



Characteristics of the edible film made from *Kappaphycus alvarezii* of Sumenep seawaters, Madura

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ABSTRACT

Edible film is a primary packaging in the form of a thin layer that covers food products, and it is usually made from hydrocolloids, lipids, and mixtures of both. Edible film from seaweed carrageenan (*Kappaphycus alvarezii*) extracts may serve as an alternative to plastic packaging, which is environmentally friendly and safe for consumption. This research aims to analyze the proximate composition of *K. alvarezii* samples (lab-scale drying and conventional drying) and investigate its effects on physical characteristics (thickness values, solubility in water, water vapor transmission rate, elongation, and tensile strength) of the edible film. The research was carried out in several stages: sampling, sample preparation, carrageenan extraction, and edible filmmaking. The research was carried out using a completely randomized design with five treatments, namely the addition of 1%, 2%, 3%, 4%, and 5% (w/v) carrageenan extract. The research results showed significant differences in proximate values (water, ash, fat, fiber, and carbohydrates) between seaweed dried by farmers and seaweed dried in the laboratory. The addition of carrageenan extract significantly affected the edible film's thickness, water solubility, and tensile strength. The best characteristics were obtained at a concentration of 2% carrageenan extract, resulting in a thickness of 0.12 mm, solubility in water of 60.43%, water vapor transmission rate of 5.77 g/cm²/hour, elongation of 251.33%, and tensile strength of 2.42 Mpa. The results of this research are essential for the development of packaging technology in the future.

Introduction

Indonesia, a maritime country with a water area covering almost 70% of its total territory, is rich in biological resources, including seaweed. The seaweed production in 2021-2022 reached 2.392.877 tons, with a 7.14% increase, according to a report issued by the Ministry of Maritime Affairs and Fisheries in 2022. The seaweed cultivated in Indonesia includes red seaweed, green seaweed, brown seaweed, and blonde seaweed. Fatmawati and Wahyudi (2016) noted that the cultivation of seaweed (*Kappaphycus alvarezii*) in East Java has significant potential, with 16,420 hectares and 372 hectares or 2,27% still being utilized, including in the waters of Sumenep, Madura.

Seaweed is known to produce agar (Uju *et al.*, 2018), carrageenan (Erjanan *et al.*, 2017) and alginate (Laksanawati *et al.*, 2017) which act as a natural

thickener (Jazuli and Ninsix, 2015; Akbar and Hasan, 2024), gel-forming (Wenno *et al.*, 2012), stabilizer (Violisa *et al.*, 2012), emulsifier (Safia *et al.*, 2020) and so on. With its diverse nutritional and chemical content, seaweed has yet to be utilized optimally. Most of the seaweed produced in Indonesia is exported abroad as dried and in raw or wet form. The types of widely used seaweed are red seaweed and brown seaweed. Saraswati *et al.*, (2022) stated that the type of seaweed in Indonesia that has economic value and is widely produced is the type *K. alvarezii*, which is a carrageenan-producing seaweed or carrageenophyte (Nurjanah *et al.*, 2019). Carrageenan is one of the seaweed processing products that has high economic value. Carrageenan is sourced from red seaweed from the Rhodophyceae group, a sulfated polysaccharide with hydrocolloid properties

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and widely used in food and industrial products (Salam and Larasati, 2013).

The carrageenan content in seaweed is meaningful for edible or biodegradable films (Nasution et al., 2019) because it has several advantages as follows: having gel-forming properties, high fiber content, good stability, and most importantly, a renewable source. Edible film can act as primary packaging, applied as a thin layer, coating food ingredients, and can be made from hydrocolloid compounds (carbohydrates and proteins), lipids, and mixtures of hydrocolloids and lipids (Indarti et al., 2022; Akbar and Mustari, 2024). As a raw material for making edible film, carrageenan is classified as a natural material that can be renewed or renewable resources, so the resulting packaging is environmentally friendly. Saragih et al., (2016) stated that carrageenan, as a material for making edible films, has the advantage of forming an elastic, edible, and renewable gel but has the disadvantage of low water vapor transfer ability. Carrageenan is usually applied to make edible films using plastic-forming materials or plasticizers. The plasticizers used in making edible films are glycerol, sorbitol, and polyethylene glycol because they can absorb water vapor (Wirawan et al., 2012). The addition of glycerol plasticizer in making edible films affects the characteristics of edible films, namely the mechanical properties of tensile strength and elongation (Rusli et al., 2017).

Research on the use of seaweed as the edible film was carried out by Fardhyanti and Julianur (2015), namely by using seaweed carrageenan extract (*K. alvarezii*) and sorbitol as a plasticizer, Rani and Kalsum, (2016), a namely edible film from the seaweed *Gracillaria* sp. and glycerol as a plasticizer; Rusli et al., (2017), a namely edible film from commercial carrageenan flour and glycerol plasticizer; (Wirawan et al., 2012), a namely edible film from a composite of *K. alvarezii* carrageenan and palm oil; Nasution et al., (2019), namely edible film made from carrageenan extracted from *K. alvarezii* from Aceh; Febianti et al., (2020), namely edible film mixed with kappa carrageenan flour, crab shell chitosan, and glycerol; Nurdin et al., (2022) namely edible film from seaweed (*K. alvarezii*) from Kupang with a mixture of glycerol and sorbitol; Indarti et al., (2022), namely edible film from the extraction of dried seaweed (*K. alvarezii*) from Banda Aceh and glycerol as a plasticizer. Making an edible film from *K. alvarezii* seaweed from the waters of Sumenep, Madura, has never been done. The characteristics of edible film from *K. alvarezii* seaweed carrageenan extract originating from Sumenep, Madura, still need to be considered. This research aims to analyze the

chemical characteristics (proficient value) of *K. alvarezii* seaweed raw materials and analyze the effect of adding *K. alvarezii* seaweed carrageenan extract on the physical characteristics of edible film, namely thickness test, solubility in water, water vapor transmission rate, elongation, and tensile strength test.

Materials and Methods

Research procedure

K. alvarezii was harvested from the waters of Sumenep, Madura (S 07°05.604'; E 113°51.868'). Samples were taken in January 2024 (rainy season) from seaweed farmers, as much as 5 kg of dry samples and 10 kg of wet samples. Subsequently, the wet seaweed was dried in the Environmental Laboratory at Universitas Trunojoyo Madura. The seaweed was then characterized (SNI 2690-2018) and extracted, referring to (Ruku et al., 2021). The edible films were prepared and characterized according to (Rusli et al., 2017), as well as data analysis. The characterization of seaweed included proximate analysis (ash, water, fiber, fat, and protein content) referring to SNI number 01-2891 of 1992 (SNI 1992), and carbohydrate content using the by difference method refers to Novianti and Arisandi, (2021). Characterization of the resulting edible film includes thickness tests ((Rusli et al., 2017), water solubility tests and water vapor transmission rates (Togas et al., 2017), elongation and tensile strength tests (Zahwa et al., 2020).

Sample collection

Samples of *K. alvarezii* seaweed were taken from seaweed farmers in Pagar Batu area, Saronggi District, Sumenep Regency, Madura. *K. alvarezii* seaweed was obtained in dried and fresh form. Farmers dry seaweed raw materials without prior preparation and washing. Seaweed was harvested and dried directly on the beach using a mat/waring container or fishing net, which take 5-7 days. Such drying procedure may result in physical contamination of sand, wood twigs, and pieces of netting. A traditionally dried seaweed (5 kg) was then taken to the laboratory in a plastic bag for preparation. Fresh samples of 10 kg were also taken from farmers to be characterized by comparing them with dry samples from farmers. Wet samples were taken to the laboratory using a container box for the preparation and testing process.

