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The effect of glycerol concentration as a plasticizer on edible films made from alginate towards its physical characteristic

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ABSTRACT

This study aims to determine the effects of the addition of the best glycerol concentration as a plasticizer on edible film alginate for tensile strength test, thickness test, percent elongation, and transparency test. The research method used was experimental with a Completely Randomized Design consisting of five treatments and three replications. The treatment of the addition of glycerol concentration was 0.3% based on the volume of solution, 0.5% based on the volume of solution, 0.7% based on the volume of solution, 0.9% based on the volume of the solution, and 1.1% based on the volume of the solution. Observations on the physical characteristics of edible films include thickness, tensile strength, percent elongation, and transparency. The results of the study of physical characteristics of thickness, tensile strength, percent elongation, and transparency concluded that the addition of glycerol concentration in edible films as much as 0,9% was the best treatment based on Japanesse Industrial Standard (JIS) with an average value of 0,094 mm thickness, tensile strength 8,25 MPa, elongation percent value 10,83%, and transparency value is 1,86.

***Keywords*:** alginate, edible film, glycerol, hydrocolloid, plasticizer

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1. INTRODUCTION

So far, the most popular packaging is plastic packaging. The plastic packagings that are commonly used to package foodstuffs are polyethylene and polystyrene. Although the use of plastic has many advantages, it has many disadvantages, namely that it cannot be degraded biologically and there is a possibility of dangerous substances migrated into food. With the requirement that the packaging used is environmentally friendly packaging, it makes the use of edible films is very promising. The advantages of edible films compared to plastic packagings which are commonly used is that it protects food products, the original appearance of the product can be maintained, it can be eaten directly and safe for the environment (Fransisca et al. 2013).

Edible films have been used to pack meat, sausages, fruits and fresh vegetables. Edible films can maintain the quality of food that is packaged because edible films can withstand carbon dioxide, oxygen diffusion, evaporation of water, and contamination of taste with other products. Another benefit of edible films is that it can extend the storage life and is environmentally friendly, and edible films can be eaten together with the product (Junianto et al. 2012).

Alginate is a hydrocolloid polysaccharide that has the potential to be made into an edible film, because it is rigid, edible and renewable. One component that has been added in the manufacture of edible films made from alginate is plasticizer. The addition of plasticizers to edible films is important to overcome the brittle nature of the film due to extensive intermolecular forces. The most widely used type of plasticizer is glycerol (Togas et al. 2017).

Various studies have been carried out regarding the making of edible films from hydrocolloid and other gelatin with glycerol as plasticizers. Rusli et al (2017) have conducted research on the manufacture of edible films from carrageenan with glycerol. Setiawan et al (2015) have made edible films from chitosan shrimp skin with glycerol. Making edible films from alginate raw materials with the addition of glycerol as plasticizer has not been done. Therefore, more specific research is needed regarding the use of alginate in edible films with the addition of glycerol concentration to obtain good edible film characteristics with different concentrations.

2. MATERIALS AND METHOD

Materials and Tools

The materials used in this study were alginate obtained from a shop in Surabaya, while glycerol and distilled water were obtained from a shop in Bandung. The tools used in this study were analytic scales (sonic), beaker glass (pyrex), measuring cups (pyrex), hot plate stirrer (nouva), magnetic stirrer (nouva), thermometer (hedao), volume pipettes (pyrex), and oven (SL).

Research Method

The research method used was experimental with a completely randomized design consisting of five treatments and three repetitions with the treatment of adding glycerol concentrations, respectively 0.3%, 0.5%, 0.7%, 0.9% and 1.1%.

Edible Film Making

Edible film making refers to the method used by Anward et al. (2013) which is modified. Alginate was dissolved with 100 ml of distilled water. Alginate solution was heated on a hot plate up to 80 ºC with the stirring using a stirrer magnet assisted with a stirring rod. Then the stirring was done and during the heating at a temperature of 60 ºC, glycerol plasticizer was added. After a temperature of 80 °C, it was expected that the mixture has been homogeneous. Then the edible film that had been prepared, was put into the oven for about 4 hours, this was intended so that the alginate edible film solution forms sheets of alginate edible film. The alginate edible film was then peeled off the print media, and then tested for the physical characteristics of the edible film alginate.

