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# Characterization of edible film from catfish (*Pangasius* sp.) surimi waste water with the addition sorbitol as plasticizer

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**ABSTRACT**

This research aims are know and determine the best concentration of sorbitol as a plasticizer that produces the best edible film characteristics. This research was conducted at Laboratorium Pengolahan Hasil Perikanan, Faculty of Fisheries and Marine Science Universitas Padjadjaran. Research began in July to August 2019. The method used was a Completely Randomized Design (CRD) with 3 treatments and 3 repeat, namely treatments A (0.4%), B (1.2%), and C (2%). The parameters measured are thickness, tensile strength, percent elongation, transparency, moisture content, and solubility. The results showed that the addition of sorbitol had a significant influence on the characteristics of edible films. The best concentration is the addition of sorbitol 1.2% with 0.079 mm thickness value, 6.09 MPa tensile strength, 111.67% elongation, 4.37% and 95.63% transparency and clear degrees, 9.20% water content, and 35.56% solubility. Edible films in this research have met The Japanese Industrial Standard (JIS).

***Keywords*:** catfish, edible film, sorbitol, surimi waste water, *Pangasius*

## 1. INTRODUCTION

Packaging is one way to protect or preserve food and non-food products. Packaging that is widely used today can mostly cause environmental pollution, especially if it is made with materials that cannot be recycled or difficult to experience biodegradation, such as plastic [1].

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Food packaging materials in Indonesia are generally made of plastic. That is because plastic has various advantages including flexible, easily formed, transparent, not easily broken and the price is relatively cheap. Plastic as a packaging material has a problem for the environment that is difficult to experience biodegradation, thus causing a buildup of waste that pollutes the environment [2].

Indonesia is ranked second in the producer of plastic waste to the sea which reached 187.2 million tons after China which reached 262.9 million tons [3]. Meanwhile, the calculation that the total amount of Indonesian waste in 2019 will reach 68 million tons, and plastic waste is expected to reach 9.52 million tons or 14 percent of the total waste that exists [4].

One alternative to substitute plastic packaging is to make packaging that is environmentally friendly and biodegradable such as edible film. Edible film is a thin layer made from edible material, formed to coat the product (coating) or placed between product components that serve as a barrier to mass transfer (eg water vapor, gas, solutes, light) and to increase the shelf life of a product [5].

The main components making up edible film are grouped into three namely hydrocolloid (protein or carbohydrate), lipids (fatty acids, acyl glycerol or wax), and composites which are a mixture of lipids and hydrocolloids [6]. Cellulose, starch, pectin, seaweed extract, gum, and chitosan are examples of polysaccharides used as the basis for edible films. Proteins used as the basis for edible films include soy protein, corn, casein, collagen, gelatin, and fish protein. Furthermore, fats that are commonly used include beeswax, paraffin wax, carnauba wax, and fatty acids.

The basic material for forming edible films greatly influences the characteristics of edible films. Edible films derived from hydrocolloids are very good as inhibitors of the transfer of oxygen, carbohydrates, and fats, and have excellent mechanical characteristics so that they are well used to improve the structure of the film so it is not easily destroyed. Hydrocolloids can prevent deterioration reactions in food products by inhibiting reactive gases, especially oxygen and carbon dioxide. This material is also resistant to fat, due to its polar nature. Films from hydrocolloid materials are generally water-soluble and have good mechanical properties for use as packaging materials [7]

Catfish is one of the many potential fisheries in Indonesia which contributes to a large enough fish production. According to the 'Direktorat Jendral Perikanan Budidaya Kementerian Kelautan dan Perikanan' (2018) [8], reported achievement data (tons) in 2017 national catfish production amounted to 437,111 tons, an increase of 28.91% from 2016 which was only 339,069 tons. Patin production in 2018 increased 38.31% to 604,587 tons. The rate of consumption of catfish per capita tends to increase every year in the domestic market demand which reaches 21.9% from 2014 to 2017 with the preference of products consumed by fresh fish as much as 76% and preserved fish 15%.