Sample Preparation

Sample preparation followed the method of Tapotubun (2018), namely by washing and soaking in water. The *K. alvarezii* seaweed obtained from farmers was weighed first, followed by washing using flowing

well water until it was clean of adhering dirt in the form of wood chips, sand, and gravel, as well as pieces of fishing net. Washing was carried out 3 times until the seaweed samples were clean. The seaweed samples were then soaked for 12 hours. The seaweed was drained and cut until a sample with a small grain size was obtained. It was then crushed using a blender without adding water. The seaweed samples were then dried in a tray in the sun for 7 days. The dried seaweed samples were then weighed again to obtain yield data. The analysis carried out at this stage included proximate analysis of dry samples from farmers and the laboratory.

Carrageenan Extraction

The raw material used in the extraction stage was seaweed flour, which was dried in the laboratory. The seaweed extraction stages are referred to (Ruku et al., 2021). Briefly, 30 g of dried seaweed was soaked in distilled water for 15 minutes and then filtered. The filtered seaweed was heated with 0.4 N KOH Merck (CAS-No.1310-58-3 made in Germany) solvent for 30 minutes at 90°C with a pH of 8-10. The sample was then filtered using a hot filter cloth. The sample was collected in a beaker containing 96% alcohol solution, and the sedimentation process was carried out in the alcohol solution for 15 minutes. The resulting precipitate was then filtered and dried using an oven for 24 hours at a temperature of 80°C. Then, after drying, it was ground to obtain carrageenan flour.

Edible Films Preparation

The raw material for making edible film was carrageenan extract from seaweed flour that was dried in the laboratory. The stages of making edible film refer to the method used by (Rusli et al., 2017), namely: 1% carrageenan extract (1 g); 2% (2 g); 3% (3g); 4% (4 g) and 5% (5 g) which were then referred to as formulas (F1, F2, F3, F4 and F5) were dissolved in 100 mL of distilled water previously heated at 95°C for 30 minutes. The process was terminated after solution was homogeneous. Then, they were added with 10% v/v glycerol (10 mL) while stirring for 10 minutes. The solution was cooled to 80°C. The solution was poured onto an aluminum pan measuring 25 × 25 cm. The edible film formed was left at room temperature for 2 hours, then dried for 24 hours using an oven at 50 °C. The edible film was removed from the mold, left at room temperature for 2 hours, and then tested.

Thickness Test

The edible film thickness test from *K. alvarezii* seaweed carrageenan extract refers to the method by (Rusli et al., 2017) which edible film samples in sheet form were taken individually. The sample was then

measured with a screw micrometer. Measurements on each sample were carried out at five different points, and the results obtained were then recorded, and the average value was calculated.

Water Solubility Test

The solubility test of edible film in water was carried out using the method used by (Togas et al., 2017). Edible film samples were cut to a size of 2×2 cm. Samples and filter paper were weighed separately with an analytical balance as initial weight. The sample was placed in a beaker containing 50 mL of distilled water. The sample was soaked in water for 6 hours while stirring. The sample was filtered with filter paper and then dried at 105°C for 24 hours. Samples in filter paper are weighed with an analytical balance to determine the final weight. The formula calculates solubility in water:

$$\text{Water solubility (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100\%$$

Water Vapor Transmission Rate Test

The water vapor transmission rate test was carried out according to (Togas et al., 2017). The edible film sample is cut and placed on the mouth surface of a beaker that has been filled with 10 g of silica gel (0% relative humidity). The sample was placed over the mouth of the beaker until it is tightly closed, then secured with a rubber band. The beaker was weighed, then placed in a desiccator containing distilled water (100% relative humidity). The beaker was weighed every 1 hour for 8 hours, and the weight value was recorded then the calculation is carried out using the formula:

$$\text{Water vapor transmission rate} = \frac{W}{A \times t}$$

Where: W = Increase in glass weight (g)
t = Storage time interval (hours)
A = Edible film surface area (cm²)

Elongation and Tensile Strength Test

Elongation and tensile strength tests were carried out using a Texture Analyzer (Stable Micro Systems TA-XT) in the Laboratory of Agroindustrial Technology, Universitas Trunojoyo Madura. The film's elongation and tensile strength tests refer to the method carried out by Zahwa et al., (2020): Samples were cut to size 4×1 cm. Samples were measured using a texture analyzer. The results obtained from the tool are data for the force required for elongation and maximum tensile force until the edible film breaks.

Experimental design

The research was carried out using quantitative methods in the form of experiments, using a

completely randomized design (CRD) with 5 treatments of seaweed carrageenan extract concentration (*K. alvarezii*): 1%, 2%, 3%, 4%, and 5% (w/v). Each treatment was repeated 3 times.

Data analysis

Data analysis was carried out using Microsoft Excel in the form of a descriptive statistical t-test carried out on the results of proximate analysis of the chemical characterization of seaweed raw materials (*K. alvarezii*) and the analysis of variance test (ANOVA) with a confidence level of 95% on the characteristics of edible film, namely thickness test, solubility in water, water vapor transmission, elongation and tensile strength, the treatments were significantly different, then further tests were carried out using the Duncan's Multiple Range Test (DMRT).

Results

Characteristics of seaweed *K. alvarezii*

The seaweed *K. alvarezii* in this study was obtained in dry form. Preparation was carried out to clean and wash off adhering dirt. The seaweed *K. alvarezii* has the physical characteristics of a yellowish-green color, a blunt thallus tip, and a soft surface. The morphological characteristics of *K. alvarezii* seaweed originating from the waters of Sumenep, Madura, can be seen in Figure 1a. Dried and ground *K. alvarezii* seaweed can be seen in Figure 1b.

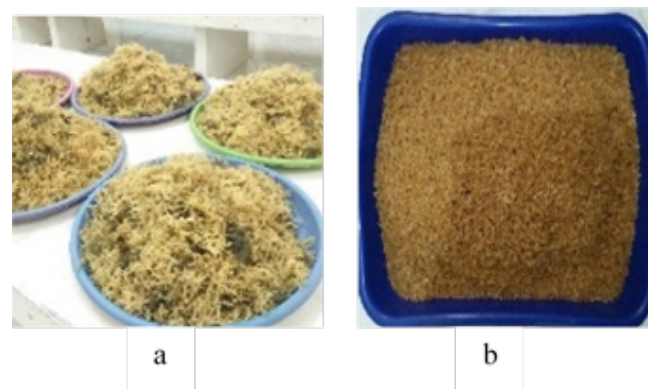


Figure 1. Raw material of seaweed; (a) wet form; (b) dry form pieces

The yield value is also known as the percentage of the product obtained, calculated by comparing the final weight with the initial weight and then multiplying it by 100%. The yield value for *K. alvarezii* seaweed after the drying and grinding process was $32.85\% \pm 1.78$ within six repetitions.

Proximate content of *K. alvarezii*

Proximate analysis includes tests for ash, water, fat, fiber, fat, protein, and carbohydrate content. Table 1 shows the results of the proximate analysis of raw seaweed *K. alvarezii* with two different treatments: seaweed dried from farmers and seaweed dried after the preparation process in the laboratory.

