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# Proceedings of the 9th International Conference of the Indonesian Chemical Society ICICS 2021 Mataram-Lombok, West Nusa Tenggara, Indonesia

## Preface

It is a great pleasure to present to our readers the collection of research papers presented at the 9th International Conference of the Indonesian Chemical Society (ICICS) 2021. The conference was successfully held on August 11-12, 2021, in the City of Mataram, Lombok Island, Indonesia. The event was conducted online, after one year postponed, due to the Covid-19 pandemic. This conference is an ICICS series of conferences organized by the Indonesian Chemical Society (HKI) and was hosted by the University of Mataram through the Department of Chemistry and Department of Chemical Education, jointly coordinated with the Nusa Tenggara Branch of Indonesian Chemical Society.

Despite being at the pandemic's peak, ICICS 2021 successfully gathered prominent speakers, researchers, academicians, and industry practitioners from Indonesia and other countries to share their expertise. The discussion spans all main areas of chemistry and intertwining areas such as biochemical engineering, nanotechnology, computational chemistry, environmental chemistry, bio and chemoinformatics, and chemical education. The two days event brought together over 175 participants. The two days event brought together over 175 participants. There were ten plenaries and seven invited speakers from Indonesia, Japan, Malaysia, and the Philippines sharing their experiences. There were 155 oral presentations filled in the conference program.

We would like to express our appreciation and gratitude to all keynote and invited speakers, as well as all participants, for the insightful discussion. We also thank our reviewers and proofreaders for maintaining a good quality standard of the published manuscripts. We do hope that the proceedings will serve as a valuable reference and be able to stimulate further research in chemistry and interdisciplinary fields.

Editors

Lalu Rudyat Telly Savalas

Saprizal Hadisaputra

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# Production of functional edible film from modified starch of banana's hump using *Kappaphycus alvarezii* seaweed as stabilizer

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Hasnah Natsir, Brigita Lestari Merba, Seniwati Dali, et al.

# Production of Functional Edible Film from Modified Starch of Banana's Hump Using *Kappaphycus alvarezii* Seaweed as Stabilizer

Hasnah Natsir[1 a)], Brigita Lestari Merba[2)], Seniwati Dali[1)], Nunuk Hariani Soekamto[1)], Abd. Wahid Wahab[1)], and Siti Fauziah[1)]

*[1]Department of Chemistry, Mathematics and Natural Sciences Faculty, Hasanuddin University, Perintis Kemerdekaan Street Km. 10 Tamalanrea, Makassar 90245, Indonesia*
*[2]Master Program, Department of Chemistry, Faculty of Mathematics and Natural Sciences, Biochemistry Lab, Hasanuddin University, Perintis Kemerdekaan Street Km. 10 Tamalanrea Makassar 90245, Indonesia*

*[a]Corresponding author: hasnahnatsir@unhas.ac.id*

**Abstract.** This study aims to produce and analyze the characteristics of edible films from modified starch of banana's hump (*Musa Balbisina* L) and determine the stabilization effect of *Kappaphycus alvarezii* seaweed addition at various concentrationr. The core stages of this research started from the extraction and modification of banana's hump starch by autoclaving-cooling method, extraction of *K. alvarezii* seaweed as a stabilizer, making an edible film by varying the concentration of stabilizer (0.5% – 2.0%), and analysis the characteristic of functional edible films. The results showed that modified starch of banana's hump could be beneficial in producing edible films using 2% *K. alvarezii* as the best stabilizer concentration. The characteristic value of the edible film is that it has a thickness of 0.20 mm and a water vapor transmission rate of 3.15 g/24 hours m$^2$, the tensile strength of 4.30 MPa, elongation of 26.38%, and degradable in the environment for 6 days. The resulting edible film is a biodegradable packaging and edible with the product because the modified starch of the banana's hump can have added value, namely functional value for digestive health. The use of stabilizers from seaweed can also improve the mechanical and microbiological characteristics of the edible film. This research showed that modified edible film with banana's hump starch and *K. alvarezii* seaweed potential to be developed as functional plastic packaging for food.