One way to further increase the added value of catfish is to process to be made surimi. Meat catfish is very potential to be made surimi because it is quite thick, white and has elastic and rubbery texture [9]. Surimi can be defined as a chopped form of fish meat that has undergone a process of bone removal (deboning), washing and partial removal of water (deatering) so it is known as a wet protein concentrate from fish meat [10]. The washing stage of the making surimi causes the concentration of myofibril protein in the surimi to increase and the sarcoplasmic protein, fat, pigment, blood fat, and protease enzymes dissolve with washing water [11]. Surimi waste water has great utilization potential. The results of the research of

Trilaksani et al. (2007) [12] states that surimi waste water contains 1.58% protein (w / v) and contains 17 amino acids with glutamic acid as the dominant component.

Edible film made from hydrocolloid base material besides having advantages there are also disadvantages. Weaknesses edible films of hydrocolloid-based include easily fragile and low ability as a barrier (barrier) to the transfer of water vapor, thus limiting its use as a packaging material [13]. Efforts to overcome this need the addition of plasticizer.

Plasticizer can be defined as a substance that does not evaporate, has a high boiling point, and if added to other materials can change the physical and mechanical properties of the material [14]. The addition of plasticizer can increase flexibility and permeability to water vapor and gas. Plasticizers that are commonly used are polyols, glycerol, sorbitol, and polyethylene glycol [15].

Sorbitol is a type of sugar alcohol that does not have a free carbonyl group. Sorbitol has the advantage of being able to reduce internal hydrogen bonds in intermolecular bonds so that it is good for inhibiting the evaporation of water from the product [16]. Addition of sorbitol in the manufacture of edible film acts as a plasticizer to reduce the fragility, increase the flexibility and resilience of the film. The addition of sorbitol that is too high can reduce the value of the elongation process so that the edible film is not flexible, increases the water content, the resulting color is not transparent and the appearance is less attractive [17]. Based on the above background, it is necessary to do research on the addition of sorbitol plasticizers edible films to surimi waste water to produce good characteristics according to the JIS (Japanese Industrial Standard 1975) [18].

## 2. REASEARCH METHODS

### 2. 1. Tools and Materials

The tools used in this research are analytical balance, O'haus balance, micrometer, instron, spectrophotometer UV, desiccator, oven blower, orbital shacker, erlenmeyer, filter paper, beaker glass 300 ml, cup , thermometer, pH meter, hotplate, magnetic stirer, mold size 22 x 18 cm, volumetric pipette, drop pipette, measuring cup, knife, plastic container, meat grinder, stirrer, and calico cloth. The material used are catfish surimi waste water, modified tapioca, plasticizer sorbitol, NaOH 1M, and aquades.

### 2. 2. Research Methods

The method used was a completely randomized design (CRD) consisting of three treatments and three repeat. The treatment of adding concentrations sobitol in the manufacture edible films surimi waste water is as follows:

A = addition of plasticizer sorbitol 0.4% from the solution edible film.
B = addition of plasticizer sorbitol 1.2% from the solution edible film.
C = addition of plasticizer sorbitol 2.0% of the solution edible film.

Formulation of edible film of catfish surimi waste water with solution percentage edible 100 mL can be presented in Table 1.

**Table 1.** Formulation of Edible Film

| Material | Treatment | | |
|---|---|---|---|
| | **A** | **B** | **C** |
| Catfish surimi waste water (ml) | 10 | 10 | 10 |
| Modified tapioca (g) | 2 | 2 | 2 2 |
| Sorbitol (ml) | 0,4 | 1,2 | 2 |
| Aquades (ml) | 87,6 | 86,8 | 86 |
| **Total** | **100** | **100** | **100** |

The process of manufacturing edible film refers to [19] which is modified on the base material, pH, temperature and plasticizer concentration, i.e.:

1) Surimi waste water is measured as much as 10% of 100 ml of aquades and put in a beaker glass 300 ml.
2) Surimi waste water was added with aquades and 1 M NaOH to pH 10 then stirring and heating using a hotplate at 60 ºC for 30 minutes.
3) Tapioca 2% is added to the solution and stirred using a stirrer.
4) Each solution edible film homogeneous was then added with plasticizer as much as 0.4%, 1.2%, and 2% sorbitol while stirring and heating until the temperature reached 70 ºC for ± 25 minutes.
5) The solution is poured over a 22 × 18 cm mold and flattened to obtain the same thickness.
6) The edible film is then dried and put in an oven blower at 50 ºC for ± 24 hours.
7) The layer film is cooled to room temperature.
8) After it cools, the layer is film released from the mold.

