CaCO3 was used for bleaching, resulting in a moisture content of 9.74%.

Based on this data, the less KOH solution used, the higher the moisture content of ATCC. Instead, higher CaCO3 addition tends to result in lower ATCC moisture content.

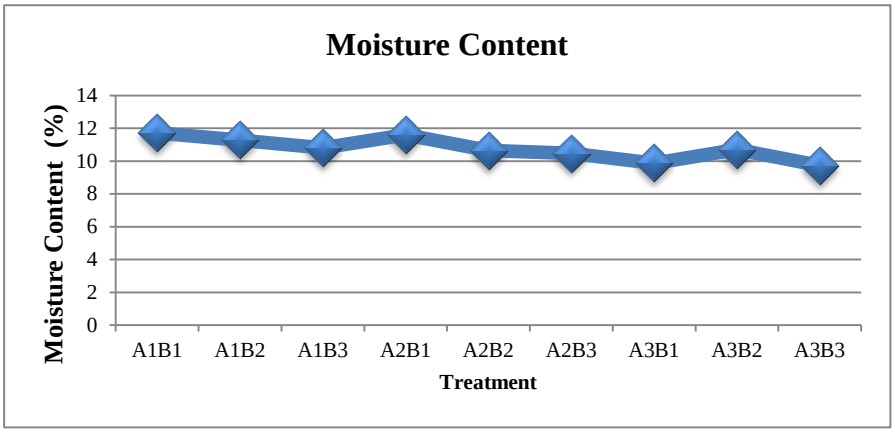

Chart 1. The average value of ATCC moisture content obtained from the effect of KOH and CaCO3 solution concentrations
Source: Processed Data by Researcher

pH Value

The pH value (Power of Hydrogen) is an indicator to show the acidity or basicity of a solution. The results of chemical analysis of the pH value of the concentration effect of KOH and CaCO3 solution on the quality of Alkali Treated Cottoni Chips (ATCC) can be seen in Chart 2.

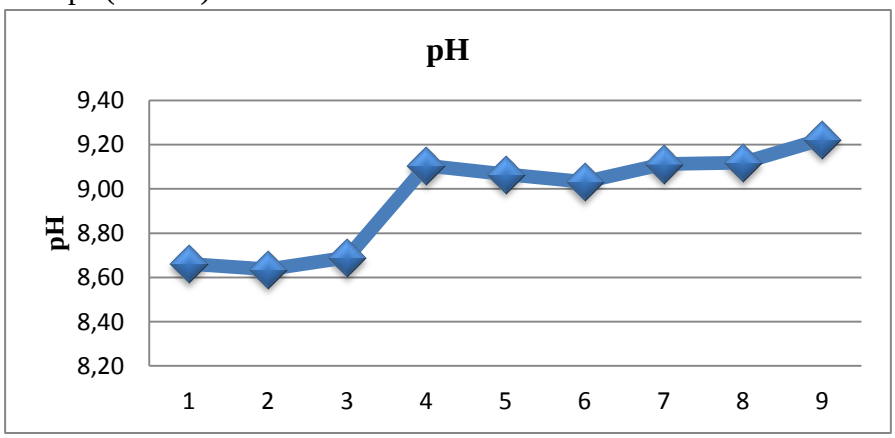

Chart 2. Average pH value produced during the ATCC treatment process
Source: Processed Data by Researcher

The pH analysis in Chart 2 indicates that the highest average pH value occurred in treatment A3B3, where KOH solution was used as much as 1.83g during soaking and CaCO3 as much as 9.9g during bleaching, with a value reaching 9.22. On the other hand, the lowest average pH value was found in treatment A1B1, with 1.22g KOH solution during soaking and 6.6g CaCO3 during bleaching, which reached 8.66.

Gel Strength

Gel strength is a main physical character of carrageenan as it indicates its ability to form a gel (Diharmi et al., 2020). The gel strength measurement results for the quality of Alkali Treated Cottoni Chips (ATCC) can be seen in Chart 3 below.

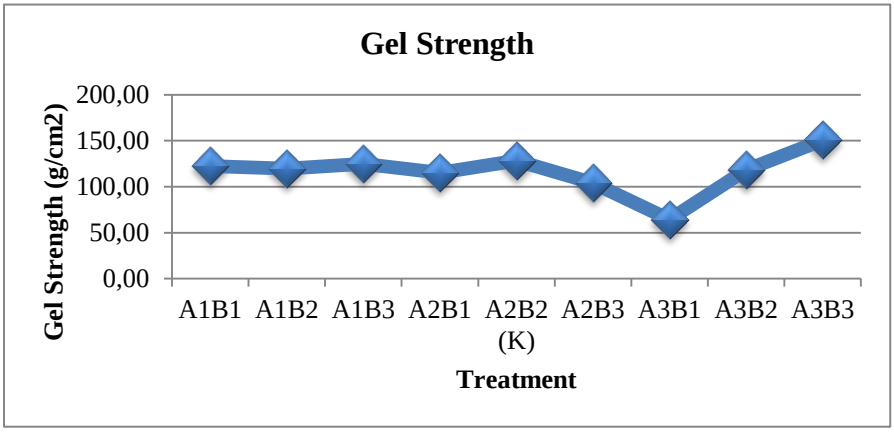

Chart 3. Gel strength values at ATCC
Source: Processed Data by Researcher

The results of the gel strength analysis at ATCC shown in Chart 3 indicate that the highest gel strength was obtained in the A3B3 treatment with a KOH solution concentration of 1.83g during the soaking process and a bleaching process with CaCO3 of 9.9g, with a value of 150.70g. While the lowest gel strength was obtained in the A3B1 treatment with a KOH solution concentration of 1.83g during the soaking process and a bleaching process with CaCO3 of 6.6g, with a value of 64.13g.