## INTRODUCTION

Plastic is a ubiquitous packaging material because it is economical, inexpensive, and provides good protection in preservation. However, most of the plastic packaging circulating in the community is still composed of synthetic materials. The use of synthetic materials impacts environmental pollution [1], so that research on environmentally friendly packaging materials, one of the environmentally friendly packaging alternatives is an edible film [2].

The edible film is a plastic packaging formed on the product, while the edible coating is a package (liquid form) immersed in the packaged product [3]. Edible films have many advantages when compared to synthetic packaging, namely: 1. Edible film can be eaten together with the packaged product, 2. Edible film that is not consumed or disposed of into the environment can be decomposed in nature without causing environmental pollution, 3. Edible film applied to a multi-layer packaging system, 4. Edible films can function to improve the organoleptic properties of packaged foods by providing a variety of coloring, sweetener, and flavoring components that blend with food [4], 5. Edible film can serve as a nutritional supplement in food.

The characteristics possessed by edible films are generally almost the same as the characteristics of other packaging, especially plastic packaging. The characteristics possessed by edible films are thickness, tensile strength

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and elongation, water vapor transmission rate, and biodegradability. The feasibility of edible film characteristics can be measured using the standard of edible film characteristics as in Table 1.

**TABLE 1.** Characteristics Standard of edible film

| Characteristic of Edible Film | Japanese Industrial Standard |
|---|---|
| Thickness | Max 0.25 mm |
| Water Vapor Transmission Rate | Max 7 g/m$^2$/24 jam |
| Tensile Strength | 0.3 MPa |
| Elongation | 10-50% |

Source: [5]

The main components (raw materials) that make up edible films are three groups, namely hydrocolloids, fats, and composites (mixtures). The utilization of hydrocolloids in starch is very effective and efficient because it is available in large quantities, affordable, renewable, non-toxic, and easy to decompose [6].

Starch is a polymer that forms complex bonds and is composed of amylose and amylopectin components. A high amylose content will make the film more compact and robust [7] because amylose has an intricate nature and a structure. It allows hydrogen bonds to form between its constituent glucose molecules.

The starch of Banana's Hump is one type of natural starch from banana tree plant waste that can be analyzed and applied to processed starch products, as shown in Figure 1. The yellow kepok banana (*M. balbisiana* L.) is a type of banana that is effectively used as a starch source because it has a hump diameter of 0.54 m and a height of 3.75 m larger than other types of bananas [8].

**FIGURE 1.** Banana's hump

Starch can be divided into two types, namely natural starch and modified starch (modified starch). Physical modification is relatively safe for consumption because it does not use chemical reagents or leave chemical residues. Based on several studies, the autoclaving-cooling method can improve chemical properties, such as amylose content and functional properties, such as starch resistance, various varieties of campolay starch [9], and on corn-rice starch [10].

Resistant starch is a type of physically modified starch or starch that has undergone additional treatment. The most specific characteristic of resistant starch is starch that cannot be digested in the small intestine by digestive enzymes because the starch fraction is resistant to the enzyme hydrolysis process in the small intestine [11]. Resistant starch has the same physiological effect as dietary fiber, namely as a prebiotic food (a source of energy or food for probiotic bacteria) that. Based on potential of banana's hump as a natural material from waste, utilization of resistant starch, and characteristic of edible film, so that analysis of resistant starch from banana's hump as edible film material can support about utilization of resistant starch and influence for edible film characteristic.

Other additives that can improve the characteristics of edible films are plasticizers and stabilizers. Plasticizers are additional materials to manufacture edible films with specific concentrations to overcome their brittleness, breakability, and low elasticity [12]. Stabilizer functions in the formation of a smoother film surface and increases tensile strength.

The use of stabilizers from marine natural materials can support the application of natural materials from the sea, especially in Indonesia as a maritime country. *K. alvarezii* is one of the seaweeds in red algae phylum, as shown in Figure 2, and is effectively used as a stabilizer in processed chicken products [13] and an effective stabilizer with a concentration of 0.5-2% [14]. So, analysis of *K. alvarezii* concentration as an edible film stabilizer can improve some characteristic edible film, particularly in texture characteristics, like in a chicken product.