## 2. 3. Observed Parameters

### 2. 3. 1. Thickness

The thickness of the edible film is measured using a micrometer with the accuracy of 1 μm. Measurements were made at 5 different points [20]. Thickness values are measured from an average of five thickness measurements edible film.

### 2. 3. 2. Tensile

Strength Tensile strength is the maximum force that can be edible film until broken [20]. Tensile strength and percent elongation are measured using an instron tool with a 5 kg load. Tensile strength measurements are calculated using the formula [21]:

$$\text{Tensile strength} = \frac{F\ max}{A}$$

Information:

$F_{max}$ = maximum tensile strength (N)
A = cross-sectional area ($mm^2$)

### 2. 3. 3. Percent Elongation

Percent elongation is the change in the maximum length that a material can experience during stretching or pulling before it breaks [22]. Percent lengthening test is carried out to determine the percentage increase length film in when pulled until it is torn or broken. Measurement of elongation percent is calculated using the formula:

$$\text{Percent Elongation} = \frac{break\ distance}{flops\ distance} \times 100$$

### 2. 3. 4. Transparency

Transparency is the ability of a material that can indicate the level of clarity of a material marked by the ability of the material to transmit light [23]. The transparency test is edible film measured using a spectrophotometer UV at a wavelength (λ) of 550 nm. The transparency calculation formula is as follows:

$$T = \frac{A_{550}}{x}$$

Information:

T = Transparency
$A_{550}$ = Absorbance at a wavelength of 550 nm
X = thickness film (mm)

### 2. 3. 5. WaterWater

Water content is one of the chemical properties of the material which shows how much water is contained in the material. Water content testing is done using an oven. Water content is determined by the formula:

$$\text{Water content} = \frac{w1 - w2}{w1} \times 100\%$$

Information:

$w_1$ = initial weight
$w_2$ = final weight

### 2. 3. 6. Solubility

Percent solubility of edible film is percent dry weight of film dissolved dipped in water for 24 hours [24]. Water solubility test is carried out to determine and predict the stability of edible films on the influence of water. Percentage of solubility is calculated by using the following equation:

$$\text{Solubility} = \frac{w0 - w1}{w0} \times 100\%$$

Information:

$w_0$ = initial weight
$w_1$ = final weight

### 2. 4. Data Analysis

Observation data is processed statistically using a Completely Randomized Design (Completely Randomized Design (Completely Randomized Design) CRD), namely the F test with a test level of 5%.

## 3. RESULT AND DISCUSSION

### 3. 1. Thickness

Thickness is one of the important parameters that influence the formation of edible film and its purpose for coating or packaging products. This is due to the fact that edible films which are of a standard thickness will provide good protection for the product being packaged. In addition the thickness of the edible film is a physical characteristic that is affected by the concentration of dissolved solids in the solution film and the size of the printed container used [24]. The results of observations of the thickness of the film solid surimi waste water are presented in Figure 1.