Table 1. Proximate content of seaweed *K. alvarezii*

Parameters	Content		
	Original dried from farmers	Preparation and dring in Laboratory	Standart
Ash (%)	14.54 ± 0.46^a	23.74 ± 0.49^b	$25.99 \pm 0.22\%$ (Kumar et al., 2022)
Moisture (%)	35.08 ± 0.17^a	12.93 ± 0.33^b	Max 38% (SNI 2690-2018)
Fiber (%)	0.10 ± 0.00^a	0.16 ± 0.00^b	$21.0 \pm 0.68\%$ (Kumar et al., 2022)
Lipid (%)	0.61 ± 0.01^a	1.13 ± 0.02^b	$0.72 \pm 0.00\%$ (Kumar et al., 2022)
Protein (%)	6.98 ± 0.22^a	7.44 ± 0.18^a	$8.92 \pm 0.41\%$ (Kumar et al., 2022)
Carbohydrate (%)	42.79 ± 0.40^a	54.75 ± 0.41^b	$22.0 \pm 0.00\%$ (K. S. Kumar et al., 2022)

Different letter marks on the same line indicate significant differences ($p < 0.05$).

Table 1 shows that the proximate content of *K. alvarezii* in the form of ash, water, fiber, fat, protein, and carbohydrate content in prepared seaweed is higher than the content of seaweed obtained from farmers, namely 23.74%; 12.93%; 0.16%; 1.13%; 7.44% and 54.75%.

Characteristics of carrageenan

Characterization of carrageenan produced from seaweed (*K. alvarezii*) extraction in this study, namely yield and water content.

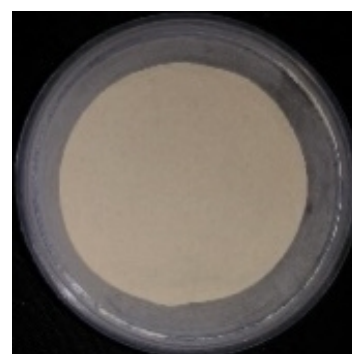


Figure 2. Carrageenan extract form seaweed *K. alvarezii*

The yield value produced in this research was 39.13%, while the moisture in carrageenan was 9.68%. Carrageenan extracted from *K. alvarezii* seaweed from Sumenep seawaters can be seen in Figure 2. The carrageenan yield value in this study was 39.13%, so it has met FAO requirements, namely >25%. The yield in this study was still higher compared to the study (Vairappan et al., 2014) with sun drying treatment, which obtained a carrageenan yield of 28%. Other research suggests that the carrageenan yield in *Kappaphycus alvarezii* is 30% (de Faria et al., 2014). Environmental factors such as the

habitat in which seaweed is grown, preparation and drying, extraction methods and solvents used will affect the quality of carrageenan (Kumalaningrum et al., 2025; Tahliluddin et al., 2025; Wakibia et al., 2006).

Characteristics of Edible Film

This research characterized edible films by conducting a thickness test, a water solubility test, a water vapor transmission rate test, an elongation test, and a tensile strength test. Figure 3 shows edible film produced from *K. alvarezii* seaweed carrageenan.

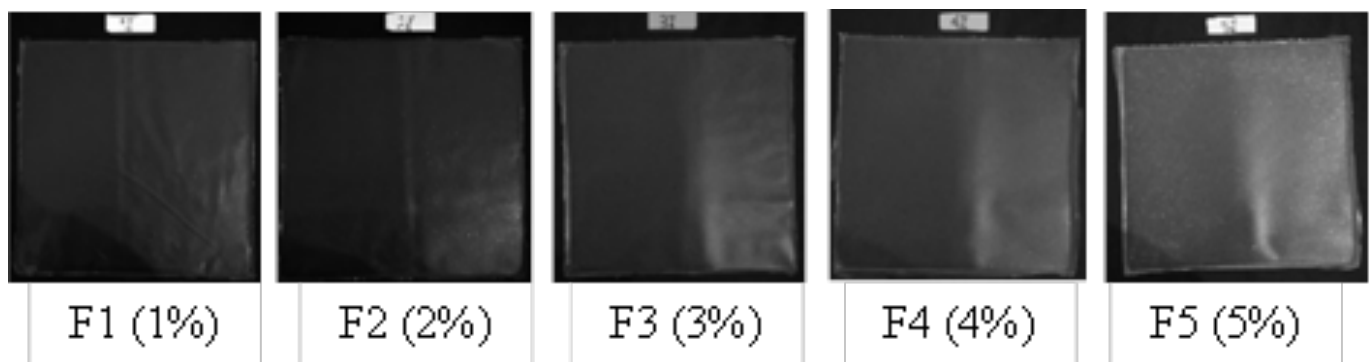


Figure 3. Edible film from carrageenan extract seaweed *K. alvarezii*

Thickness of Edible Film

The thickness test is one of the physical observations of edible film. It is essential in determining its suitability as a packaging material for food products and influences other film characteristics, namely tensile strength and elongation (Arham et al., 2016). The results of the edible film thickness test can be seen in Figure 4.

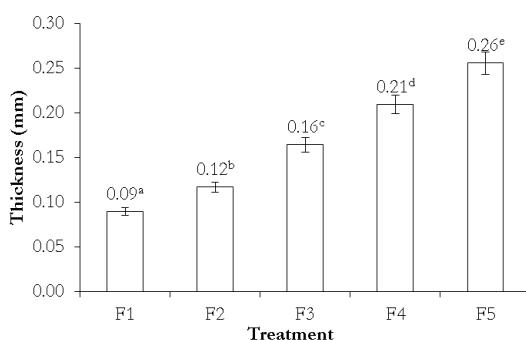


Figure 4. The thickness of edible film from carrageenan extract of seaweed *K. alvarezii*; Different superscripts showed a significant difference ($p < 0.05$)

Water Solubility

Water solubility is important parameter for edible film since it represents how the film changes in the water. The water solubility test is the ability of edible film to dissolve in water for 24 hours, which is shown

in the percentage value of the difference between the initial weight of the film before it is dissolved and the final weight after the film is dissolved (Susilowati and Lestari, 2019). Edible films with the lowest and highest water solubility values in this study were F5 and F2 with carrageenan extract concentrations of 5% and 2%, 41.01%, and 60.43%. The water solubility value of *K. alvarezii* seaweed edible film originating from Sumenep waters can be seen in Figure 5.

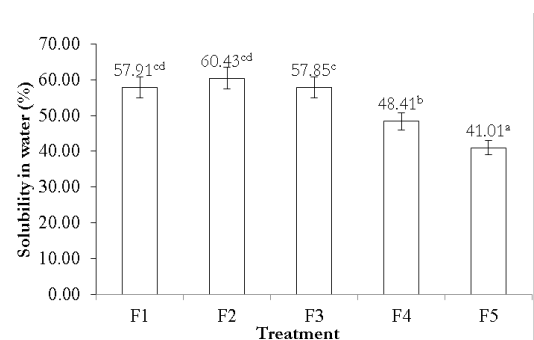


Figure 5. Solubility in water of edible film from carrageenan extract of seaweed *K. alvarezii*; Different superscripts showed a significant difference ($p < 0.05$)

Water Vapor Transmission Rate

The water vapor transmission rate test is carried out by measuring the ease with which water vapor

can pass through a material without considering the thickness of the material and the difference in air pressure inside and outside the material (Pudjiastuti et al., 2013). The results of the water vapor transmission rate test on edible film from *K. alvarezii* seaweed carrageenan data are seen in Figure 6.

