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A REVIEW: ALGINATE BASED EDIBLE FILM (MECHANICAL AND PHYSICAL PROPERTIES)

Sandra Eka Putriadi[1], Iis Rostini[2], Rusky Intan Pratama[2], Emma Rochima[2]

[1]*Fisheries Program Study, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Indonesia.*
[2]*Fisheries Departement, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Indonesia*

E-mail: sandraekaputriadi97.sep@gmail.com

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ABSTRACT

Alginate is a polysaccharide hydrocolloid that has the potential to make edible films, because of its rigid, edible and renewable nature. Alginate is a product produced from the extraction process of brown seaweed. The use of alginate at this time is still limited as a raw material for jelly or gelatin. Alginate constituents in the form of hydrocolloids have the potential to be used as biodegradable food packaging materials. Making edible film from alginate is one of the efforts to increase the utilization of seaweed. One of the components added in the manufacture of edible films is a plasticizer. The addition of plasticizers to edible films is important to overcome the brittle nature of the film. This article aims to explain the use of alginate into edible films, how to process them, and the characteristics of edible films. The characteristics of edible films can be seen from the thickness, tensile strength, percent elongation, and transparency. Based on several studies, the amount and type of plasticizer used in the manufacture of edible films affects the quality of the edible film product

INTRODUCTION

Food are generally very sensitive and easily degraded due to environmental, chemical, biochemical, and microbiological factors. The decline in quality can be accelerated in the presence of oxygen, water, light, and temperature. One way to prevent or slow down this phenomenon is with proper packaging. Packaging is an indispensable material to maintain the quality of a food material in order to remain good, because if a food is left open and infected with the environment such as in contact with oxygen, the food will be damaged quickly, so that it can reduce the quality and shelf life of the food. Generally, the type of packaging that is often used is plastic [1].

Plastic has barrier properties against oxygen, carbon dioxide and water vapor. Plastic is non-biodegradable so that waste from plastic can pollute the environment and is not safe for consumption. Based on data obtained from the Indonesian Plastic Industry Association (INAPLAS) and the Central Statistics Agency (BPS), there is a surprising fact that Indonesia is the second largest plastic waste contributor in the world. Plastic waste in Indonesia reaches 64 million tons / year, of which 3.2 million tons is plastic waste that is dumped into the sea. According to the same source, 10 billion plastic bags are disposed of into the environment per year or as many as 85,000 tons of plastic bags [2]. Therefore, it is necessary to develop an environmentally friendly packaging called edible film [3].

Edible film is one of the alternative packaging that can be applied to food because it is biodegradable so it is environmentally friendly, made from materials that are safe for health so that it can be consumed together with the food that is coated with it. Edible films are made from natural materials such as polysaccharides, proteins, fats or a combination of several materials (compost) [4]. One of the natural ingredients used in the manufacture of edible films is the algae *Sargassum* sp. [5].

One of the most common types of algae in Indonesia is brown algae (*Sargassum* sp.). Brown algae can be used to obtain alginate compounds which are one of the building blocks of cell walls in brown algae. The isolation and modification technique of alginate can produce a thin film that can be used as a wrapping membrane for various products such as capsules and other materials. The properties of the film made of alginate are clear, brittle and inflexible. Alginate film is resistant to oil and grease, but less resistant to water vapor, although less resistant to water vapor, but this film can regulate humidity because the hydroxyl group is strong hydrophilic [6]

The addition of plasticizers in the manufacture of edible films is needed to increase the elasticity and flexibility of edible films, in this study glycerol plasticizer was used. The use of glycerol in the manufacture of edible films is an important parameter that affects the mechanical properties of edible films, because of its plasticizing effect on the formation of the polymer matrix. Glycerol also has a low molecular weight so that it easily enters the protein chain and can form hydrogen bonds with reactive groups of 3 proteins [7]. Plasticizer is a non-volatile material (non-volatile) and will affect the physical and mechanical properties of the formed film, if added to the film formula. This is due to a decrease in the internal hydrogen bonds in the intermolecular bonds. Glycerol, sorbitol, and polyethylene glycol are the most common types of plasticizers used in the manufacture of edible films [8].