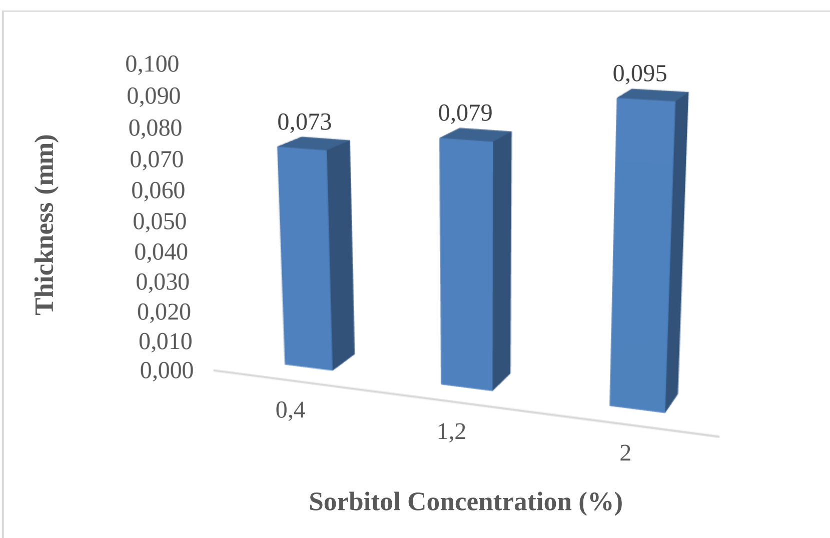


**Figure 1.** Average Thickness of Edible Film

The results of measuring the thickness of the edible film in this study ranged from 0.073 to 0.095 mm (Figure 1). The thickness is edible film lowest obtained from the addition of sorbitol 0.4% which is equal to 0.073 mm. The thickness of edible film highest is the addition of sorbitol 2% which is equal to 0.095 mm. The value of thickness edible in this study meets the JIS (Japanese Industrial Standard) because the thickness value in the research is less than 0.25 mm.

The thicker edible film the resulting, the higher its ability to inhibit the rate of gas and water vapor, so that the shelf life of the product is longer [25]. However, edible film that is too thick will affect the appearance, taste, and texture of the product when eaten.thickness Edible films also relate to their ease of form. The thicker an edible the film will be more rigid and difficult to form, but will provide better mechanical protection against the material it is packed in [19].

The addition of sorbitol is directly proportional to the thickness value. The greater the concentration added to the edible film surimi waste water thickness increases. This is because sorbitol added to edible can increase solids in solution that affect the thickness of the edible film. The addition of concentration of the plasticizer will increase the polymer matrix making up the film as the increase in total dissolved solids in solution, resulting in thickness film increased [26]. In addition the thickness of the edible film can be influenced by the area of the mold, the volume of the solution when poured into the mold, and the total amount of solids in solution [19].

### 3. 2. Tensile

Tensile strength is the maximum pull that can be achieved until the film breaks [4]. Tensile strength measurement to determine the amount of force achieved to achieve maximum pull in each unit area of the film to stretch or elongate. The results of observations of tensile strength of edible films in this research can be presented in Figure 2.

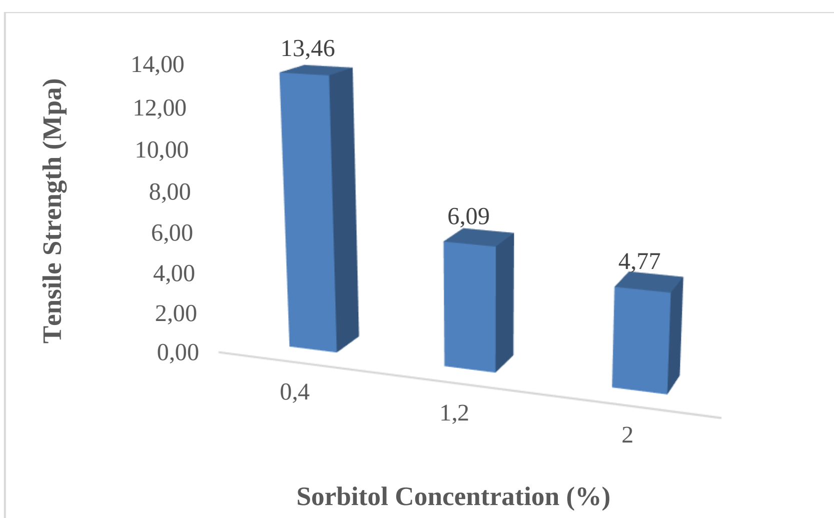


**Figure 2.** Average Tensile Strength of Edible Film

Tensile strength values of this research range from 4.77 MPa - 13.46 MPa. Treatment A (sorbitol addition 0.4%) is the treatment that has the lowest tensile strength value of 4.77 MPa. The greatest tensile strength value is in treatment C with the addition of sorbitol 2% by 13.46

MPa. The tensile strength value in this research has met the standards set by JIS (Japanese Industrial Standard), because the standards set are at least 0.3 MPa.

