



CONCENTRATION ADDITION OF PLASTICIZER SORBITOL TO THE CHARACTERISTICS OF CARRAGEENAN EDIBLE FILM

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KeyWords

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ABSTRACT

The research was conducted at the Laboratory of Pressology of Fisheries and Fisheries Faculty of Marine Sciences Padjadjaran University, starting from July to August 2018. This study aims to determine the right concentration of sorbitol so that it can produce the best edible film characteristics. The method used is an experimental method with a completely randomized design (CRD) consisting of 5 different concentration treatments of the sorbitol addition, it is 0.4%, 0.8%, 1.2%, 1.6%, and 2% with 3 repetitions. Parameters measured were tensile strength, percent elongation, thickness, rate of water vapor transmission, water vapor content and solubility. Data were analyzed using analysis of variance with F test and differences between treatments were tested by Duncan's multiple range test with a level of 5%. The results showed that the addition of sorbitol concentration had an effect on the characteristics of edible films. The best concentration is the addition of 2% sorbitol with a thickness value of 0.095 mm, tensile strength of 2.25 Mpa, elongation percent of 28.89%, water vapor transmission rate of 13.93%, water content of 7.66%, and 9.56% solubility.

Introduction

Plastic food packaging is one of the increasing amounts of waste due to the increasing consumption rate, which is 30% of the total solid waste worldwide in 2012 (Hoornweg 2012). Increased use of plastic can lead to increased plastic waste and environmental pollution because plastics are nonbiodegradable or that means they cannot be naturally broken down by microbes in the soil. Therefore, an alternative is needed to replace plastic packaging that has environmentally friendly and easily decomposed properties, one of which is edible film.

Sitompul et al. (2017) said that the edible film is a continuous thin layer made of edible and used material by wrapping, dyeing, brushing or spraying to provide selective containment of gas, water vapor and dissolved materials and protection against mechanical damage. The main components of edible film compilers are categorized into three, namely hydrocolloid (protein or carbohydrate), lipids (fatty acids, acylglycerol or wax), and composites. Dhapanal et al. (2012) said several types of hydrocolloid which can be used in edible films are gelatin, pectin, alginate, carrageenan, starch and so on.

According to Rianingsih et al. (2013) carrageenan has the potential to be developed into edible film because it has the properties of being able to form gels, is stable, edible can be eaten and renewed also contains lots of fiber. Carrageenan is a seaweed sap of the type *Eucheuma cottonii* which is extracted with water or alkaline solution. However, edible films made from carrageenan have the disadvantage of being fragile and low ability as a barrier to water vapor transfer, thus limiting their usage as packaging materials (Handito 2011). To improve the quality of edible film, it is necessary to add plasticizers.

Plasticizer is defined as a substance that does not evaporate, has a high boiling point, and when those added to other materials it is can change the physical properties and mechanical properties of the material (Lee and Wan 2005). Plasticizer acts to reduce fragility, increase film flexibility and durability. The commonly used plasticizers are polyols, glycerol, sorbitol, and polyethylene glycol (Mindarwati 2006). Sorbitol has the advantage of being able to reduce internal hydrogen bonds in intermolecular bonds so that it is good for inhibiting water evaporation from the product (Astuti 2010).

The purpose of this research is to find out the effect of adding sorbitol concentration and to find out the best concentration of sorbitol plasticizers which produce the best edible film characteristics.

Materials and Methods

Time and Place of the Research

The research was conducted at the Fisheries Product Processing Technology Laboratory of the Faculty of Fisheries and Marine Sciences, Padjadjaran University and the Educational Laboratory of the Faculty of Agricultural Industrial Technology, Padjadjaran University, from July to August 2018.

Tools and Materials

The tools used include analytic scales, beakers glass, thermometers, hot plate, magnetic stirrer, stirring rods, printing media, volume pipettes, ovens, micrometers, desiccators, porcelain dishes, and rubber bands. Materials used include carrageenan, sorbitol, distilled water, and silica gel.