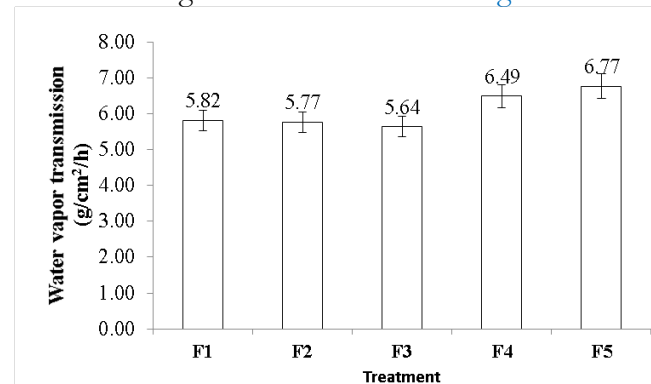


Figure 6. Water vapor transmission rate of edible film carrageenan extract of seaweed *K. alvarezii*

Elongation

The elongation or elongation test is the increase in the maximum length of the edible film from before it breaks due to the pulling process. The higher the elongation value of the film, the better the elasticity of the edible film because it does not tear easily when given a load (Qotimah et al., 2020). The results of the edible film elongation test from *K. alvarezii* seaweed carrageenan can be seen in Figure 7.

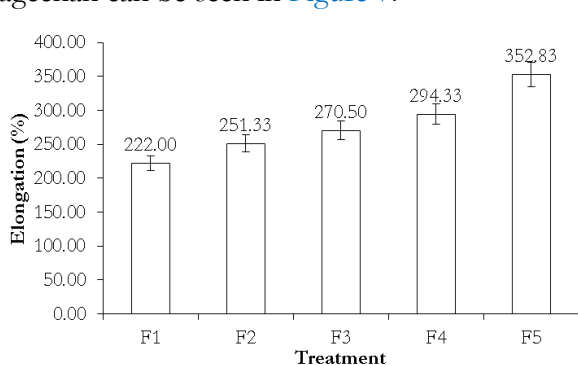


Figure 7. Elongation of edible film from carrageenan extract of seaweed *K. alvarezii*

Tensile Strength

The tensile strength test is the ability of a material to accept a maximum load or tensile force until it breaks (Suwarda et al., 2019). The results of the edible film elongation test from *K. alvarezii* seaweed carrageenan can be seen in Figure 8.

Discussion

Characteristics of seaweed *K. alvarezii*

Seaweed *K. alvarezii* is a type of red seaweed. Figure 1 shows that *K. alvarezii* from Sumenep in dried form has the characteristics of yellowish-green color, a blunt thallus tip, and a soft surface. This is in

accordance with the study that The thalli are cylindrical, soft, and pulpy, with irregular alternate branches that are strongly constricted at the base (Rajasulochana et al., 2011; Yan et al., 2023).

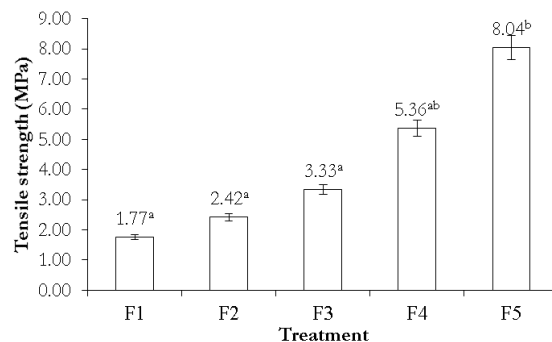


Figure 8. Tensile strength of edible film from carrageenan extract of seaweed *K. alvarezii*; Different superscripts showed a significant difference ($p < 0.05$)

Figure 1 also shows *K. alvarezii* seaweed that has been made into flour after drying with a flour yield of $32.85\% \pm 1.78$. This flour yield is slightly different from several previous research results (Periyasamy et al., 2014; Sani et al., 2023). This is caused by several factors, namely the water content and other chemical components in the material, other factors, namely environmental influences, harvest age, habitat and impurities carried during harvest.

The water content influences the yield value of raw material in the material (Azzahra, 2022). The yield value of a material is correlated with the nutrients and chemical elements, as well as the bioactive content contained therein, including carrageenan in seaweed. Senduk et al., (2020) stated that the higher the yield value, the greater the substance content in a material. Kuswurjanto and Triantarti, (2015) said that the yield value of seaweed is influenced by the quality of the raw material, harvest age, habitat, and the amount of adhering impurities.

Proximate content of *K. alvarezii*

The results (table 1) are inversely proportional to the water content of seaweed. Seaweed that has been prepared has a lower water content than that obtained from farmers, namely 12.93%. The preparation and drying processes cause this difference. The long drying process carried out after preparation causes high water evaporation from the seaweed material, thus making the water content in the material smaller.

Ash content is a mineral component other than organic compounds contained in materials (Bagau et al., 2023). The results of the analysis of the ash content of seaweed (*K. alvarezii*) obtained from drying farmers and those that went through the preparation

process can be seen in Table 1. The ash content of seaweed from drying farmers and seaweed that has undergone the preparation process is 14.54% and 23.74%. Based on the results of the t-test on seaweed ash content showed that there was a significant difference ($p < 0.05$) in the two treatments. The water content influences the high ash content in the prepared seaweed in the sample. The smaller the water content in the sample, the higher the ash content. Drying causes the water content in the material to evaporate so that the remaining chemical content becomes a high percentage.

The ash content value in this study was lower than in the study of (Nosa et al., 2020) and (Syafitri et al., 2022), namely 38.63% and 24.74%, and higher than research by (Fatriyanti et al., 2022), namely 3.04%. Differences in seaweed ash content in various studies are due to several factors, namely the drying process (Bagau et al., 2023); other factors include the type of seaweed, the content of chemical compounds in the material, and the availability of mineral elements in the aquatic environment that are absorbed in the seaweed ((Nosa et al., 2020).

Moisture is the largest constituent of fishery products, including seaweed (*K. alvarezii*). The results of measuring the moisture in seaweed can be seen in Table 1. The moisture of seaweed from drying by farmers and seaweed that has undergone the preparation process is 35.08% and 12.93%. The t-test results on the water content of *K. alvarezii* seaweed from Sumenep waters showed a significant difference ($p < 0.05$) in the two treatments. Preparation and drying treatments are the most critical factors in determining water content. Temperature and drying time cause the water content in different materials. Weather conditions during drying also affect the water content produced. The particle size of the material also has an effect; the smaller the particle size, the faster the evaporation process will be.

The moisture of this seaweed still meets the quality requirements for dried seaweed in SNI 2690-2018, namely a maximum of 38%. The drying process carried out in the laboratory provides better water content values, this will be useful for maintaining quality during storage and during the carrageenan extraction process. The moisture in this study was lower than in the study by (Safia et al., 2020) and (Fatriyanti et al., 2022), namely 38.00% and 38.86%, and higher than the research from (Masrikhiyah, 2021), which ranged from 7.45-8.06%. The moisture of seaweed is influenced by environmental conditions, temperature, humidity, storage time, and drying method and time (Syafitri et

al., 2022). Daud et al., (2019) added that the particle size of the material also influences the drying process; the smaller the size of the material article, the faster the evaporation process, thereby quickly reducing the water content.