Based on Figure 2, it can be seen that the addition of sorbitol is inversely proportional to the tensile strength value. The greater the concentration of sorbitol added, the value of the tensile strength decreases. Plasticizer is a material with a small molecular weight that can be joined into a matrix of proteins and polysaccharides to increase the nature of flexibility and the ability to form edible films. The results of this test are in line with the results of research [26] regarding the addition of sorbitol to the edilbe film breadfruit starch which states that the higher the concentration of sorbitol added the tensile strength will decrease. The addition of sorbitol as a plasticizer causes the molecules of sorbitol to interact by forming hydrogen bonds in the inter-polymer chains, thereby reducing the interaction between biopolymer molecules [27].

Edible films with a high tensile strength value are able to protect the packaged product from mechanical interference well. The value of tensile strength is usually inversely proportional to the percent elongation. The lower the tensile strength, the greater the elongation, and vice versa. Edible film which has a large percent elongation value, the quality of edible film is getting better because it is more elastic and not easily torn [25].

### 3. 3. Elongation

Percent of elongation is the change in maximum length that a can experience film if pulled. Percent elongation is related to the concentration of plasticizer added in making edible film. The results of observations of percent elongation of edible film surimi waste water catfish can be presented in Figure 3.

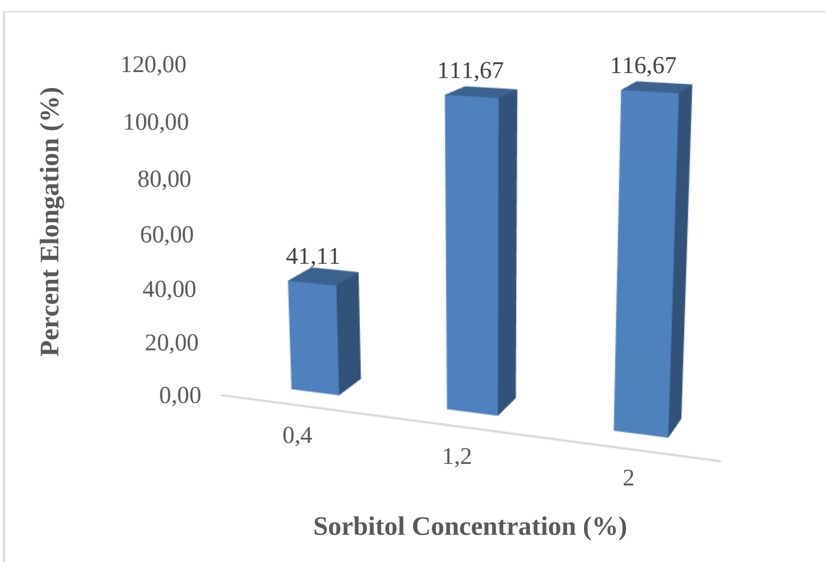


**Figure 3.** Average Percent Elongation of Edible Film

Based on the Figure 3, the addition of sorbitol is directly proportional to the percent elongation. The higher the concentration of sorbitol added to the solution edible film, the greater the resulting elongation. The results of this percent elongation are in line with research conducted by [16] on edible films carrageenan that the higher sorbitol addition treatment will increase elongation due to intermolecular space stretching of the matrix structure edible film. The use of plasticizers tends to decrease the tensile strength and increase the percent elongation in edible films [28]. This is due to the increasing concentration of sorbitol activation energy for the movement of molecules in the matrix decreases so as to cause increased elasticity of the edible film [30]. The mechanism of sorbitol as a plasticizer is because sorbitol is a low molecular weight hydrophilic compound that can enter the intermolecular tissue. Sorbitol can make the distance between molecules wider and produce flexible properties and reduce the level of fragility of film the resulting.

The percent value of elongation of edible film waste water in this research ranged from 41.1% - 116.67%. The lowest elongation percentage is 41.1% in treatment A (0.4%) and the highest in treatment C (2%), while treatment B (1.2%) has a percent elongation value of 111.67%. The percent elongation value in this research has fulfilled the JIS 1975 standard. The percent elongation value of edible film is categorized as poor if less than 10% and categorized as very good if more than 50% [18].

