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EDIBLE FILM CHARACTERISTICS WITH CARRAGEENAN (*Eucheuma cottonii*) FLOUR EXTRACTED WITH DIFFERENT BASE SOLVENTS

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ABSTRACT

Edible film is a primary packaging in the form of a thin layer and functions as a coating for food ingredients, which can be made from hydrocolloid compounds. Carrageenan polysaccharide is one of the hydrocolloids used to make edible films because it produces strong gel properties. *Eucheuma cottonii* is a seaweed that produces relatively high levels of kappa carrageenan, namely around 50%. This research aims to determine the physical and mechanical characteristics of edible film with carrageenan flour from *E. cottonii* extracted with different base solvents. The research method was carried out experimentally with an experimental design, namely a non-factorial Completely Randomized Design (CRD) with three levels of treatment, namely differences in carrageenan flour extracted with KOH, NaOH and $Ca(OH)_2$ solvents. The parameters of this research are physical and mechanical analysis of edible film, including testing tensile strength, thickness, percent elongation, and water vapor transmission rate. The research results showed that the best results were in the treatment of carrageenan flour extracted with KOH solvent, where the physical and mechanical analysis of the edible film showed a tensile strength value of 9.49±0.50 MPa, a thickness of 0.03±0.003 mm, a water vapor transmission rate of 30.13±0.41 g/m^2/day, and a percent elongation 9.86±0.41%.

Keywords: Base Solvent, Carrageenan, Edible Film, *Eucheuma cottonii*, Extraction

1. INTRODUCTION

Edible film is a primary packaging material in a thin layer and serves as a food coating. Edible film is shaped like a dense, thin sheet used as a wrapper. Edible film can be made from hydrocolloid compounds. Hydrocolloid compounds are produced from land and sea plants. One of the hydrocolloids used to make edible films from the polysaccharide group has many advantages, including the potential to be used as a base material because it is economical, and the latest is carrageenan.

Carrageenan is a natural polysaccharide extracted from red seaweed with water or an alkaline solution, which is then separated from the solvent. Carrageenan extraction can be done physically, such as cooking at 70-100°C, or chemically using KOH, NaOH, $Ca(OH)_2$ and KC[1].

The usefulness of carrageenan serves as a thickener, emulsifying agent, suspending agent and stabilizers. Carrageenan is divided into three types: kappa, iota, and lambda, which are distinguished based on differences in cell binding and gel properties. Kappa carrageenan produces the strongest gel properties, and the type of seaweed that produces kappa carrageenan with a relatively high content of about 50% is *Eucheuma cottonii*.

The characteristics of edible film have been reported by several researchers, such as the results of research[2], using a

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concentration of 1.5% carrageenan extracted using KOH, which produced the best edible film with a tensile strength value of 5516.67 kgf/cm^2 and a percent elongation of 43.05%. Another research study by Nurmilla & Aprillia[3] showed that the best edible film was produced on carrageenan extracted from NaOH with a concentration of 2.5% because it had the best percent elongation of 77%. Other research, Rusli et al.[4] reported the best edible film using 3% carrageenan and 10% glycerol with a tensile strength of 4.65 MPa, and an elongation of 16.67%.

The study aimed to determine the physical and mechanical characteristics of edible film from carrageenan flour of *E. cottonii* seaweed extracted with KOH, NaOH and Ca $(OH)_2$ as base solvents.

2. RESEARCH METHOD

Time and Place

This research was conducted in May-July 2024. Sample preparation was conducted at the Fishery Products Chemistry Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Riau and sample analysis was conducted at the Food Technology and Agricultural Products Test Laboratory, Faculty of Agricultural Technology, Gajah Mada University.

Method

This research uses an experimental method: making edible film from *Eucheuma cottonii* carrageenan flour extracted with different base solvents. The experimental design used was a completely randomized design (CRD) using carrageenan flour extracted with KOH, NaOH and Ca $(OH)_2$ solvents.

Procedures

This research consists of edible film making from *Eucheuma cottonii* carrageenan flour and analysis of physical and mechanical testing of edible film.