The fiber content of seaweed (*K. alvarezii*) obtained from farmers and has undergone a preparation process is 0.10% and 0.16%. The t-test results on seaweed fiber content showed significant differences ($p < 0.05$) in the two treatments. The difference in fiber content is caused by differences in the water content of the material; the lower the water content in the material, the higher the other components, including the fiber.

The fiber content in this study was lower than in the study by Safia et al., (2020) and Syafitri et al., (2022), namely 2.82% and 0.31%. Shafwan et al., (2018) stated that the drying time is directly proportional to the fiber content value; the longer the drying time, the water content will decrease so that it can increase the fiber content. Different fiber content is also influenced by several other factors, namely temperature, salinity, and seaweed habitat (Orilda et al., 2021); season influences the photosynthesis process, and fiber formation in seaweed (Herliany et al., 2023).

The fat content of seaweed (*K. alvarezii*) obtained from farmers and has undergone a preparation process is 0.61% and 1.13%. The t-test results on seaweed fat content showed significant differences ($p < 0.05$) in the two treatments. Differences in fat content are influenced by other nutritional content, especially water content. The lower the water content in the material, the higher the other nutritional components, including the fat content.

The fat content value in this study is lower compared to research by Masrikhiyah (2021) and Orilda et al., (2021), which ranges between 3.33-3.38% and 2.23-3.65%, and is higher than the research of (Yanuarti et al., 2017); Safia et al., (2020) and (Dean et al., 2023), namely 0.58%; 0.36% and 0.56%. The fat content in seaweed in this study was relatively low; this is to the statement of Nosa et al., (2020), namely that seaweed is not rich in fat content, ranging from 0.9-4%. The low-fat content is because seaweed generally stores food reserves in polysaccharides, so its content is low (Yanuarti et al., 2017). Fat content has an inverse relationship with water content, according to the statement of Dean et al., (2023), namely that low water content causes the fat content of the material to be higher. Differences also influence the value of fat content in seaweed in harvest age and weather conditions when seaweed cultivation occurs (Nosa et al., 2020).

The protein content of seaweed (*K. alvarezii*) obtained from farmers undergoing the preparation process is 6.98% and 7.44%. The t-test results on seaweed protein levels showed no significant differences ($p > 0.05$) between the two treatments. The protein content value in this study was lower than the research by Kumar et al., (2015), namely 19.25%, and higher than the research by Yanuarti et al., (2017) and Syafitri et al., (2022), namely 1.02% and 0.27%. Nosa et al., (2020) stated that the value of protein content in seaweed is influenced by differences in harvest age and weather conditions, type, and season period; seaweed has a low protein content value during summer or dry season cultivation (Mišurcová, 2011). Masrikhiyah (2021) added that the nutrients in the water cause the difference in protein content in seaweed.

The carbohydrate content of seaweed (*K. alvarezii*) obtained from farmers who have undergone the preparation process is 42.79% and 54.75%. The t-test results showed significant differences ($p < 0.05$) in the two treatments. These differences are influenced by other proximate levels, namely water, ash, protein, fat, and fiber. The carbohydrate value is obtained from the difference in the total nutritional value of the ingredients minus the measured nutritional content.

Carbohydrate levels in this study were lower than in the study by Orilda et al., (2021); Syafitri et al., (2022) and Fatriyanti et al., (2022), which ranges from 56.85-64.26%; 58.54% and 55.29%, and higher compared to research by Safia et al., (2020); Nosa et al., (2020), namely 25.50% and 32.47%. Dean et al., (2023) stated that seaweed carbohydrate content is influenced by several factors, namely habitat, cultivation techniques, environmental conditions, processing methods, and harvest age. Masrikhiyah (2021) states that differences in habitat cause differences in seaweed's polysaccharide or carbohydrate content.

Characteristics of carrageenan

The yield value in this research is lower than the research (Ega, 2016), namely 45.26%, and higher than the Mappiratu (2014) research, ranging from 26.17 to 33.53%. The yield of carrageenan is influenced by environmental conditions or habitat, type, age of harvest, temperature, and length of time for extracting seaweed in the process of making carrageenan; the age of harvesting seaweed to produce a good yield of carrageenan is a seaweed that is cultivated for a minimum of 45 days (Kumayanjati and Dwimayasanti, 2018). The yield value increases as the alkaline solvent concentration increases; this is because the alkaline concentration will cause the

melting point of the seaweed to increase so that less extract dissolves during the heating process (Saputra et al., 2021).

According to the Food and Agriculture Organization (FAO) in Saputra et al., (2021), the excellent water content value for carrageenan is a maximum of 12%. The water content value of carrageenan in this study was 9.68%, so it meets FAO requirements. The water content value in this study is lower than the Mappiratu (2014) research and Asikin and Kusumaningrum (2019) research, namely ranging from 10.79-11.38% and 10.58-13.82%, and higher than Ega's (2016) research. was 9.23%, and research by Kumayanjati and Dwimayasanti (2018) showed 2.54-4.85%. The age of harvest influences the water content of seaweed carrageenan; the longer the age of harvest, the higher the water content value of the carrageenan produced (Asikin and Kusumaningrum, 2019). Moreover, the drying process also affects the water content of carrageenan; this is in line with the results reported by Kumayanjati and Dwimayasanti (2018), finding that different drying processes markedly affect water content. In addition, the original properties of materials are also important factors contributing to drying behaviors.

Thickness of Edible Film

The lowest and highest edible film thickness values in this study were found in F1 and F5 with carrageenan extract concentrations of 1% and 5%, namely 0.09 mm and 0.26 mm. According to the Japanese Industrial Standard (JIS) 1975 in Warkoyo et al., (2022), good edible film thickness values, namely a maximum of 0.25 mm. The thickness value of the *K. alvarezii* seaweed edible film meets JIS requirements. The analysis of variance (ANOVA) shows an authentic influence of the concentration of carrageenan extract on the thickness value of edible film at the 95% confidence level. Further, DMRT tests showed significantly different values for all treatments (Figure 4); the higher the concentration of carrageenan extract, the higher the edible film thickness value. Carrageenan is a hydrocolloid that can form a gel when heated and form a film or polymer when it binds with water (Warkoyo et al., 2014).

The results of the edible film thickness test in this study were smaller than those in the research of Setyaji et al., (2019), which ranges from 0.21 to 0.36 mm, and more significant than the research of Rusli et al., (2017) and Indarti et al., (2022) which ranges between 0.04-0.09 mm and 0.06-0.07 mm. The thickness value of edible film increases as the concentration of carrageenan extract increases; this is

caused by an increase in the polymer that makes up the film framework and the total dissolved substances in making edible film (Warkoyo et al., 2014). Rusli et al., (2017) stated that edible film has a thin thickness, but the ability to protect food ingredients well is a factor in its suitability.

Water Solubility

The results of the analysis of variance (ANOVA) show that there is a significant effect ($p < 0.05$) of the concentration treatment of carrageenan extract on the solubility value in water. The results of further DMRT tests showed that there were significant differences in the added concentration of F3 (3%), F4 (4%), and F5 (5%) carrageenan extract with values of 57.85%, 48.41%, and 41.01%, respectively. However, it is not significantly different in F1 (1%) and F2 (2%), with values of 57.91% and 60.43%. The difference in solubility of edible film in water is due to the high and low levels of minerals, mainly inorganic, in the edible film; the higher the concentration of carrageenan used, the higher the mineral impurities included in the edible film, so the solubility in water is reduced.