The high percent elongation value in this research occurs because proteins and polysaccharides which have a polymer matrix are thought to produce intermolecular tensile strength becoming stronger so that the stretching ability of the film also increases. The addition of tapioca starch means an increase in the amount of amylopectin in the matrix film. Amylopectin forms branch bonds with glycosidic α-1,4 bonds. Edible films Starch-based containing high amylose or amylopectin will produce different characteristics edible film, if the high amylose edible film produced is stronger and permeable [21].

The high percent elongation value indicates edible film that the resulting is not easily broken because it is able to withstand the load and the tensile force applied [1]. The use of hydrocolloids can increase the breaking strength value and percent elongation because it produces a lubrication effect that makes the emulsion edible film more flexible, elastic, and stronger.

### 3. 4. Transparency

Transparency is the ability of a material to pass on light and aesthetic assessments in the marketing of food packaging. Transparency values indicate the degree of clarity of a film [24]. Transparency of edible film can be tested using a spectrophotometer with a wavelength of 550 nm. The results of observations of transparency can be presented in Table 2.

**Table 2.** Transparency Value and Clear Degree of Edible Film

| Treatment | Average Transparency (%) | Average clear degree (%) |
|---|---|---|
| A (0.4%) | $5.37 \pm 1.26^{b}$ | $94.63 \pm 1.26^{b}$ |
| B (1.2%) | $4.37 \pm 0.22^{b}$ | $95.63 \pm 0.22^{b}$ |
| C (2%) | $2.79 \pm 0.29^{a}$ | $97.21 \pm 0.29^{a}$ |

Edible film in this research has a transparency value ranging from 2.79% - 5, 37% and the degree of clarity ranges from 94.63% - 97.21%. Based on Table 1, it can be seen that the addition of sorbitol is directly proportional to the degree of clarity film. The greater the concentration of sorbitol, the greater the degree of clarity of the edible film. These results are in line with [32] regarding the application of sorbitol to the biodegradable film Nata de Casava that the higher sorbitol addition results in film a more transparent. It is suspected that the addition of sorbitol can cause the starch and protein contained can be gelatinized completely. In addition it is caused due to reduced hydrogen bonds (hydroxyl groups). Sorbitol has the ability to reduce hydrogen bonds [33]. The addition of sorbitol in making biodegradable films will reduce hydrogen bonds so that the resulting color will look more transparent.

### 3. 5. Water Content

Water content is one of the chemical properties of the material that shows how much water is contained in the material. The water content edible films has an important role on the stability of the product being coated, therefore edible film is expected to have a low water content so that in its application as a primary packaging it does not contribute water to the product which will have an impact on product damage and decreased shelf life. The results of observations of edible film water content of surimi waste water fish can be presented in Figure 4.