Preparation of edible film

This stage refers to the method[5] where each carrageenan flour treatment was weighed as much as 1 g and dissolved with distilled water to 100 mL in a glass beaker, resulting in a 1% carrageenan flour solution. The solution was homogenized using a magnetic stirrer while heated on a hot plate to a temperature of 60°C. Then, 0.5% (v/v) glycerol was added as a plasticizer while stirring at 80°C for 5 minutes. The carrageenan solution was poured into a glass mould and baked in an oven for 24 hours at 50°C. The resulting edible film was then analyzed for its physical and mechanical properties.

Tensile Strength

Tensile strength was measured using a Universal Testing Machine (Zwick Z.05), referring to the ASTM method[6]. The test is carried out using the end of the sample, which is tested by placing it on the test device and pulling until it breaks. The tool will display the highest force required to cut the film. The maximum load at the point where the film breaks is used to calculate the tensile strength. The sample's length and thickness are multiplied to determine the cross-sectional area. According to Saputro et al.[7], the range of tensile strength values that can be applied to edible films is 10±100 MPa. Tensile strength testing can be calculated using the following calculation.

$$\text{Tensile strength (MPa)} = \frac{\text{F (N)}}{\text{A}\ (mm^2)}$$

Description:
F = Maximum force to tear the film
A= Cross-sectional area

Thickness

The dried edible film was measured using a screw micrometer that has an accuracy of 0.01 mm. Measurements were taken at 5 different points on the edible film. Then the average measurement of edible film thickness was taken[8].

Water Vapour Transmission Rate

The water vapour transmission rate (WVTR) refers to the method[9,] which was modified to be determined gravimetrically. The film sample to be analyzed is covered on a cup containing 10 g of silica gel. The silica gel will absorb moisture that diffuses through the film, thus increasing the weight of the gel. For 8 hours, the weight of the cup is recorded every hour. The data obtained was transformed into an equation for linear regression, and the slope was determined. The following equation was used to calculate the water vapour transmission rate. The water vapour transmission rate was determined by the equation.

$$\text{Water vapour transmission rate} = \frac{\text{slope of increase in cup weight (g/hour)}}{\text{film surface area (m}^2\text{)}}$$

Percent Elongation

Percent elongation was measured using a Universal Testing Machine (Zwick Z.05), referring to the ASTM method[6]. The length of the edible film at break and the length before being pulled by the device were compared to determine the percent elongation. Elongation was calculated by dividing the incremental length of the cut film (b) by the initial length of the film (a) before tearing, with the following calculation:

$$\text{Elongation} = \frac{b-a}{a} \times 100\%$$

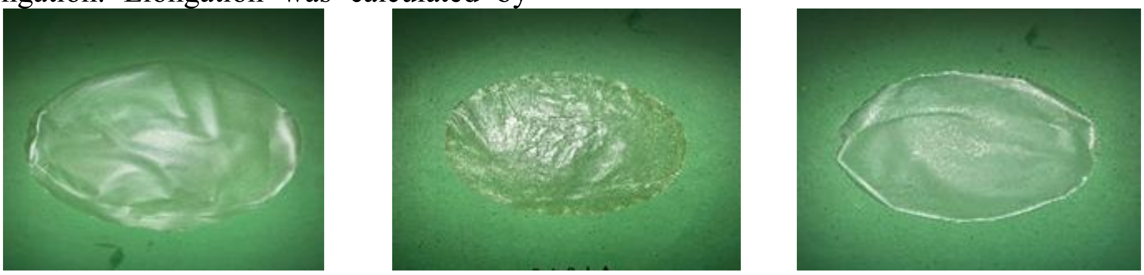
Description:

a = The initial length of the film before pulling
b = Increased length of the cut film at the tear-off

3. RESULT AND DISCUSSION

Edible Film

Edible film is a primary packaging in a thin layer and functions as a food coating; edible film is shaped like a dense thin sheet used as a wrapper. Edible films can be made from hydrocolloid compounds10. The results of making edible film with carrageenan flour extracted with different base solvents can be seen in Figure 1.



KOH NaOH $Ca(OH)_2$

Figure 1. Edible film from carrageenan (*E. cottonii*) flour

Edible film in this study uses carrageenan flour from previous research[11]. Edible films produced from each treatment had differences in visual and texture. The best results were obtained from edible films made with carrageenan flour extracted using KOH solvent, where edible films were obtained with a clear transparent colour and smooth and elastic texture, but they were firm and not easily torn. This is related to the function of KOH solvent itself to help the extraction of polysaccharides to be more perfect and accelerate the elimination process of 6-sulphate to 3,6-anhydro-D-galactose to improve the quality of carrageenan used in making edible films[12].