Edible Film

According [9] edible film can be defined as a packaging material that has been formed in advance and is in the form of a thin layer (film) before being used to package food products, or it can be interpreted that edible film acts as a stand-alone thin sheet material and can be used as packaging or wrapping food product [10]. Edible film is a thin film that can be consumed, coated on food or placed as a barrier between food and the surrounding environment. For 10 years research on edible films and coatings on food has been carried out by food experts due to the high demand for consumer needs for durability and good quality of fresh food. A common example of edible packaging is meat sausage that does not need to be removed when cooked and eaten. Such films can protect food mechanically, prevent contamination from microorganisms, prevent deterioration of food quality due to mass transfer (eg moisture, gas, taste, etc.).

Edible films can be classified into three categories based on their constituent materials, namely: hydrocolloids (containing proteins, polysaccharides or alginates), lipids (fatty acids, acylglycerols or waxes) and combinations (made by combining the two substances of the two categories) [11]. Edible films made from polysaccharides (carbohydrates), proteins, and lipids have many advantages such as biodegradable, edible, biocompatible, aesthetic appearance, and ability as a barrier to oxygen and physical stress during transportation and storage. Edible films made from polysaccharides are selective for O_2 and CO_2 gas exchange so that they can reduce respiration rates in fruits and vegetables [11]. The application of polysaccharide coating can prevent dehydration, fat oxidation, and browning on the surface and reduce the respiration rate by controlling the composition of CO_2 and O_2 gases in the internal atmosphere.

Other advantages of polysaccharide-based films are improving flavor, texture, and color, increasing stability during sales and storage, improving appearance, and reducing spoilage levels [12]. Edible films also have weaknesses such as films from starch for example, they are easily damaged/torn due to their low resistance to water and low barrier properties to moisture due to the hydrophilic nature of starch [13]. The mechanical properties of the starch film are also not good because it has low elasticity. To improve its characteristics, starch is usually mixed with hydrophobic biopolymers or water-resistant materials such as chitosan.

The function of the edible film is to inhibit the transfer of water vapor, inhibit gas exchange, prevent loss of aroma, prevent fat transfer, improve physical characteristics, and as a carrier for additives. Edible films made of lipids as well as bilayer films or mixtures made of lipids and proteins or polysaccharides are generally better used as water vapor transfer inhibitors compared to edible films made of protein and polysaccharides because they are more hydrophobic [14].

Alginates are phycocolloids or hydrocolloids extracted from Phaeophyceae (brown algae). Alginate compound is a linear polymer consisting of two monomeric units, -D -mannuronic acid and -L -guluronic acid [15]. Brown seaweed that has the potential to be used as a source of alginate production includes Macrocystis, Turbinaria, Padina and Sargassum sp. Alginate content in brown seaweed depends on the season, where it grows, age of harvest and type of seaweed [16]. Alginates are found in all types of brown algae as components of cell walls such as cellulose and pectin. Chemically, alginic acid is a complex compound that includes hydrophilic colloidal carbohydrates resulting from the polymerization of mannuronic acid with the chemical formula $(C_6H_8O_6)n$ where the value of n is between 80 and 83 [17]. Alginate extraction is carried out by cooking brown algae in an alkaline environment with a solution of Na_2CO_3 or NaOH, then this crude alginate solution is added with strong mineral acid so that the alginic acid precipitates. Some of the refining processes for this product involve the purification, bleaching, and precipitation of calcium alginate. The final product is generally used as a form of water-soluble alginate salt, especially sodium alginate [17].