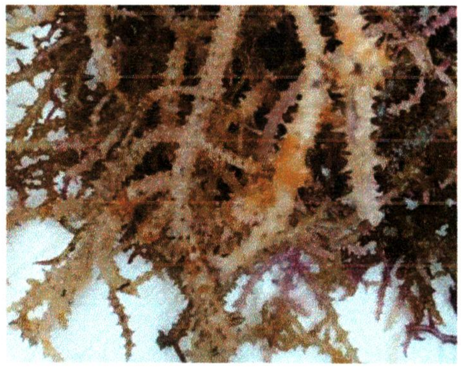

**FIGURE 2** *K alvarezii* Seaweed

# MATERIALS AND METHODS

## Materials

The materials used in the research were starch of banana's hump, sorbitol, *K alvarezii* seaweed, aquadest, sodium metabisulfite, 1 N sodium hydroxide, silica gel

## Instruments

The instruments used in the research were chemical glass 100 and 250 ml, measuring glass 100 mL, desiccator, hot plate, stirrer, petri dish cup, incubator, vernier calipers, material testing machine LR 10 K Plus

## Procedures

### *Extraction and Modification of Banana s Hump Starch by Autoclaving-Cooling Method [15]*

Kepok banana's hump was cleaned from banana bark and cut small, then it was ready milled After that, the milled result was mixed with sodium bisulfate about 1% for 2-3 minutes, then mixed with distilled water about 0 3% b/v, the mix was squeezed and separated between dregs and juice with a filter The juice was precipitated for 12 hours while combined with decantation, and the water was changed about 3 times The result was sediment that was starch extract After that, the extract was ready to be dried The extraction sample is in Fig 3

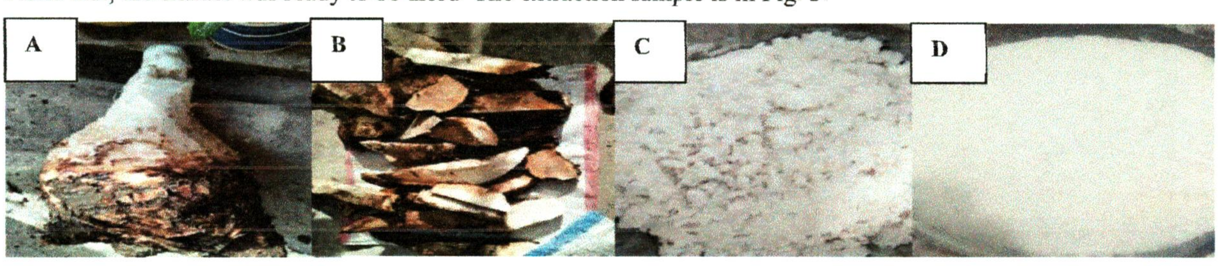


**FIGURE 3** Extraction of starch banana's hump
Note A Kepok banana s hump B Chunks of banana's hump, C Dry starch of banana s hump,
D starch filtered 100 mesh

Kepok banana's hump starch was mixed with water, by the ratio between water and starch was 20 80 The starch was readily processed in an autoclave that was given heating with high temperature (121 °C) and pressure for 15 minutes After that, the starch is stored at room temperature for 1 hour, then, it was stored at 4 °C, which was used in two cycles After that, the starch was ready to be dried by 50 °C for 4 hours

*Extraction of K alvarezii Seaweed*

The seaweed is washed until clean, cut into small pieces, and soaked with betel lime for ± one night to remove the sweet smell and become softer The seaweed is soaked in hot water, blended, and boiled with a ratio of seaweed weight and water volume of 1 2 for 20 minutes In the last stage, the seaweed is cooled until a seaweed gel is obtained

*Making of Functional Edible Film (Modified from [16])*

An edible film is made by using the raw material of modified starch of banana's hump (resistant starch) Additional materials in the manufacture of edible films are plasticizers (sorbitol) and stabilizers (seaweed gel) In the making of edible films, the concentration of seaweed gel was varied Variations of seaweed are in Table 2