Edible Film Characterization

Thickness

The edible film that had been formed was measured by using a micrometer screw. The thickness of the edible film was measured at five points, namely: the left-right end, the right-left side, the middle, and the top-bottom center, then the average thickness was calculated (Huri 2014).

Tensile Strength

Tensile strength is the maximum tensile force that can be held by the film during measurement (Akbar 2013). Tensile strength can be calculated using the following equation (Fransisca et al. 2013):

$$\boldsymbol{t = \frac{Fmaks}{A}}$$

where:
t - tensile strength (MPa)
F_{maks} - force of tenstile strength (N)
A - sample surface area (cm^2)

Percent Elongation

The percentage of elongation is based on the lengthening of the film when the film fractured. The clip distance used in the test is 20 mm with a pull speed of 50 mm/minute (Rusli et al. 2017). The equation for elongation is as follows:

$$\text{Elongation} = \frac{A-B}{B}\ x\ 100\%$$

where :
A = gauge length after fracture
B = gauge length before fracture

Transparency

Transparency of edible film was measured using a UV spectrophotometer at a wavelength (λ) 550 nm. Film transparency is measured using the method of Bao et al. (2009) and the transparency of edible film was calculated using the formula:

$$T = A_{550}/x$$

where:
T = Transparency
A_{550} = Absorbance at a wavelength of 550 nm
x = Film thickness (mm)

Data Analysis

Observation data were processed using variance analysis and Duncan's multiple difference test.

3. RESULTS AND DISCUSSION

Thickness

Thickness is an important parameter that affects the use of film in the formation of the product to be packaged. Thickness can also affect the mechanical properties of other films, such as tensile strength and elongation. But in its use, the thickness of the edible film must be adjusted to the product it packs (Anandito et al. 2013).

Table 1. Results of Edible Film Thickness Test Based on Addition of Glycerol Concentration

Treatment (Glycerol Concentration)	Average (mm)
A (0,3 %)	$0{,}060^{a}\pm0{,}003$
B (0,5 %)	$0{,}074^{b}\pm0{,}000$
C (0,7 %)	$0{,}087^{c}\pm0{,}001$
D (0,9 %)	$0{,}094^{d}\pm0{,}001$
E (1,1 %)	$0{,}098^{e}\pm0{,}002$

Notes:
- The same letter on the same line shows no real different treatment.
- This value is an average of three repetitions ± standard derivation.

The results of the analysis of variance presented in Table 1 show that the treatment of glycerol concentration significantly affected the thickness of edible films. The average thickness of edible films in each treatment A (0.3%), B (0.5%), C (0.7%), D (0.9%), and E (1.1%) is 0.060 mm, 0.074 mm, 0.087 mm, 0.094 mm, and 0.098 mm. As glycerol concentration increases, the thickness value of edible films is increased (Junianto et al. 2012). This is because glycerol is a clear compound, easily dissolves in water, increases the viscosity of the solution and binds water. So, the higher the addition of glycerol concentration, the lower the water evaporation rate will be because some of the water in the edible film solution is bound by glycerol so that it affects the thickness of the edible film produced (Sitompul and Zubaidah 2017). The thickness of edible films produced in this study ranged from 0.060 ± 0.003 to 0.098 ± 0.002 mm. Edible film thickness values obtained by Rusli (2017) with the main ingredients of carrageenan ranged between 0.035 ± 1.01 - 0.085 ± 2.27 mm. Sinaga (2013) reported the results of his research on edible films made from soybeans with variations of glycerol 4% -10% and without the addition of tapioca having a thickness of 0.173 mm - 0.294 mm. The thickness difference between the various types of films is due to the composition of different film formulas. The thickness value of edible films in this study is quite good because it is below the maximum standard thickness of edible films according to Japanese Industrial Standard (JIS) which is 0.25 mm (Ariska and Suyatno 2015). Kusumawati (2013) stated that the thickness of edible films must be adjusted to the type of food that will be coated. These results indicate that the highest thickness of edible film produced in this study still meets the requirements to be used as primary packaging material in foodstuffs.

Tensile Strength

Tensile strength is the maximum tensile force that can be held by a film. Edible films with high tensile strength are needed for food product packaging that aims to protect foodstuffs during handling, transporting, and marketing (Pitak and Rakshit 2011).