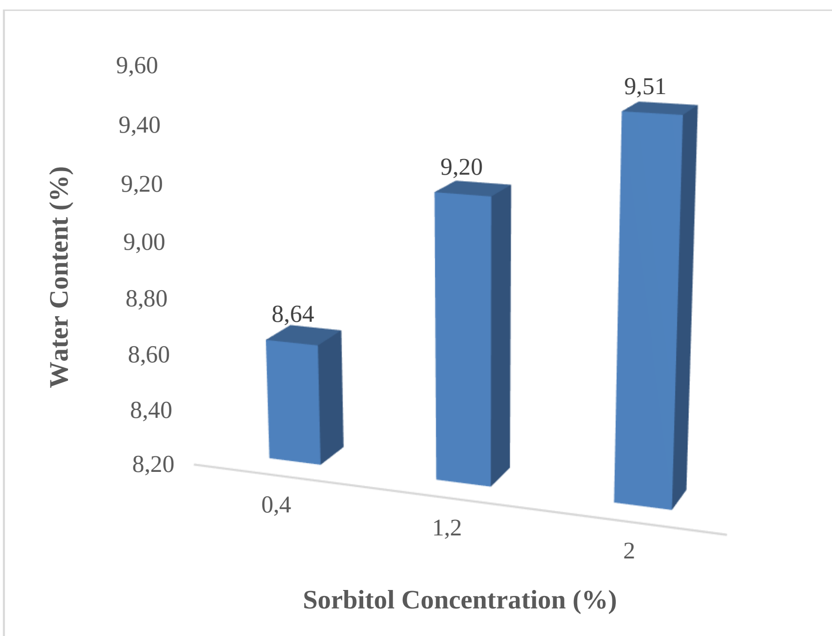


**Figure 4.** AverageWater Content Edible Film

Value of water content in this study ranged from 8.64% - 9.51%. The highest water content is 9.51% in treatment C and the lowest is 8.64% in treatment A. Based on the Japanese Industrial Standard (JIS) 1975, the value of water content in this research has met the set standards because it is less than 10%.

Based on Figure 4, it can be seen that the water content edible film increases with increasing concentration of added sorbitol. Increased water content due to sorbitol in addition to functioning as a plasticizer also functions as a sweetener or humectant, an additive that is hygroscopic and serves to maintain the water content in a material [34].

The basic ingredients in this research also affect the amount of water content. This is because surimi waste water with protein and tapioca contents with the main content of amylose and amylopectin, will form complex bonds. Starch has OH groups and protein molecules have NH groups so that these two groups have the ability to bind water [31].

### 3. 6. Solubility

Solubility is a benchmark of edible film that can dissolve when consumed and also as a determinant of biodegradable edible when used for packaging [35]. The solubility of edible film in water is determined by the composition of the material in forming edible film. The results of solubility observations can be presented in Figure 5.

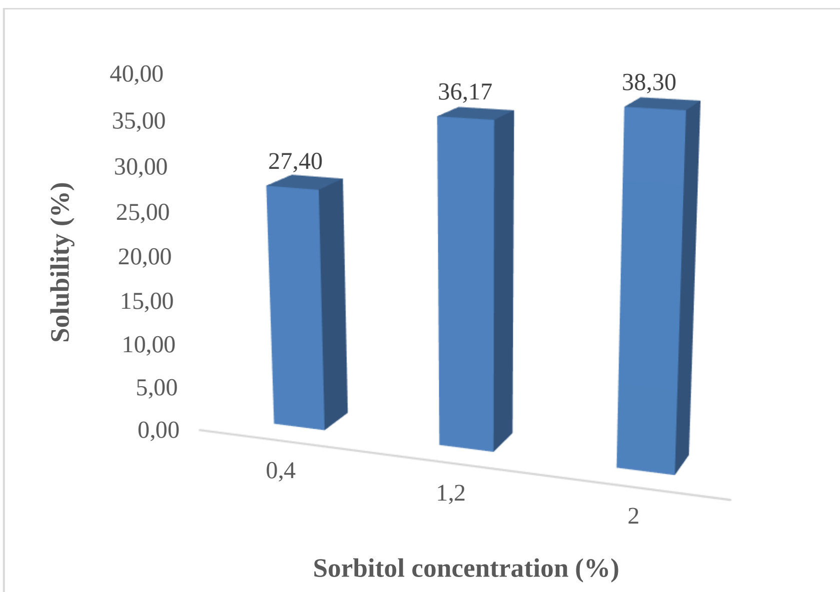


**Figure 5.** The Average Solubility of Edible Film

Based on Table 11, it can be seen that the value of the solubility of edible film waste water ranged between 26.34% - 39.83%. The highest solubility obtained from the addition of sorbitol 2% is 39.83%. The lowest solubility obtained from the addition of sorbitol 0.4% is 26.34%. The research results show that the greater the concentration of which is added to the formulation edible film surimi waste water, the higher the solubility values. This is because sorbitol is a compound that can dissolve completely in water so that the higher the concentration of sorbitol, the higher the solubility value. Sorbitol has a strong affinity for water molecules, and low molecular weight helps the entry of sorbitol between polymer chains, thereby increasing the volume of free space between polymer chains [27]. These-forming materials edible film hydrophilic will dissolve more quickly in water compared to hydrophobic materials such as beeswax, wax, and paraffin [34].