Made 8% (b/v) starch suspension and heated at a temperature of 100 °C for 10-15 minutes Furthermore, seaweed was added according to research variations The solution is heated and stirred until homogeneous and added sorbitol 3 5% b/v solution Then, it poured the heated mixture into a mold (Petri cup) with a diameter of 7 cm then flattened The volume of gel poured into each mold was 8 mL After that, the dried product is in an incubator at a temperature of ± 40 °C for one day The edible film is removed from the mold Next, the analysis for edible films was the thickness, tensile strength, elongation, water vapor transmission rate, and biodegradability

**TABLE 2** Variations of *K alvarezii* seaweed concentration

| Sample | Variations of *K. alvarezii* Seaweed (%b/v solution) |
|---|---|
| A | - |
| B | 0 5 |
| C | 1 5 |
| D | 2 5 |
| E | 3 5 |

*Thickness Test*

The thickness of the edible film was measured using a caliper and repeated 3 times at 5 different points The thickness of the edible film is read and recorded based on the scale on the caliper The measurement results are expressed in mm

*Water Vapor Transmission Rate Test (WVTR), Modification of [17]*

The LTUA test was carried out by cutting the edible film with a size of 6 x 6 cm (the size can follow the size of the mouth of the glass beaker), then gluing it on a glass beaker containing 2 g of silica gel The glued edible film was stored in a desiccator containing 1 N sodium hydroxide solution for 6 days and then weighed The addition of silica gel weight becomes the data for the calculation of LTUA edible film The water vapor transmission rate is calculated using the following equation 1

$$\mathrm{WVTR} = \frac{Berat\ B - Berat\ A}{A x t} \qquad (1)$$

Where Weight A = initial weight of beaker + silica gel (grams)
Weight B = Weight of beaker + silica gel after storage (grams)
A = Surface area of edible film ($m^2$)
t = Time (minutes)

*Tensile Strength and Elongation Test*

The tensile strength test was by cutting the edible film with a size of 5 x 2 cm, and the test was using the LR 10 K Plus Material Testing Machine. The tensile strength of the sample was measured until it broke using speed 60. The results of the tensile strength test at the same time obtained the elongation value. Tensile strength is expressed in units of kgf/mm2 and Elongation in units of %.

*Biodegradability Modification of [18]*

The edible film is planted in the soil with a film size of 3 x 3 cm with the conditions and soil depth (± 15 cm) must be the same for each variety of edible film. Determination of the biodegradability of the test sample is the decomposition of edible film in the soil by visual observation.

## RESULTS AND DISCUSSION

### Thickness

Thickness is an edible film characteristic influenced by the solution volume's uniformity, the mold's size, and the number of solids. Determination of thickness is carried out using a caliper on the five sides of the sample to represent the entire sample. Based on standard [5], the standard size of edible film thickness is a maximum of 0.25 mm. The measurement results are in Fig. 4.