Method

The method used in this study is an experimental method with a Completely Randomized Design (CRD) consisting of 5 different concentration treatments of the addition of sorbitol, it is 0.4%, 0.8%, 1.2%, 1.6%, and 2% with 3 repetitions. Parameters

measured were tensile strength, percent elongation, thickness, rate of water vapor transmission, water vapor content and solubility. Data were analyzed using analysis of variance with F test and differences between treatments were tested by Duncan's multiple range test with a level of 5%. The data of the research results are processed and presented in the form of tables and graphs and then analyzed in a comparative descriptive way.

Result and Discussion

Thickness

Film thickness is an important characteristic in determining the expedience of edible films as food product packaging. Thickness can affect the physical and mechanical properties of edible films such as tensile strength, elongation, and solubility. Thick edible film will increase the value of tensile strength, but the elongation value and solubility in water will decrease (Ariska 2015).

The analysis results of thickness variance in edible film which was then followed by Duncan's multiple test showed that the addition of different sorbitol concentrations in carrageenan edible film formulation had a significant effect ($P < 0.05$).

Table 1. Average Number of Edible Film Thickness

Sorbitol Treatment (%)	Average number of Thickness (mm)
0,4	$0,052 \pm 0,0010^a$
0,8	$0,059 \pm 0,0017^b$
1,2	$0,065 \pm 0,0006^b$
1,6	$0,079 \pm 0,0010^c$
2	$0,095 \pm 0,0107^d$

Explanation: the number followed by an unequal letter means that it is significantly different at the 5% level.

As a packaging, the thicker the edible film is the greater the ability of the retainer will become, so that the product's shelf life will be longer (Mc Hugh 1994 in Dwimayasanti 2016). Based on research result, edible film that is too thick will affect the appearance and texture of the product when it consumed. The appearance of edible film that is too thick looks bad and difficult to apply to the product, the thick texture of edible film will slow the solubility when it consumed. Edible film that is not too thick will be easily applied because it is more flexible and easily dissolved.

The thickness of edible film carrageenan ranged from 0.052 mm - 0.095 mm. The highest thickness of edible film was produced in the treatment of 2% sorbitol concentration, which was 0.095 mm, while the lowest edible film thickness was produced in the treatment of 0.4% sorbitol concentration, which was 0.052 mm. Marseno (2003) said that the addition of the plasticizer concentration would increase the polymer that composes the film matrix to coincide with the increase in total dissolved solids in the film solution, thus increasing the thickness of the film.

The thickness of the edible film carrageenan in this study is relatively thinner than some of the previous research, it is called edible films of semirefined composites of carrageenan and beeswax, thickness of 0.065 mm - 0.399 mm (Subiyanto 2013), edible films of carrageenan with 0.222 mm thickness (Rahmawati 2017) and breadfruit starch edible film thickness of 0.19 mm - 0.25 mm (Putra 2017), whereas in Anggraeni's (2002) research on the effect of sorbitol concentration on edible film quality of seaweed for candy coatings, the thickness values obtained were in range of 0,0900 – 0,0975 mm. Standard value of thickness of edible films according to Japanese Industrial Standard (1975) the maximum value is 0.25 mm. The thickness of edible films produced in this research has met the standards, it is ranging from 0.052 to 0.095 mm.

Tensile Strength and Elongation Percentage

Tensile strength is the maximum pull that can be achieved until the film remains before breaking / tearing. Tensile strength properties depend on the concentration and type of edible film composition (Krisna 2011).

The analysis results of the variance showed that the treatment of sorbitol concentrations in carrageenan edible film formulation significantly ($P < 0.05$) on the tensile strength of carrageenan edible film. The average value of edible film tensile strength can be seen in Table 2.

Table 2. Average Number of Edible Film Tensile Strength

Sorbitol Treatment (%)	Average Number of Tensile Strength (Mpa)
0,4	$4,73 \pm 0,36^a$
0,8	$4,41 \pm 0,36^b$
1,2	$3,76 \pm 0,97^{bc}$
1,6	$3,47 \pm 0,36^{bc}$
2	$2,25 \pm 0,68^c$

Explanation: the number followed by an unequal letter means that it is significantly different at the 5% level.