Table 2. Test Results of Edible Film Tensile Strength Based on Addition of Glycerol Concentration

Treatment (Glycerol Concentration)	**Average (MPa)**
A (0,3 %)	$23{,}92^{a}\pm3{,}29$
B (0,5 %)	$13{,}40^{b}\pm1{,}29$
C (0,7 %)	$11{,}08^{bc}\pm0{,}88$
D (0,9 %)	$8{,}25^{c}\pm1{,}20$
E (1,1 %)	$4{,}73^{d}\pm0{,}43$

Notes:
- The same letter on the same line shows no real different treatment.
- This value is an average of three repetitions ± standard derivation.

The results of the analysis of variance presented in Table 2 show that the treatment of glycerol concentration significantly affected the tensile strength of edible films. The average tensile strength of edible films in each treatment A (0.3%), B (0.5%), C (0.7%), D (0.9%), and E (1.1 %) is 23.92 MPa; 13.40 MPa; 11.08 MPa; 8.25 MPa; and 4.73 MPa. As glycerol concentration increases, the tensile strength of edible films decreases (Junianto et al. 2012). Tensile strength testing in edible films shows that the higher the concentration of glycerol, the lower the tensile strength of edible films. This is allegedly due to the value of tensile strength inversely proportional to the percent value of elongation. According to Jacoeb et al. (2014), glycerol and alginate will dissolve each molecule thereby reducing the movement of polymer molecules so that the polymer formed becomes soft.

Increased glycerol concentration in the alginate/pectin edible composite formulation reduced the tensile strength (Vieira et al. 2011). In general, the tensile strength values of edible films produced in this study have met the minimum standards of the tensile strength values of edible films based on Japanese Industrial Standard (JIS) of 3.92 MPa (Ariska and Suyatno 2015). The tensile strength of edible films produced in this study ranged from 4.73 ± 0.43 to 23.92 ± 3.29 MPa.

The tensile strength of edible films produced in this study was greater than the tensile strength of edible films obtained by Harumarani et al. (2016) where edible film made from semirefined carrageenan *Eucheuma cottonii composite* and beeswax with glycerol concentration of 0.3% - 0.9% had a tensile strength of 8.36±0.18 - 15.66±0.10 MPa. The greater the value of tensile strength in this study compared with the research of Harumarani et al. (2016) due to the research of Harumarani et al. (2016) the main ingredients used are semirefined carrageenan *Eucheuma cottonii composite* and beeswax. The stated that high moisture content can also reduce the tensile strength of a material. Beeswax in the form of lipids does not have good solubility for water when making edible film solutions. Non-polar lipid properties cannot dissolve well in polar water solvents. So that the bond that occurs is not formed properly and decreases the tensile strength or tensile strength.

The choice of edible film as packaging material depends on its use by paying attention to the tensile strength value of edible film. According to Katili et al. (2013), edible films that have high tensile strength can be used as packaging materials for products that need high protection such as ink packaging, while edible films that have low tensile strength values can be used as packaging materials for light products such as candies, noodles, snacks, and other food products.

Percent Elongation

Percent elongation is the percent increase in length of edible film material measured from the initial length at the time of withdrawal to fracture (Nurindra et al. 2015). This prolonged percentage illustrates the nature of edible film. Plasticity or extension is generally needed by edible films to maintain their integrity when applied to food products (Galus and Lenart 2013).

The results of the analysis of variance presented in Table 3 show that the treatment of glycerol concentration had a significant effect on the percent elongation of edible film. The average percent of edible film elongation in each treatment A (0.3%), B (0.5%), C (0.7%), D (0.9%), and E (1.1 %) is 3.33%; 5.00%; 6.67%; 10.83%; and 26.67%. Along with the increase in glycerol concentration, the elongation percent value of edible film is increased (Junianto et al. 2012). The higher the concentration of glycerol tends to increase the value of elongation.

This is because the higher the concentration of glycerol, the higher the elongation value, which means that the edible film packaging is more flexible and plastic. According to Sitompul and Zubaidah (2017), the use of plasticizers tends to reduce the tensile strength and increase the percentage of elongation in edible films because plasticizers can reduce intermolecular forces and increase the mobility of biopolymer chains.