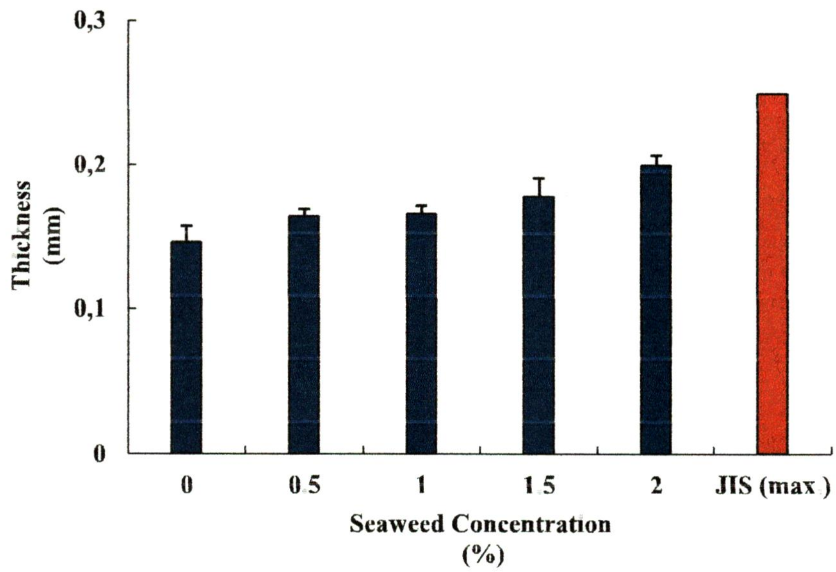


**FIGURE 4.** The thickness of edible film from modified starch of banana's hump and seaweed stabilizer

Fig. 4 shows that the thickness of the edible film is affected by the concentration of seaweed added; the more seaweed added to the edible film solution, the thickness of the edible film will increase. The data in Figure 4 also shows that the edible film produced in this study has the highest thickness value of 0.2 mm and the smallest value of 0.15 mm. Besides that, Figure 4 shows that the edible film meets the standard [5] so that the application of the edible film will be more effective. The thickness of the edible film is one of the characteristics that affect the overall characterization of other edible films, so thickness analysis is beneficial to understand the relationship between each characteristic.

## Biodegradability

Biodegradability aims to determine the decomposition process of a material that occurs in the environment by utilizing the activity of decomposing enzymes from living organisms found in the environment. The ability to decompose edible films in the environment is one of the characteristics of edible films as biodegradable plastics. The standard of biodegradability analysis is that the faster the plastic decomposes, the better the quality of the edible film produced. The results of the biodegradability analysis are in Fig. 5.

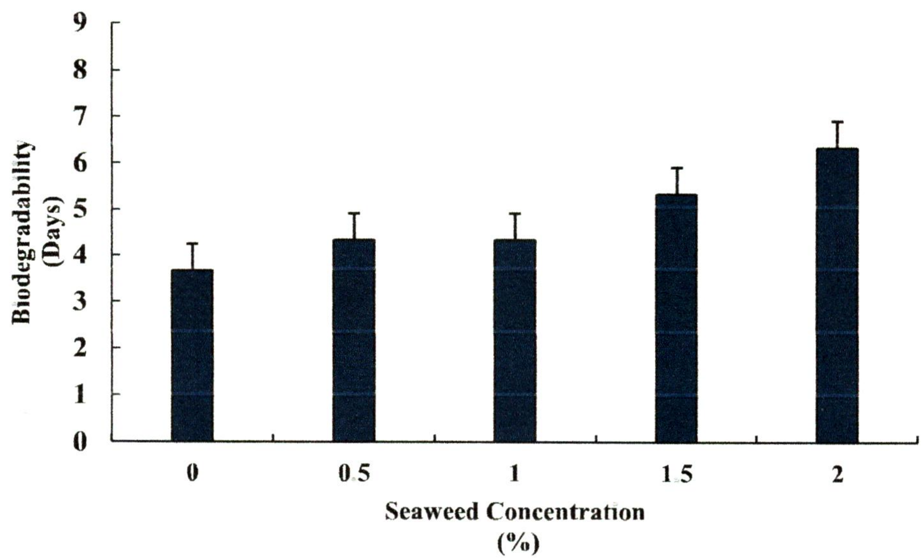


**FIGURE 5.** Biodegradability of edible film from modified starch of banana's hump and seaweed stabilizer

Fig. 5 shows that the addition of seaweed concentration affects the length of time for biodegradability. However, the addition of seaweed did not cause a significant difference in the decomposition time of each concentration. Several factors cause a longer decomposition process with the addition of seaweed, namely the increased polymer content and the increase in film thickness along with the increase in seaweed concentration so that the decomposition process will take longer and several studies, [19] and [20], showed that the category of red seaweed, one of which was *K. alvarezii*, contained antimicrobial compounds so that the process of decomposition by enzymes from microorganisms in the environment would take longer.