The higher the concentration of sorbitol used, the value of the tensile strength of the edible film produced will decreased. This is due to the fact that sorbitol as a plasticizer can reduce the energy needed by the molecule to move so that its stiffness decreases and causes a decrease in tensile strength (Putra 2017). In addition, sorbitol can also reduce internal hydrogen bonds and increase molecular distance so that the structure of the formed film becomes smoother and more flexible (Gandhi *et al.* 2011).

With the increasing concentration of sorbitol used, then the lower the tensile strength value. The tensile strength value of carrageenan edible film ranged between 2.25 MPa - 4.73 MPa. The highest tensile strength of edible film was obtained from 0.8% sorbitol concentration treatment, which was 4.73 MPa, while the lowest tensile strength of edible film was obtained from the treatment of 2% sorbitol concentration, which was 2.25 MPa.

Previous research conducted by Putra (2017), called edible film made from breadfruit starch has a tensile strength of 10.33 MPa, Rahmawati (2017) with an edible film from carrageenan the value of the tensile strength is 7.136 MPa, and Subiyanto (2013) with edible film made from composite semirefined carrageenan produces tensile strength values ranging from 0.9549 MPa - 4.8654 MPa. According to Japanese Industrial Standard (1975) the minimum tensile strength value of edible film is 0.3 MPa. Based on this value, the tensile strength of edible film on the addition of sorbitol research has met the standard of 2.25 MPa - 4.73 MPa.

Elongation percentage is a length change percentage of the edible film when it is pulled to break (Krochta 1997). The greater the elongation percentage value, the better the edible film is because it is more elastic and not easily to torn (Yulianti 2012).

The analysis results of the variance showed that the treatment of sorbitol concentrations in carrageenan edible film formulations significantly effected ($P < 0.05$) on edible film lengthening percent. The average of carrageenan edible film elongation percentage can be seen in Table 3.

Table 3. Average Number of Edible Film Elongation

Sorbitol Treatment (%)	Average Number of Elongation Percentage (%)
0,4	7,78 ± 1,92 ^a
0,8	16,67 ± 1,67 ^b
1,2	23,33 ± 1,67 ^c
1,6	27,22 ± 4,81 ^c
2	28,89 ± 0,96 ^d

Explanation: the number followed by an unequal letter means that it is significantly different at the 5% level.

Edible film elongation Percent increases with increasing concentrations of sorbitol in edible film formulations. This increasing happen due to the sorbitol characteristic as a plasticizer that can increase the flexibility of the film. This is supported by the opinion of Khwaldia et al. (2004) that the addition of plasticizers can also cause intermolecular forces to decrease along the polymer chain so as to increase film flexibility.

As the concentration of sorbitol increases, the percentage of elongation increases. The tensile strength value is inversely proportional to the percent elongation value (Rusli 2017). Percentage value of carrageenan edible film lengthening ranging between 7.78% - 28.89% (Table 3). The highest tensile strength of edible film was obtained from 2% sorbitol concentration treatment which was 28.89%, while the lowest tensile strength of edible film was obtained from 0.4% sorbitol concentration treatment which was 7.78%.

Edible films with a high percentage of elongation have high flexibility (Katili 2013). Based on research result, if it is applied as food packaging it is easy to apply and not easily torn so that the packaged product will be safer and longer lasting. Edible films with a low percentage value of elongation have low flexibility and are rather rigid so that it is difficult to apply as a food product packaging.