The results of the water solubility test in this study were smaller than those in the research of Rusli et al., (2017), Setyaji et al., (2019), and Indarti et al., (2022), which ranges from 60.51-74.20%, 45.43-88.35% and 84.71-85.43%. The high solubility of edible film can cause edible film to dissolve easily in water, safe to consume but not resistant to water (Indarti et al., 2022). The best treatment based on water solubility characteristics is F2 with 2% or 2 grams of carrageenan extract.

Water Vapor Transmission Rate

Edible films with the lowest and highest water vapor transmission rate values in this study were F3 and F5, with carrageenan extract concentrations of 3% and 5. %, namely 5.64 g/cm²/hour and 6.77 g/cm²/h and is in accordance with JIS requirements. The value of a good edible film water vapor transmission rate according to the Japanese Industrial Standard (JIS) 1975 in Warkoyo et al., (2022) is a maximum of 10 g/cm²/h. The results of the analysis of variance (ANOVA) showed that there was no significant effect ($p > 0.05$) of the concentration of carrageenan extract treatment on the elongation value.

The results of the water vapor transmission rate test in this study were smaller than those in the research of Setyaji et al., (2019), which ranges from 5.83-14.39 g/cm²/hour, and more significant than the research of Togas et al., (2017), which ranges from 2.53-3.86 g/cm²/hour. Edible film with lower water vapor transmission values is recommended; Setyaji et

al., (2019) stated that a small water vapor transmission rate value shows that edible film can protect food from water vapor entering the environment so that the product can last longer. Santoso et al., (2012) explained that the hydrophilic component, which is higher than the hydrophobic component, is the main factor causing edible film's high water vapor transmission rate value. Other influencing factors are the structure of the edible film (homogeneity and emulsion or a mixture of two liquids that cannot be combined), crystal type, shape and size, and fat distribution.

Elongation

Edible films with the lowest and highest elongation values were found in F1 and F5 with carrageenan extract concentrations of 1% and 5%, namely 222% and 352.83%, and were by JIS requirements. The higher the concentration of carrageenan, the higher the elongation test value. The excellent elongation value of the edible film, according to the Japanese Industrial Standard (JIS) 1975 in Warkoyo et al., (2022), is $> 50\%$. The results of the analysis of variance (ANOVA) showed that there was no significant effect ($p > 0.05$) of the concentration of carrageenan extract on the elongation value (Figure 7). The higher the concentration of carrageenan, the higher the edible film elongation test value; this is due to the nature of carrageenan, which is in the form of a polymer when it binds with water and forms a film.

The elongation test results in this study were greater than those in the studies by Rusli et al., (2017) and Setyaji et al., (2019), which range between 10.61-18.67% and 7.74-28.66%. Edible film with higher elongation values is recommended because it shows that the edible film is more elastic and does not tear easily when loaded (Qotimah et al., 2020).

Tensile Strength

Edible films with the lowest and highest tensile strength values were found in F1 and F5 with carrageenan extract concentrations of 1% and 5%, namely 1.77 MPa and 8.04 MPa. The tensile strength value of edible film according to the Japanese Industrial Standard (JIS) 1975 in Warkoyo et al., (2022) is a minimum of 0.392 MPa. The tensile strength value of edible film produced with several concentrations of carrageenan extract ranges from 1.77 to 8.04 MPa, so it meets JIS requirements. The results of the analysis of variance (ANOVA) showed that there was a very significant effect ($p < 0.05$) of the concentration of carrageenan extract on the tensile strength value. DMRT further test results showed that when adding the concentration of F5 (5%) carrageenan extract with a value of 8.04 MPa, there

was a significant difference with F1 (1%), F2 (2%), and F3 (3%) with values of 1, respectively. 77 MPa, 2.42 MPa, and 3.33 MPa, but not significantly different from F4 (4%) with a value of 5.36; this is because there is molecular binding between the edible film constituents, namely water and the hydrocolloid compounds in the carrageenan extract.

This study's tensile strength test results were smaller than those in Rani and Kalsum's (2016) research, ranging from 6.83-12.99 MPa, and greater than those in Rusli et al., (2017) research, which ranges from 4.17-6.66 MPa. The higher the tensile strength value, the better the ability of the edible film as a protective layer for the product. The higher concentration of carrageenan extract increases the tensile strength value of the edible film; this is influenced by the bonds between the molecules that make up the edible film so that it forms a more robust film framework and the force to break. Edible film is getting bigger (Rusli et al., 2017). Safitri et al., (2020) stated that the greater the tensile strength value, the more excellent the resistance to damage due to strain and pressure.

Conclusion

The chemical characteristics of seaweed harvested from Sumenep seawaters used for making edible film were as follows: ash content 14.54-23.74%; water content 12.93-35.08%; fiber content 0.10-0.16%; fat content 0.61-1.13%; protein content 6.98-7.44% and carbohydrate content 42.79-54.75%. The proximate content of *K. alvarezii* dried by farmers were significantly different from that dried in the laboratory. Although the addition of carrageenan extract showed a considerable impact on the characteristics of edible film in terms of thickness, solubility in water, and tensile strength, it did not affect water vapor transmission rate and elongation characteristics. The best formulation for making edible film with seaweed carrageenan extract (*K. alvarezii*) from Sumenep seawaters is F2 with the addition of 2% carrageenan extract (2 g) with a characteristic thickness of 0.12 mm; solubility in water 60.43%; water vapor transmission rate 5.77%; elongation 251.33% and tensile strength 2.42 MPa. Edible film from carrageenan extract from *K. alvarezii* seaweed from Sumenep waters has the potential to be developed and applied in the food and non-food sectors in the future.

References

Akbar, S. A., A. Mustari. 2024. Food packaging based on biodegradable polymers from seaweeds: a systematic review. *BIO Web of Conferences*, 87: 01005.