Related research on the biodegradability of starch-based edible films, [21], with a thickness characteristic of ±0.2 mm, has the longest biodegradability time, 11 days. Figure 4 showed that the longest biodegradability time is 6 days with a thickness characteristic of 0.2 mm (Fig. 4), figuring the biodegradability time is quite fast. The utilization of modified starch to produce edible films can accelerate the biodegradability process. It is because modified starch has prebiotic characteristics as an energy source for microorganisms that decompose organic matter, mainly starch so that the activity of decomposing enzymes will be more effective and faster. In addition, modified starch has gone through breaking the branch chains into simpler straight chains to be more easily broken down by microbial decomposers [22]. The use of organic solvents, namely water, also provides added value so that the decomposition process is faster.

Based on data from variations in the concentration of edible film, which has the best biodegradability characteristics, it is at a concentration of 0.5-1%. However, the concentration of 1.5-2% also still has good biodegradability characteristics because it can decompose in a matter of days even faster than previous related studies.

## Water Vapor Transmission Rate (WVTR)

Water vapor transmission rate analysis aims to analyze the ease of a material passing by water vapor in a certain time and size without considering the thickness and pressure outside and inside the material. The measurement standard of the water vapor transmission rate analysis is data from the standard [5] with a maximum transmission rate of 7 gr/24 hours $m^2$ The results of the analysis of the water vapor transmission rate can be seen in Fig 6

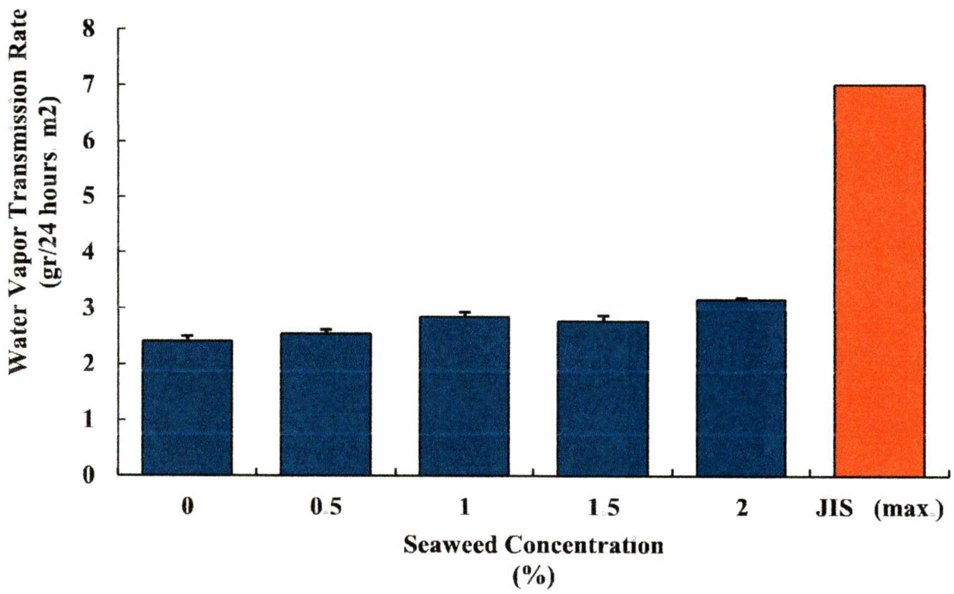


**FIGURE 6** Water vapor transmission rate of edible film from modified starch of banana s hump and seaweed stabilizer

Based on the data from Fig 6, it can be seen that the addition of seaweed concentration affects the increase in the value of the water vapor transmission rate of the edible film However, the addition of seaweed did not cause a significant difference in the value of the water vapor transmission rate of each concentration Several factors cause an increase in the rate of water vapor transmission, namely the nature of seaweed that is easy to absorb or easily binds to water (hydrophilic)

Related research on edible films also supports data analysis [23], that the higher the concentration of dissolved solids ingredient, the higher the water vapor transmission rate The increase in the value of the transmission rate of each concentration of edible film still meets the requirements of the standard [5] The suitability of the water vapor transmission rate value from this study with the standard [5] stated that modified starch is a raw material for an edible film that has an increase in amylose content Their characteristics are easily bound to water and do not significantly affect the transmission rate of the product so it is adequate to be used as a feedstock as a functional packaging material