Plasticizer

Plasticizer is defined as a non-volatile material, with a high boiling point which, when added to other materials, can change the physical properties of the material. The addition of plasticizers can reduce the intermolecular strength, increase flexibility and decrease the barrier properties of a film. Plasticizers are low molecular weight organic materials added to polymers to reduce stiffness and increase flexibility and extensibility of the polymer. Plasticizer serves to increase the flexibility, elasticity and extensibility of the material, prevent the material from cracking, and increase the permeability to gases, water vapor, and dissolved substances [18].

Plasticizers such as glycerol, polyethylene glycol and sucrose are often used to modify the mechanical properties of films, although the incorporation of these materials also causes significant changes in the barrier properties of the films [12]. The use of plasticizers in the manufacture of films aims to improve the profile of the film, maintain its integrity and avoid holes and cracks. Plasticizers can vary the mechanical properties of the film. The addition of plasticizers makes the film more flexible, stronger and not easily broken but also affects its barrier properties. The plasticizer film matrix will reduce the intermolecular bonds between polymer chains thereby weakening the intermolecular forces [13]. One of the plasticizers that is often used in the manufacture of edible films is glycerol with varying levels depending on the type of polymer used to obtain the desired final film properties.

The use of glycerol in the manufacture of edible films is an important parameter that affects the mechanical properties of edible films, because of the plasticizing effect on the formation of the polymer matrix [7]. The use of glycerol as a plasticizer is better than sorbitol, because the edible film produced is more flexible and not brittle, and its mechanical properties and appearance do not change during storage [19]. The use of glycerol plasticizer alone is more effective in improving the mechanical properties of edible films [20]. Glycerol as a plasticizer is able to reduce internal hydrogen bonds by increasing the empty space between molecules that will be filled by glycerol, thereby reducing stiffness and increasing film flexibility [21]. The addition of more and more glycerol to a certain limit of edible film will make the film elastic and flexible [22].

Alginate Manufacture

The process of making alginate according to [22] begins with soaking the seaweed with 5% HCl for 1 hour to remove the remaining dirt that is still attached so as to facilitate the process of alginic acid formation, then washed with distilled water to remove the remaining acid. The washed sample was added with 4% sodium carbonate solution for the formation of sodium alginate while stirring until it became a paste. The paste formed is diluted with distilled water while stirring and then filtered. Then it was blanched by adding 25% hydrogen peroxide solution to the filtrate and then adding 5% calcium chloride solution to form a white precipitate. To the precipitate formed was added a 5% hydrochloric acid solution. The alginic acid formed is characterized by the appearance of lumps at the top of the liquid. After filtering, the residue obtained was added with 10% sodium hydroxide solution. For the purification process and to facilitate filtration, 95% isopropanol is added to the mixture. The precipitate with filter paper whose weight was known was dried in an oven at 60^{o}C. The dried precipitate was weighed with filter paper to determine the sodium alginate content. The result obtained is sodium alginate, then mashed and analyzed for sodium alginate content, water content and viscosity value.

Edible Film Manufacture

Making edible films refers to the method used by [23] regarding the effect of edible film formulations from carrageenan on mechanical and barrier properties. Seaweed flour is dissolved as much as 1.5 grams with 100 ml of distilled water. The seaweed solution is heated at 90°C for at least 15 minutes while stirring. Glycerol plasticizer was added to four solutions, each of which used concentrations of 0%, 2%, 4%, and 6%. The film-forming solution was left at 90° C. with stirring for 10 minutes, after which the solution was cooled to 80° C. Edible film is printed by pouring the film solution on a plastic mold. The formed edible film was left at room temperature for ±2 hours, then dried at 50°C for ±24 hours using an oven. The edible film is removed from the mold and left at room temperature for ± 2 hours. The edible film was put in a zip lock plastic and stored at room temperature before testing.

The characteristics of edible films

The characteristics of edible films are a tool to determine the feasibility of using edible films. The characteristics of edible films can be seen from their physical, mechanical, and sensory properties. Physical characteristics of edible films can be seen from the results of the water vapor transmission rate, and thickness. Small value of water vapor transmission rate and high thickness can produce good edible film [24].