### 3. 7. Recapitulation of Research Result

Based on research that has been done, recapitulation of research results on thickness, tensile strength, percent elongation, transparency, water content, and solubility of *edible films are* presented in Table 3.

**Table 3.** Recapitulation of Research Results

| Parameter | Treatment | | | Japanese Industrial Standard (JIS) |
|---|---|---|---|---|
| | A (0.4%) | B (1.2%) | C (2%) | |
| Thickness (mm) | 0.073[a] | 0.079[b] | 0.095[c] | Max. 0.25 mm |
| Tensile strength (MPa) | 13.46[a] | 6.09[b] | 4.77[c] | Min 0.3 Mpa |
| Percent Elongation (%) | 41.11[a] | 111.67[b] | 116.67[b] | Min. 10% |
| Transparency | 94.63[b] | 95.63[b] | 97.21[a] | - |
| Water content (%) | 8.64[a] | 9,20[ab] | 9.51[b] | Max. 13% |
| Solubility (%) | 26.34[a] | 35.56[b] | 39.83[b] | - |

Edible film can be said to meet the criteria as a packaging material that is meeting the standards according to the Japanese Industrial Standard. Good edible film that has a thickness of less than 0.25 mm, high tensile strength, percent elongation of more than 10% (the higher the value the better), low transparency with a high clear degree value, low water content which is less than 13% and a value of high solubility.

The thickness value in this research has met The Japanese Industrial Standard 1975. The thickness of the edible film serves as a protection for both physical and chemical damage. The addition of sorbitol 2% is the best treatment on thickness because the value is not too tips or thick at 0.095 mm.

Tensile strength values range from 4.77 MPa - 13.46 MPa. The greater the value of tensile strength, edible film the better because it is able to protect the food it packs from mechanical interference. The tensile strength value in this research meets the JIS 1975 standard, but the best treatment is the addition of sorbitol 0.4% which produces the highest tensile strength value of 13.46%.

The percent value of elongated edible film research has met the 1975 JIS standard, because it is more than 10%. Percentage value of elongation ranges from 41.1% - 116.67%. Based on research results, the largest percent elongation value is the addition of sorbitol 2% by 116.67%. However, the percentage value of the addition of sorbitol addition 2% was not significantly different from the addition of sorbitol 1.2%, so the addition of sorbitol 1.2% was chosen as the best treatment for the percent elongation.

Edible film is well categorized as food packaging, if it has a high level of clarity [36]. Based on the research results, the addition of sorbitol 2% is the best treatment because it has the highest clarity value of 97.21%.

The value of water content in this research has met the Japanese Industrial Standard (JIS) because it is less than 13%. The value of water content in food will affect the shelf life of the products it packs [37], so the higher the shelf life will be shorter. The results of research on the parameters of water content edible film, the addition of sorbitol 0.4% is the best treatment with a moisture content of 8.64%.

Solubility is a measure of edible film that can dissolve when consumed [35]. The greater the solubility value, the better the edible film can be consumed. Based on research results, the highest solubility value is the addition of sorbitol 2% by 39.83%. The addition of sorbitol 2% was not significantly different from the addition of sorbitol 1.2% to the solubility, so the 1.2% treatment was chosen as the best treatment.

Based on research summary, it can be concluded that the treatment of 1.2% sorbitol is the best treatment in this research. This is because edible films with 1.2% sorbitol addition have high elongation and solubility values so that they are easily applied and consumed. Besides that, it has good tensile strength and thickness values and good water content which is not significantly different from treatment A.

## 4. CONCLUSIONS

Based on the research results, the addition of sorbitol has a significant effect on thickness, tensile strength, percent elongation, transparency, water content, and solubility of edible film water in catfish surimi washing water. Edible film in this research meets the standards of the Japanese Industrial Standard (JIS) 1975, so it can be applied to packaging materials. The best results in this research are the addition of sorbitol by 1.2%. Edible film with the addition of 1.2% sorbitol has a thickness value of 0.079 mm, a tensile strength of 6.09 MPa, elongation of 111.67%, transparency and clear degrees of 4.37% and 95.63%, water content of 9.20%, and 35.56% dissolution rate.

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