Comparison of percentage elongation value edible film with previous research called Putra (2017), edible film made from breadfruit starch produced a percent elongation value of 5.29%, Subiyanto (2013) with edible film made from semirefined composites, carrageenan and beeswax has percent elongation values ranging from 0.6077% - 0.7370%, and Rahmawati (2017) with edible films made from carrageenan, the percentage of elongation produced was 20.46%. According to Japanese Industrial Standard (1975) for the percent elongation value of edible films is categorized as not good if it is less than 10% and categorized as very good if more than 50%. In this research the percent elongation value in the addition of 0.4% sorbitol was categorized as poor and the treatment of adding sorbitol 0.8%, 1.2%, 1.6%, and 2% was categorized as good.

Water Vapor Transmission Rate

Water Vapor Transmission Rate (WVTR) is a method to measure the amount of water vapor that can pass through the packaging layer. The higher the WVTR value, the more water vapor comes out from inside or into the packaging. A good edible film must not be easily passed by steam or has a low WVTR value.

The analysis results of the variance showed that the addition of sorbitol concentration in the edible film carrageenan formulation had a significant effect ($P > 0.05$) on the rate of transmission of edible film vapor. The average value of the water vapor transmission rate can be seen in Table 4.

Table 4. Average Number of Edible Film Water Vapor Transmission Rate

Sorbitol Treatment (%)	Average Number of Water Vapor Transmission Rate (%)
0,4	10,41 ± 0,06 ^a
0,8	10,89 ± 1,12 ^a
1,2	12,28 ± 0,86 ^{ab}
1,6	12,81 ± 1,64 ^b
2	13,93 ± 0,49 ^b

Explanation: numbers followed by unequal letters mean that they differ significantly at the 5% level.

The rate of water vapor transmission increases with the addition of sorbitol concentrations in edible film formulations. This is because the type of plasticizer used is sorbitol. Sorbitol is a polyhydric alcohol monosaccharide compound which is hydrophilic, increasing the hydrophilic component contained in the film causes the water to penetrate the film easily, thereby increasing the value of the water vapor transmission rate (Putra 2017).

According to Namet et al. (2010) an increase of water vapor transmission rate is thought to be caused by the plasticizer characteristic which is hydrophilic and is able to reduce the voltage between molecules in the edible film matrix which causes the space between molecules to increase so that water vapor can penetrate the edible film.

The water vapor transmission rate value of carrageenan edible film ranges between 10.41 g / mm² / 24 hours - 13.93 g / mm² / 24 hours. The highest water vapor transmission rate of edible film was produced in 2% sorbitol concentration treatment, which was 13.93 g / mm² / 24h, while the lowest water vapor edible film transmission rate was obtained in the 0.4% sorbitol concentration treatment which was 10.41 g / mm² / 24 hours.

Comparison of water vapor transmission rate with previous research called Putra research (2017) edible film made from breadfruit starch produced a value of water vapor transmission rate of 462.11 g / m² / 24 hours and Rahmawati (2017) edible film made from carrageenan has a water vapor transmission rate value of 6.83%. According to Japanese Industrial Standard (1975) the maximum value of edible film vapor transmission rate is 10 g / m² / day. The value of the transmission rate of water vapor edible film in this research ranges from 10.41 - 13.93 g / mm² / 24 hours does not met the standard because it exceeds the maximum value.

Water Content

The water content of edible films has an important role in the stability of the product to be coated. Edible films with low water vapor content will affect their shelf life so they can last longer. The water content of edible films is related to thickness, the thicker the edible film the higher the water content.

The analysis results of the variance showed that the treatment of sorbitol concentration in carrageenan edible film formulation has a significant effect ($P < 0.05$) on the water content of edible films. The average water content of edible films can be seen in Table 5.

Table 5. Average Number of Edible Film Water Content

Perlakuan Sorbitol (%)	Average Number of Water Content (%)
0,4	4,07 ± 0,51 ^a
0,8	7,18 ± 0,28 ^b
1,2	6,24 ± 0,69 ^c
1,6	9,50 ± 0,26 ^c
2	7,66 ± 0,32 ^d

Explanation: the number followed by an unequal letter means that it is significantly different at the 5% level.