- Akbar, S. A., M. Hasan. 2024. Evaluation of bioactive composition and phytochemical profile of macroalgae *Gracilaria edulis* and *Acanthophora spicifera* from the Banda Aceh Coast, Indonesia. *Science & Technology Asia*, 29(1): 194–207.
- Arham, R., M. T. Mulyati, M. Metusalach, S. Salengke. 2016. Physical and mechanical properties of agar based edible film with glycerol plasticizer. *International Food Research Journal* 23(4):1669-1675.
- Asikin, A.N., I. Kusumaningrum. 2019. Physicochemical Characteristics of Carrageenan Based on Different Harvesting Times From Bontang Coastal, East Kalimantan. *Jurnal Pengolahan Hasil Perikanan Indonesia* 22(1):136-142.
- Azzahra, F. 2022. Determination of yield and chemical content of katuk leaf extract (*Saururus androgynus* (L.) Merr.) based on different drying methods. *Sasambo Journal of Pharmacy* 3(2):83-90.
- Bagau, B., S.A.E. Moningkey, S.P. Pangemanan. 2023. Effect of storage time on moisture content, ash, and organic matter of corn straw complete feed wafers. *Jambura Journal of Animal Science*, 5(2):71-76.
- Daud, A., Suriati, Nuzulyanti. 2019. Study of the application of factors that influence the accuracy of determining water content using the thermogravimetric method. *LuTjanus*, 24(2):11-16.
- Dean, C., Sunadji, M.D.R. Oedjoe. 2023. Kandungan nutrisi dan karaginan rumput laut (*Kappaphycus alvarezii*) dari perairan Semau Kabupaten Kupang. *Jurnal Vokasi Ilmu-Ilmu Perikanan (JVIP)*, 4(1):11-18.
- de Faria, G. S. M., Hayashi, L., & Monteiro, A. R. (2014). Effect of drying temperature on carrageenan yield and quality of *Kappaphycus alvarezii* (Rhodophyta, Solieriaceae) cultivated in Brazil. *Journal of Applied Phycology*, 26(2), 917–922.
- Ega, L., C.G.C. Lopulalan, F. Meiyasa. 2016. Study of seaweed (*Eucheuma cottonii*) carrageenan quality based on physicochemical properties by extraction using different potassium hydroxide (KOH). *Jurnal Aplikasi Teknologi Pangan*, 5(2):38-44.
- Fardhyanti, D.S., S.S. Julianur. 2015. Characterization of edible film based on carrageenan extract from seaweed (*Eucheuma cottonii*). *Jurnal Bahan Alam Terbarukan*, 4(2):68-73.
- Fatmawati, I., D. Wahyudi. 2016. Seaweed potential in Sumenep Regency. *Jurnal Pertanian Cemara*, 12(1):1-9.
- Fatriyanti, D., Warsidah, M.S.J. Sofiana, S. Helena. 2022. Analysis of proximate and zinc mineral from macroalgae *Eucheuma cottonii* of Lemukuta. *Oceanologia*, 1(1):28-32.
- Herliany, N.E., M.A.F. Utami, M.D. Wilopo, D. Purnama, Y. Johan, Zamdial, N. Permatasari. 2023. Nutritional composition of brown (Phaeophyta) and red (Rhodophyta) seaweed from Sepang Bay waters, Bengkulu City. *Jurnal Enggano*, 8(2):147-153.
- Indarti, E., M.N. Zara, A. Srimarlita, B.M. Nur. 2022. Edible film characteristics of seaweed (*Eucheuma cottonii*) with variety of concentrations. *Jurnal Teknologi Pengolahan Pertanian*, 4(1):34-39.
- Jazuli, J., R. Ninsix. 2015. The effect of adding seaweed as a thickener on the characteristics of papaya sauce. *Jurnal Teknologi Pertanian*, 4(2):42–49.
- Kementerian Kelautan dan Perikanan. 2022. Data kelautan dan perikanan triwulan IV tahun 2022. Pusat Data, Statistik Dan Informasi. Sekretariat Jenderal Kementerian Kelautan Dan Perikanan, April:1–4.
- Kumar, S.K., K. Ganesan, R.P.V. Subba. 2015. Seasonal variation in nutritional composition of *Kappaphycus alvarezii* (Doty) Doty—an edible seaweed. *Journal of Food Science and Technology*, 52(5):2751-2760.
- Kumayanjati, B., R. Dwimayasanti. 2018. The Quality of carrageenan from *Kappaphycus alvarezii* seaweed at different locations in Southeast Maluku waters. *Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan*, 13(1):21-32.
- Kuswurjanto, R., Triantarti. 2015. Individual cane yield analysis using Near Infrared Spectroscopy (Nirs) to support the increase of sugar production. *Prosiding Seminar Nasional "Swasembada Pangan"*:154-160.
- Laksanawati, R., U. Ustadi, A. Husni. 2017. Development of alginate extraction method from seaweed *Turbinaria ornata*. *Jurnal Pengolahan Hasil Perikanan Indonesia*, 20(2):362-369.
- Mappiratu. 2014. Study of carrageenan processing technology from