Physical and mechanical properties of edible film

The physical and mechanical properties of the edible film analyzed were tensile strength, percent elongation, and water vapour transmission rate. The results of the physical and mechanical properties of edible film are presented in Table 1.

The tensile strength test measures the maximum strength (pull) that an object can withstand when stretched or pulled before the film breaks or tears[13]. Table 1 shows that this study's edible film tensile strength results were the highest in the KOH treatment, 9.49±0.50 MPa and the lowest in the NaOH treatment, 4.02±0.33 MPa. The three treatments are significantly different and have met the minimum tensile strength standard set by the Japanese Industrial Standard[14], which is at least 3.92 MPa. Film thickness is one of the main characteristics in determining the feasibility of edible film as food product packaging because thickness greatly affects the physical and mechanical properties of other edible films, such as tensile strength, elongation, solubility and water vapour permeability[15]. Table 1 shows that the highest film thickness in this study was 0.07±0.004 mm in the Ca $(OH)_2$ treatment and the lowest was 0.03±0.003 mm in the KOH treatment. The three treatments are significantly different and have met the minimum tensile strength standard set by the Japanese Industrial Standard[14], a maximum of 0.25 mm.

Table 1. Physical and mechanical results of edible film

Parameters	Carrageenan flour treatment	Result
Tensile strength (MPa)	KOH	9,49±0,50^c
	NaOH	4,02±0,33^b
	Ca $(OH)_2$	5,81±0,35^a
Film thickness (mm)	KOH	0,03±0,003^a
	NaOH	0,06±0,002^b
	Ca $(OH)_2$	0,07±0,004^c
Water vapour transmission rate (g/m^2/day)	KOH	30,13±0,41^a
	NaOH	26,20±0,24^b
	Ca $(OH)_2$	25,55±0,11^c
Percent elongation (%)	KOH	9,86±0,41^a
	NaOH	19,62±0,91^b
	Ca $(OH)_2$	12,02±0,34^c

Description: Different letters in the row indicate a significant difference ($p<0.05$).

Water vapour transmission rate is the amount of vapour lost over time divided by the area of the film. The water vapour transmission rate is determined by the water vapour permeability of the film[16]. Table 1 shows that the results of the water vapour transmission rate in this study were highest in the KOH treatment, namely 30.13±0.41 g/m^2/day, and the lowest was Ca $(OH)_2$, namely 26.20±0.24 g/m^2/day. The three treatments differed significantly but did not meet the minimum tensile strength standard set by the Japanese Industrial Standard[14] of <7 g/m^2/day.

The average value of water vapour transmission rate exceeded the edible film quality standard limit due to the use of carrageenan and glycerol, which are hydrophilic. Hydrophilic properties can reduce the intermolecular tension in the film matrix and expand the distance between molecules, allowing water vapour to penetrate the film layer. Due to the hydrophilic nature of carrageenan, the polymer is surrounded by moving water molecules, so the carrageenan solution thickens. This follows other researchers, Gozali et al.[17], who stated that several factors can affect water vapour transmission rate in edible films, such as the raw materials used, the concentration of plasticizing agents and environmental or storage conditions.

Percent elongation is the percentage change in film length calculated when the film is pulled until it breaks4. The higher the stretching value of the edible film, the better its strength in resisting pressure/pull, so that it is not easily torn[18]. Table 1 showed that the results of the percent elongation of edible film in this study were highest in the NaOH treatment, namely 19.62% and the lowest in the KOH treatment, namely 9.86%. The three treatments were significantly different and met the minimum tensile strength standard set by the Japanese Industrial Standard[14], namely <10% poor, 10-50% good, and >50% very good.

4. CONCLUSION

Based on the results, it can be concluded that edible film from *Eucheuma cottonii* carrageenan with different base solvents (KOH, NaOH, and $Ca(OH)_2$) has a significant influence on physical and mechanical characteristics (tensile strength, thickness, water vapour transmission rate, percent elongation). The KOH treatment was the best, with the highest tensile strength value of 9.49±0.50 MPa and the lowest thickness of 0.03±0.003 mm.

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