Water content in foodstuffs affects the shelf life of these foodstuffs. The higher the value of edible film water content, the shorter the shelf life of edible films, and vice versa (Setiani 2013). Water content has an influence on the character of edible films, especially on the physical properties of the edible film. The higher the water content value of edible film causes edible film to become more fragile and soft texture. If the water content in edible film is low, edible film has flexible properties, but if it is too low edible the film will be rigid and have a low stretch (Ilah 2015).

The value of water content in this research fluctuated, while the difference in the high value of water content in this research was suspected due to the surrounding air humidity associated with the storage of materials, the characteristic and type of material and the treatment experienced by the material (Wirakartakusumah 1981). Increased water content due to sorbitol besides functioning as a plasticizer also functions as a sweetener and humectant, which is an additive that is hygroscopic and serves to maintain water content in a material (Bourtoom 2007).

The addition of different sorbitol concentrations has varying water content values. The value of edible film carrageenan water content ranged from 4.07% - 9.50%. The highest water content was produced in the treatment of 1.6% sorbitol concentration, which was 9.50%, while the lowest water content was produced in the treatment of 0.4% sorbitol concentration, which was 4.07%. The increase in the addition of sorbitol concentration can increase the water content value of edible films.

Based on the results of previous research conducted by Riyanto (2017), the edible film made from wheat starch has a water vapor content ranging from 5.7% - 11.46% and Subiyanto (2013) with edible films made from composite semirefined carrageenan and beeswax to produce water vapor content of 44.62% - 51.49%. According to Japanese Industrial Standard (1975) the maximum value of edible film water content is 13%. The water content value of edible film in research with the addition of different sorbitol has met the standard because it does not exceed the maximum value of 4.07% - 9.50%.

Solubility

Solubility in edible films is done to determine the ability of edible film to dissolve in water, so that in ingested process, it can be digested properly. The level of solubility is determining possibility factor of an edible film being applied (Garcia et al. 2000).

The results of the analysis of variance showed that the treatment of sorbitol concentrations in carrageenan edible film formulations has a significant effect ($P < 0.05$) on the solubility of edible films. The average solubility value of edible films can be seen in Table 6.

Table 6. Average Number of Edible Film Solubility

Sorbitol Treatment (%)	Average Number of Solubility (%)
0,4	$7,53 \pm 0,17^a$
0,8	$8,79 \pm 0,26^b$
1,2	$8,47 \pm 0,66^b$
1,6	$9,49 \pm 0,26^c$
2	$9,56 \pm 0,17^c$

Explanation: the number followed by an unequal letter means that it is significantly different at the 5% level.

The greater the solubility value of edible film, the more edible film dissolved. Bourtoom (2008) states that edible film forming materials that are hydrophilic will dissolve more quickly in water compared to hydrophobic materials such as beeswax, wax and paraffin. Edible films with low solubility values will be difficult to dissolve in water so that they are less suitable to be applied as

food product packaging.

The solubility value of carbohydrate edible films ranged from 7.53% - 9.56%. The highest solubility was obtained in the treatment of 2% sorbitol concentration which was 9.56%, while the lowest water content was produced in the treatment of 0.4% sorbitol concentration, which was 7.53%. Along with the addition of sorbitol the solubility of edible films is higher.

Solubility value comparison of edible films with previous research, called Subiyanto's research (2013), edible films made from semirefined composites of carrageenan and beeswax have solubility values ranging from 20.11 - 21.17% and Riyanto (2017) with edible films made from wheat starch producing value solubility ranged from 39.14 to 64.04%.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the addition of sorbitol concentration has a significant effect on thickness value, tensile strength, elongation percentage, water vapor transmission rate, water content, and solubility of carrageenan edible film.

Edible film with the addition of 2% sorbitol is the best concentration with a thickness value of 0.095 mm, tensile strength of 2.25 Mpa, elongation percentage of 28.89%, water vapor transmission rate of 13.93%, water content of 7.66%, and solubility of 9, 56%. 2% concentration produces edible films that almost met the standards so it is good to be used as food products packaging.

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