- Eucheuma cottonii* seaweed on a household scale. Jurnal Litbang, 2(1):1-6.
- Masrikhiyah, R. 2021. Antioxidant activity and total phenolic of seaweed *Gracilaria* sp. from Brebes. Jurnal Pengolahan Hasil Perikanan Indonesia, 24(2):236-242.
- Mišurcová, L. 2011. Chemical Composition of Seaweeds. Handbook of Marine Macroalgae: Biotechnology and Applied Phycology, January:171-192.
- Nasution, R.S., M.R. Harahap, Yahya, H. 2019. Edible film from carrageenan (*Eucheuma cottonii*) from Aceh, Indonesia: characterization by FTIR and SEM. Elkawnie, 5(2):188-197.
- Nosa, S.P., K. Rahman, D. Andarini. 2020. Potential of kappa carrageenan seaweed (*Eucheuma cottonii*) as an antioxidant and inhibitor of α -glucosidase enzyme. Berkala Perikanan Terubuk, 48(2):1-10.
- Novianti, S., A. Arisandi. 2021. Analysis concentration levels of fat, protein, fiber and carbohydrates brown algae (*Sargassum crassifolium*) at different locations. Juvenil:Jurnal Ilmiah Kelautan Dan Perikanan, 2(1):32-38.
- Nurdin, W.N., K. Sari, N.R.A. Mahmud. 2022. Synthesis of bioplastics from seaweed (*Eucheuma cottonii*) in Kupang City. Jurnal Aquatik, 5(2):205-216.
- Nurjanah, S. Fauziyah, A. Abdullah. 2019. Characteristic of seaweed porridge *Eucheuma cottonii* and *Turbinaria conoides* as raw peel off mask. Jurnal Pengolahan Hasil Perikanan Indonesia, 22(2):391-402.
- Orilda, R., B. Ibrahim, Uju. 2021. *Eucheuma cottonii* seaweed drying used an oven at different temperature. Jurnal Perikanan Terpadu, 2(2):11-23.
- Periyasamy, C., Anantharaman, P., Balasubramanian, T., & Rao, P. V. S. (2014). Seasonal variation in growth and carrageenan yield in cultivated *Kappaphycus alvarezii* (Doty) Doty on the coastal waters of Ramanathapuram district, Tamil Nadu. *Journal of Applied Phycology*, 26(2), 803 – 810.
- Pudjiastuti, W., A. Listyarini, I.R. Muhammad. 2013. Effect of water vapour transmission rate of polymer blend of polybutylene succinat (Pbs) and linear low density polyethylene (Lldpe) on the self life of cream soup instant rasi. J. Kimia Kemasan, 35(1):1-5.
- Qotimah, K., E.N. Dewi, L. Purnamayati. 2020. Quality of carrageenan edible film with addition of garlic (*Allium sativum*) essential oil. Jurnal Pengolahan Hasil Perikanan Indonesia, 23(1):1-9.
- Rajasulochana, P., Krishnamoorthy, P., & Dhamotharan, R. (2011). Morphological characteristics and estimation of β -carotene of the experimental red algae. *International Journal of Pharmacy and Technology*, 3(4), 3726 – 3734.
- Rani, H., N. Kalsum. 2016. The study of proses edible film making of sea grass *Gracilaria* sp. with glyserol addition. Prosiding Seminar Nasional Pengembangan Teknologi Pertanian:219-225.
- Ruku, R.M., A.G. Kase, H.R. Solle. 2021. Carrageenan extract of seaweed (*Eucheuma cottonii*) obtained from Tablolong Beach, Kupang Regency. Indigenous Biologi: Jurnal Pendidikan Dan Sains Biologi, 3(3):119-127.
- Rusli, A., M. Metusalach, M.M. Tahir. 2017. Characterization of carrageenan edible films plasticized with glycerol. Jurnal Pengolahan Hasil Perikanan Indonesia, 20(2):219-229.
- Safia, W., Budiyanti, Misrif. 2020. Nutrition and bioactive compound of seaweed (*Eucheuma cottonii*) with hanging raft method at different depths. Jurnal Pengolahan Hasil Perikanan Indonesia, 23(2):261-271.
- Safitri, E. L. D., Warkoyo, R. Anggriani. 2020. Study of physical and mechanical characteristics of edible film based on suweg tuber starch (*Amorphophallus paeoniifolius*) with varying concentrations of beeswax. Food Technology and Halal Science Journal, 3(1), 57-70.
- Salam, M.R.B., D. Larasati. 2013. Utilization of seaweed material through carrageenan extraction for edible packaging design. Jurnal Tingkat Sarjana Senirupa Dan Desain, 3(1):1-9.
- Sani, C. S., Oedjoe, M. D. R., & Turupadang, W. (2023). Analysis of yield and types of carrageenan from different strains at Kupang Bay seaweed production center, East Nusa Tenggara. *IOP Conference Series: Earth and Environmental Science*, 1220(1).
- Santoso, B., F. Pratama, B. Hamzah, R. Pambayun. 2012. Improving the mechanical and water vapour transmission rate properties of edible film from modified ganyong starch by using beeswax and surfactants. Agritech, 32(1):9-14.
- Saputra, S.A., M. Yulian, K. Nisah. 2021. Characteristics and quality of seaweed carrageenan in Indonesia. Lantanida Journal, 9(1):26-37.
- Saragih, I.A., F. Restuhadi, E. Rossi. 2016. Kappa carrageenan as basic component for edible film maker with addition of corns starch (maizena). Jurnal Jom Faperta, 3(1):1-12.
- Saraswati, S.A., L.N.L. Toruan, A.A. Ayubi, R.H. Kristiani, G.A. Malelak. 2022. Chemical and organoleptic characteristics of dried seaweed (*Eucheuma cottonii*). Jurnal Bahari Papadak, 3(1):167-171.
- Senduk, T.W., L.A.D.Y. Montolalu, V. Dotulong. 2020. The rendement of boiled water extract of mature leaves of mangrove *Sonneratia alba*. Jurnal Perikanan Dan Kelautan Tropis, 11(1):9-15.
- Setyaji, A., I. Wijayanti, R. Romadhon. 2019. Effect of carrageenan addition to the edible characteristics of Tilapia skin gelatin film (*Oreochromis niloticus*). Jurnal Ilmu Pangan Dan Hasil Pertanian, 2(2):134-145.
- Shafwan, M.A., N.K. Sari, N.P. Putri. 2018. Characterization of seaweed *Eucheuma cottonii*. Prosiding Seminar Nasional Teknologi, Inovasi Dan Aplikasi Di Lingkungan Tropis, 1(1):15-18.
- SNI. (1992). SNI 01-2891-1992: How to test food and drinks. SNI (Satandar Nasional Indonesia), 01-2891-19:1-36.
- SNI. (2018). SNI 2690-2018: Dried Seaweed. Badan Standarisasi Nasional.
- Sopina, E., V. Dotulong, R. I. Montolalu. 2017. Carrageenan quality and gel strength of red seaweed *Kappaphycus alvarezii*. Media Teknologi Hasil Perikanan, 5(2):36-39.
- Susilowati, E., A.E. Lestari. 2019. Preparation and characterization of chitosan-avocado seed starch (KIT-PBA) edible film. JKPK (Jurnal Kimia Dan Pendidikan Kimia), 4(3):197-204.
- Suwarda, R., T.T. Irawadi, P. Suryadarma, I. Yuliasih. 2019. Stability of sago (*Metroxylon sagu* Rottb.) starch acetate edible film during storage under various temperatures. Jurnal Teknologi Industri Pertanian, 29(2):278-289.
- Syafitri, T., Hafiludin, A.B. Chandra. 2022. Utilization of *Eucheuma cottonii* extracts from Sumenep seawaters as antioxidants. Jurnal Kelautan: Indonesian Journal of Marine Science and Technology, 15(2):160-168.
- Togas, C., S. Berhimpon, R.I. Montolalu, H.A. Dien, F. Mentang. 2017. Physical Characteristics of Edible Film made from Carrageenan and Beeswax Composites through Nanoemulsion Process. Jurnal Pengolahan Hasil Perikanan Indonesia, 20(3):468-477.
- Uju, J. Santoso, W. Ramadhan, M.F. Abrory. 2018. Extraction of native agar from *Gracilaria* sp with ultrasonic acceleration at low temperature. Jurnal Pengolahan Hasil Perikanan Indonesia, 21(3):414-422.
- Vairappan, C. S., Razalie, R., Elias, U. M., & Ramachandram, T. (2014). Effects of improved post-harvest handling on the chemical constituents and quality of carrageenan in red alga, *Kappaphycus alvarezii* Doty. *Journal of Applied Phycology*, 26(2), 909 – 916.
- Violisa, A., A. Nyoto, N. Nurjanah. 2012. Use of seaweed as a stabilizer for soy milk ice cream. Teknologi Dan Kejuruan, 35(1):103-114.
- Warkoyo, B. Rahardjo, D.W. Marseno, J.N.W. Karyadi. 2014. Physical, mechanical and barrier properties of *Xanthosoma sagittifolium* starch-based edible film incorporated with *Potassium sorbate*. AGRITECH, 34(1):72-81.
- Warkoyo, W., M.A. Haris, V.A. Wahyudi. 2022. The physical, mechanical, barrier characteristics, and application of edible film from yellow sweet potato and aloe vera gel. AGRITECH, 42(4):390-399.
- Wenno, M.R., J.L. Thenu, C.G.C. Lopulalan. 2012. Characteristics of kappa carrageenan from *Kappaphycus alvarezii* at different harvesting times. Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan, 7(1):61-67.
- Wirawan, I.D.A., A.R. Pratiwi, V.K. Ananingsih. 2017. Application of *Eucheuma cottonii* carrageenan with the addition of palm oil in making edible film. Jurnal Aplikasi Teknologi Pangan, 6(4):145-149.
- Wirawan, S.K., A. Prasetya, E. Ernie. 2012. Effect of plasticizer on the characteristics of edible film from pectin. Reaktor, 14(1):61-67.
- Yan, S.-H., Wang, X.-L., Wang, L.-J., Gu, W.-H., Xie, X.-J., Gao, S., Qiang, X., Zhuo, J.-T., Guo, M.-L., Liu, X.-H., Wang, Z.-L., &

- Wang, G.-C. (2023). A *Solieria tenuis* bloom in Langyatai Bay, Qingdao: species identification and growth investigation; *Oceanologia et Limnologia Sinica*, 54(1), 149 – 159.
- Yanuarti, R., Nurjanah, E. Anwar, G. Pratama. 2017. The content of ultraviolet ray-blocking compounds from *Eucheuma cottonii* and *Turbinaria conoides* seaweed extracts. *Biosfera*, 34(2): 51-58.
- Zahwa, A.A., F. Munasaroh, A.E. Darmawan, A.N. Adiyanto, D. Sondari, Sunarno. 2020. Edible microalgae and mangrove leaf litter films based on glycerol plasticizer as biodegradable packaging

innovation. *Jurnal Binawakya*, 15(1):3885-3898.

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