## Tensile Strength and Elongation

Tensile strength analysis aims to determine the amount of force required to pull the edible film to break and elongation analysis aims to determine the ratio of the elongation of the film to break The measurement standard from the water vapor transmission rate analysis is data from the standard [5] with a tensile strength value of at least 0 3 MPa and an elongation value of at least 50% The results of the analysis of tensile strength and elongation can be seen in Fig 7

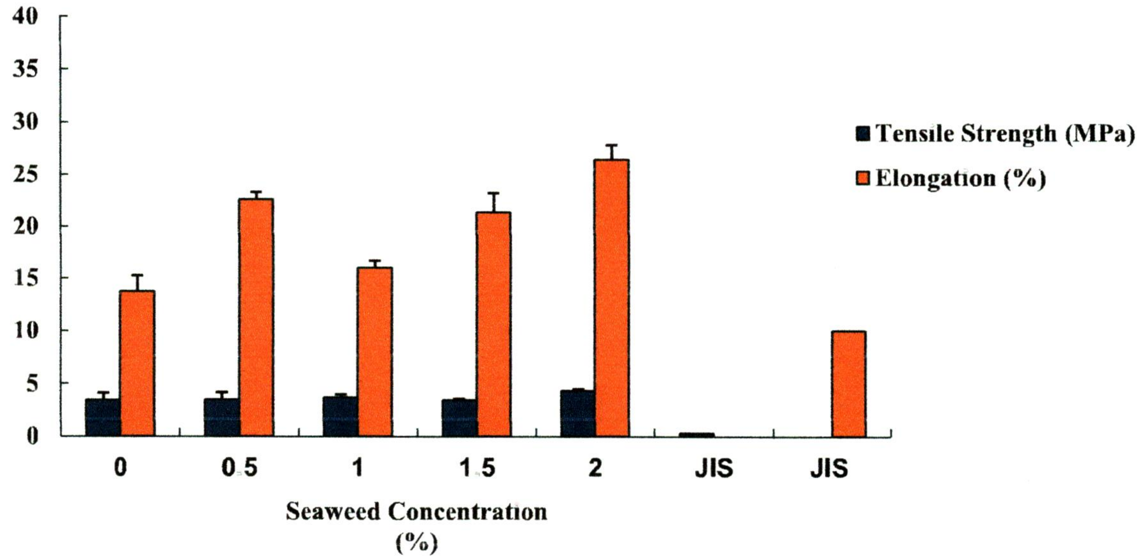


**FIGURE 7.** Tensile strength and elongation of edible film from modified starch of banana's hump and seaweed stabilizer

Based on the data from Fig. 7, it can be seen that the concentration of the addition of seaweed gives an increase in the tensile strength and elongation values. Several factors increase in tensile strength and elongation are directly proportional to the characteristics of seaweed. which is quite elastic. When the film is pulled to break, the elastic film will also form an elongation that is directly proportional to the increase in the film.

Several related journals also support the data analysis in Fig. 7, [24] and [25], that the higher the concentration of seaweed, the mechanical characteristics of the film (tensile strength and elongation) will increase, especially for the elongation characteristics of the film. the film. However, an unstable value increase at a concentration of 1-1.5% was caused by the homogeneity of the addition of seaweed was not good enough. The unstable homogeneity is caused by the ineffective mixing of starch and seaweed gel when both are heated together when the two polymers have not been homogenized with the solvents separately.

## CONCLUSION

Characteristics of edible film using starch-modified banana hump, namely 0.15 mm thickness, biodegradability for 4 days, water vapor transmission rate of 2.41 g/24 hours.$m^2$, the tensile strength of 3.46 MPa, elongation of 13.72%. The effect of variations in seaweed concentration on the process of making the edible film from modified starch of banana weevil, namely the more concentration of seaweed added, the higher the tensile strength, elongation, and thickness characteristics of the edible film, while the characteristics of biodegradability and transmission rate decreased but the decrease was not significant for each variation. The best concentration of seaweed is 2% with several characteristics, namely 0.20 mm thickness, biodegradability for 6 days, water vapor transmission rate of 3.15 g/24 hours.m2, the tensile strength of 4.30 MPa, elongation of 26.38%.

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