Mechanical characteristics of edible films can be seen from the tensile strength and elongation. The value of this tensile strength test is seen from the value of the stress strain until it breaks. The low tensile strength value was obtained from the addition of glycerol plasticizer this was due to the influence of interactions between hydrocolloids. The percentage of elongation also determines the stretchability of the edible film, a high level of elongation can increase the elasticity of the edible film [23].

Sensory characteristics of edible films can be seen based on the color produced from the edible film. This color parameter can generally be seen from the level of acceptance by the panelists. [24] The research on the physical mechanical and sensory characteristics of edible film from taro starch at various concentrations of palmitic acid showed that the clear color edible film had a value of 3.44%, the red edible film had a value of 4.00%, while the color edible film had a value of 4.00%, green has the highest value of 4.19%. This shows that bright and attractive colors can affect the level of acceptance by panelists [24].

Mechanical properties and Physical properties of Edible Film Alginat

Mechanical properties of fish flour includes tensile strength, percent elongation, and Thickness of edible film. The thickness of the edible film was measured using a digital micrometer with an accuracy of 1 m at random lengths of different places. The value of the thickness of the edible film is determined from the average of five measurement sites [25]. The thickness of the edible film is also influenced by the composition of the material and the mold used when making the edible film. According to [26] which states that thick edible films can provide better protection for the food products that are packaged. The thickness that meets the Japanese Industrial Standard is a maximum of 0.25 mm.

Tensile strength is an important mechanical property of edible film that can protect the product it is coated with. A high tensile strength value of edible film is needed as food product packaging because it can protect food ingredients starting from the process of handling, transportation, and marketing [27]. Tensile strength was measured using a digital Universal Testing Machine Auto Strain brand Instron. The tensile strength of the film is calculated by dividing the maximum force to tear the film (F) by the cross-sectional area of the film (A). Tensile strength is determined based on the maximum load at the time the film breaks. According to [28] , edible films that have a high tensile strength value indicate that the strength in resisting pressure is getting better. Tensile strength that meets Japanese industrial standards is a minimum of 3.92 Mpa.

The percentage of elongation is the result of the percentage increase in length on the edible film when it is stretched until it breaks. Elongation is calculated by dividing the increase in the length of the piece of film when tearing (b) and the initial length of the film before pulling (a). Elongation was measured using a digital Universal Testing Machine Auto Strain brand Instron. Edible film was cut into square pieces with a width of 35 mm and a length of 50 mm, then measured. Pieces of edible film are attached to the tool handle, 1 fixed handle and 1 movable handle. The handle is moved up slowly until the film tears. The maximum force value for tearing the measured film is shown on the device display. This percent elongation (elongation) is inversely proportional to the tensile strength value, if the elongation value is higher, the tensile strength value is lower [29]. The percentage of elongation that meets the standard is greater than 10%.

Transparency is a picture of the clarity of an edible film material with the standard used, usually the standard used is the clarity of distilled water with a transparency value of 0.0683. Transparency testing on edible films uses a spectrophotometer test tool, where the edible film is cut to the size of the test cuvette, then distilled water is added to determine the transparency standard, after which the cuvette containing pieces of edible film is inserted [30]. According to [31] that the decrease in the value of transparency indicates an increased degree of film clarity. The value of transparency increases due to the influence of the thickness of the film. According to [32] stated that the decreased degree of clarity was caused by the increase in the concentration of the material and the high film thickness.

Conclusion

Alginate is very potential to be used for the manufacture of edible films. The manufacture of edible films depends on the chemical composition and the availability of existing technology. The properties that determine the quality of edible film alginate are thickness, tensile strength, percent elongation and transparency properties. Edible film quality standards refer to Japanese industry standards, namely a maximum thickness of 0.25 mm, a minimum tensile strength of 3.92 Mpa, a large elongation percentage of 10%, and the transparency meets the standard of distilled water clarity of 0.0683. The addition of plasticizer will increase the thickness, percent elongation, and transparency but will decrease the tensile strength value.

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