Carrageenan Content

The results of carrageenan analysis at ATCC in Chart 4 revealed that the highest average value of gel strength was obtained in A2B2 treatment, using 1.53g KOH in the soaking process and 8.3g CaCO3 in the bleaching process, with a value of 65.98%. While the lowest average value of carrageenan was obtained in the A3B3 treatment, using 1.83g KOH in the soaking process and 9.9g CaCO3 in the bleaching process, with a value of 44.25%.

The test results of carrageenan content in ATCC products with KOH and CaCO3 addition process can be seen in Chart 4 below.

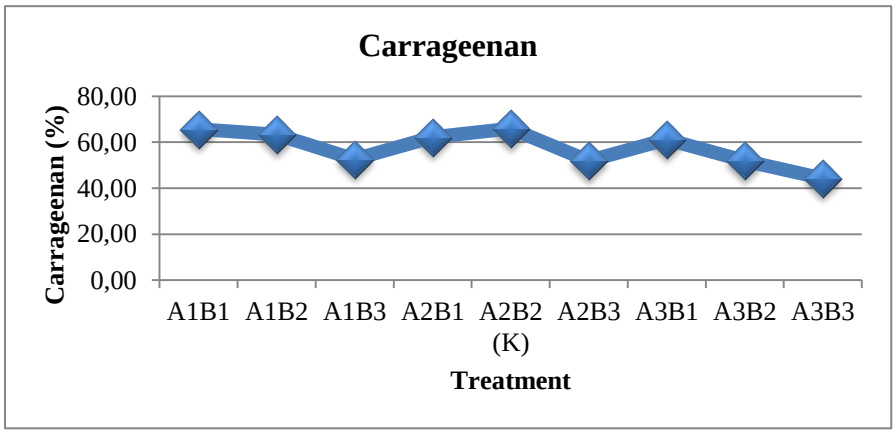

Chart 4. Carrageenan content value in ATCC products
Source: Processed Data by Researcher

Research Discussion

Moisture Content

Moisture content testing aims to determine the amount of moisture content in ATCC. The moisture content in ATCC affects its shelf life (Wenno et al., 2012). Based on the results shown in Chart 1, the average moisture content of ATCC ranged from 9.74-11.72%. The analysis showed that the concentration of KOH and CaCO3 had a significant effect on the moisture content. The less KOH solution used, the higher the moisture content of ATCC. Meanwhile, the more CaCO3 used, the lower the water content of ATCC. This might be due to the ability of KOH to extract and inhibit the increase of water in Eucheuma Cottonii seaweed molecules, so that the concentration of water is reduced. The results of this research are in accordance with Anwar et al (2013), which states that the decrease in alginate moisture content is caused by the alkaline atmosphere of the KOH solution which inhibits the increase of water in the alginate molecule. As the KOH concentration increases, the mineral salts contained are reduced. Desiana & Hendrawati (2015) also reported that with increasing KOH concentration, the moisture content decreased. According to the quality standard of commercial carrageenan, the moisture content should be under 12%, so the ATCC produced in this research has reached the quality standard.

pH Value

pH is the level of acidity used to characterize the acidity or alkalinity of a solution. ATCC products have a pH value range between 8-11. Therefore, in this research, KOH and CaCO3 were added to the soaking and bleaching process to lower the pH to match the market standard. Based on Chart 2, the average pH

value obtained is 8.66-9.22. It indicates that the addition of KOH and CaCO3 has a significant effect on reducing pH in ATCC processing.

Gel Strength

Gel strength is a main physical character of carrageenan as it indicates its ability to form a gel (Diharmi et al., 2020). Gel strength is formed due to cross-linking between polymer chains that form a three-dimensional grid. This grid is able to capture and hold water within it, thus creating a strong and rigid structure.

The average gel strength level ranged from 64.13 to 150.70g. Analysis of variation indicated that the concentration of KOH and CaCO3 had a significant effect on the gel strength of carrageenan. The higher the KOH concentration, the lower the gel strength of carrageenan. Commercial carrageenan has a high gel strength because it has a lower sulfate content compared to Eucheuma cottonii carrageenan (Desiana & Hendrawati, 2015). The low gel strength in this research may be due to the processing process and sulfate content.

Carrageenan Content

Increasing the drying temperature of carrageenan causes the carbon chains within its matrix to break. This results in shorter polymer chains and smaller molecular weight of carrageenan, thereby weakening the helical structure formed in carrageenan gel. The increase in gel formation is not only due to the formation of triple helices but also due to cation ions that influence the functional properties of carrageenan. The physical quality of dried Eucheuma cottonii carrageenan can be assessed by its gel strength. In this research, the highest carrageenan value was 74.99%, with a solution concentration of 1.22g KOH during the soaking process, which was the lowest concentration among the 9 treatments tested in the process.

CONCLUSION

Based on the research results and discussion above, it can be concluded that the concentration of KOH and CaCO3 solution in the processing of Alkali Treated Cottoni Chips (ATCC) affects the quality of ATCC. KOH and CaCO3 have an important role in analyzing the physical and chemical characters of ATCC, including their ability to control moisture content and pH, and their gel forming ability. The maximum standard for ATCC moisture content is 12%. The best treatment for ATCC moisture content was A3B3 with 9.74%. For pH, the optimal value is between pH 8-11, and treatment A1B1 achieved the best pH value of 8.66. The highest gel strength was found in treatment A3B3 with a value of 150.70g, while the highest carrageenan value was obtained in treatment A2B2 with a value of 65.98%.

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