Table 3. Percent Test Results of Edible Film Lengthening Based on Addition of Glycerol Concentration

Treatment (Glycerol Concentration)	Average (%)
A (0,3 %)	$3{,}33^{a} \pm 1{,}44$
B (0,5 %)	$5{,}00^{a} \pm 0{,}00$
C (0,7 %)	$6{,}67^{a} \pm 2{,}89$
D (0,9 %)	$10{,}83^{a} \pm 3{,}82$
E (1,1 %)	$26{,}67^{b} \pm 7{,}64$

Notes:
- The same letter on the same line shows no real different treatment.
- This value is an average of three repetitions ± standard derivation.

The elongation value of edible films produced in this study ranged from 3.33±1.44% to 26.67±7.64%. The results of this study are in line with Rusli's (2017) research using carrageenan materials with the addition of different glycerol percentages with elongation percent values ranging from 10.61±1.44 to 18.67±1.15% and Harumarani (2016) using semi refined carrageenan *Eucheuma cottonii* composite and beeswax and also with the addition of different percentages of glycerol with elongation percent values ranging from 25.99±0.87 to 48.69±0.16%. In this study, an increase in the addition of glycerol percentage caused increased elongation and decreased tensile strength. This is in line with the research of the Japanese Industrial Standard (JIS) stipulating that the percent elongation is categorized as not good if it is less than 10% and categorized as very good if more than 50% (Ariska and Suyatno 2015). Based on the elongation value, the edible film produced in this study can be applied as a primary packaging for food products.

Transparency

Transparency is an aesthetic assessment in marketing edible films. Transparency values represent the level of clarity of the films produced (Mustapa et al. 2017).

Table 4. Transparency of Edible Film Test Results Based on Addition of Glycerol Concentration

Treatment (Glycerol Concentration)	Average
A (0,3 %)	$1{,}66^{a}\pm0{,}12$
B (0,5 %)	$1{,}68^{a}\pm0{,}01$
C (0,7 %)	$1{,}77^{ab}\pm0{,}01$
D (0,9 %)	$1{,}86^{b}\pm0{,}02$
E (1,1 %)	$2{,}00^{c}\pm0{,}09$

Notes:
- The same letter on the same line shows no real different treatment.
- This value is an average of three repetitions ± standard derivation.

The results of the analysis of variance presented in Table 4 show that the treatment of glycerol concentration had a significant effect on the transparency of edible films. The average transparency of edible films in each treatment A (0.3%), B (0.5%), C (0.7%), D (0.9%), and E (1.1%) is 1.66; 1.68; 1.77; 1.86; and 2.00.

The transparency value of edible films produced in this study experienced an increase in the range of 1.66±0.12 to 2.0±0.09. The results of this study are in line with Wattimena's study (2016) which uses natural sago starch and sago phosphate starch with the addition of different percentage of glycerol with a decreased transparency value of 0.71 to 3.68 and Huri's research (2014) which uses the extract of apple skin dregs with the addition of different percentages of glycerol with transparency values that are also increased which ranged from 64 to 56.

In this study, an increase in the addition of glycerol percentage caused the transparency value of the film to increase as well. The greater the concentration of glycerol in making edible film will reduce the brightness of edible films. The higher the concentration of glycerol and alginate used will cause the colour of the edible film to become blurred so that the brightness level decreases. This is related to the increase in the amount of solids by glycerol which is greater which causes the thickness of edible films to increase. The higher the thickness value of the edible film will increase the diffusion of light so that the edible film object will appear more turbid and the brightness will be lower.

The thicker the edible film will give a colour that is not transparent and looks less attractive. In addition, the addition of viscosity will affect the increase in thickness of edible films. This is due to the increase in thickness which will reduce its translucency because the transparency is reduced.

4. CONCLUSION

The addition of glycerol with different concentrations significantly affected thickness, tensile strength, percent elongation, and transparency of edible films from alginate. The best treatment result in edible films is the addition of 0.9% glycerol concentration as the edible film with better treatment than other treatments. The edible film with the addition of 0.9% glycerol concentration has a thickness value that meets the standard of 0.094 mm, high tensile strength 8.25 MPa, elongation percentage of 10.83%, and more transparent which value is 1.86.

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