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The Effect of Sorbitol Concentration on The Characterictics of Purple Yam Starch (*Dioscorea alata*) Based Edible Film

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Abstract :
Edible film is a thin layer made of edible material, used as a food surface coating that serves to inhibit the migration of moisture, oxygen, carbon dioxide, aroma, and lipids. This research used yam starch (*Dioscorea alata*) as the main ingredient in the production of edible film and sorbitol as plasticizer. The aim of the research was to determine the effect of sorbitol at different concentration on the characteristic of yam starch-based edible film. Sorbitol was applied at different concentration (w/w): 0.67%, 0.80%, 0.93%, 1.07%, 1.20% and 4 replications. Sorbitol concentration was found to be a significant factor affecting the value of water vapor transmission rate and sweetness, but not a significant factor for thickness, transparency, brightness and solubility of edible film. The concentration of sorbitol 0.67 is preferred for edible film with 0.15mm thickness, transparency 11.87%/mm, compressive strength 52.150%, solubility 9.60%, water vapor transmission rate 18.1608g/m^{2}h and brightness 59.525.

Keywords: Edible Film, Sorbitol, *Dioscorea alata*

1. Introduction

The increasing number of people in the world have caused food demand to increase. The world community increasingly understands the importance of food quality, namely by increasing awareness of the use of packaging that is easily degrades and safe for health. Packaging is one of the important factors supporting success in the food industry. It protects the product from external damage (environment) and maintains product quality as well as a media for product information. Plastic packaging is often found in everyday life due to the various advantages of plastic such as easy to obtain, more economical and multifunctional. However, the plastic packaging is believed to have adverse effects on health and the environment (Zuhri, 2010). To overcome this, a type of food packaging that is environmentally friendly and has biodegradable characteristics has been developed, namely edible film (Amaliya et al., 2014).

Edible film is a thin layer that functions as a food packaging that can also be eaten along with the packaged product. Edible films can also be used as carriers of food components using relatively cheap materials, easily biodegradable and simple manufacturing technology. Polymeric materials that make up edible films are divided into three categories, namely hydrocolloids, fats and composites of both (Tampubolon 2012). Hydrocolloid biopolymer materials are composed of starch and protein. The manufacture of edible film uses starch-based materials such as yam starch, which is formulated with plastizicer in the form of sorbitol.

Starch has physical characteristics similar to plastic such as colorless, odorless and tasteless. Starch compounds are composed of two components, amylose and amylopectin. Starch with high amylose content produces a flexible and strong edible film because the structure of amylose can form hydrogen bonds between glucose molecules and during heating can form a three-dimensional network that can trap water to produce a strong gel, while amylopectin can influence the stability of edible film (Herawati 2011).

Yam (*Dioscorea alata*) is a starchy staple food crop that is very important in tropical and sub-tropical agriculture as it exhibits a vigorous growth cycle. Edible films made from starch are generally brittle and easily damaged/torn due to their low water vapor barrier properties because they are hydraulic. These conditions can be overcome by adding plasticizers, among others, by reducing the intermolecular forces along the constituent polymer chains. Plasticizers commonly used are monosaccharides (glucose), disaccharides (sucrose), oligosaccharides, polyols (glycerol, sorbitol, polyethylene glycol) and fats and their derivatives. Sorbitol is one of the plasticizers that is often used in the manufacture of edible films. Baldwin, et al. (2012) stated that sorbitol reduces internal hydrogen bonds in intramolecular bonds. The right sorbitol concentration will affect the characteristics of edible film. Riyanto (2017) used sorbitol concentration ranging from 1% to 2.2% (w/b) and produced film with moisture content value ranged from 5.7-11.62%, elongation 2.56 to11.94%, solubility 39.14 to 64.04%, water vapor transmission rate 54.9 to 16.7g/m.h.Pa, and tensile strength 132.04 to 339.15 kg/cm^2. Rimadianti (2007) used sorbitol concentration 1.2% with a better film characteristic such as the tensile strength ranging from 937.09 to 1384.61 Kgf/cm^2 and elongation ranging from 110.04 to 171.24%. Based on these facts, this research was conducted to determine the effect of sorbitol concentration on the characteristics of edible film made out of yam starch.

2. Research Methods

Materials and Tools

The materials used in this study were yam (*Dioscorea alata*), sorbitol, water, salt and distilled water. The tools for conducting this research were micrometer screw, petri dish, RH meter and texture analyser.

Research Design and Statistical Analysis

This experiment used a completely randomized design (CRD) with sorbitol concentration as the treatment (w/w): 0.67%, 0.8%, 0.93%, 1.07%, and 1.20%. Each treatment was repeated 4 times. Data obtained on edible film were analyzed using ANOVA and if there was an effect of treatment then further tests were carried out using Duncan New Multiple Range Test.

Extraction of yam starch (Ulyarti et al., 2016)

Yam tuber were peeled, washed and sliced with a thickness of 0.5cm. The slices were then soaked in a salt solution for 30 minutes to remove the mucus, after which they were crushed using a blender with the addition of water as much as 1:2 (yam : water). The yam pulp were then filtered using a 200 mesh sieve and deposited for 4 hours. The sediment was collected, washed with distilled water and then soaked with distilled water for 30 minutes. The sediment was collected and dried in oven for 4 hours at 50^{o}C.

Preparation of Edible Film

4 grams of yam starch was dissolved with distilled water and the volume of the solution was adjusted to 150 grams by adding distilled water taking into account the amount of sorbitol used. The solution was stirred using a stirring rod for 10 minutes followed by heating and stirring using a hotplate for 20 minutes. Sorbitol was added according to the treatment (1 gram, 1.2 grams, 1.4 grams, 1.6 grams, 1.8 grams) and the heating was continued for another 30 minutes at 80^{o}C. 25 grams of film solution was poured into a petri dish and dried in an oven at 50^{o}C for 24 hours. The film was kept in equilibrium in RH50% at room temperature at least 24 hours before analysis (Wattimena, et al., 2016).

Parameters Analysis

The parameters observed were yield, transparency (Pineroz-Hernandez, 2017), solubility (Gontard et al., 1992), film thickness (Mendes et al., 2016), compressive strength (N/m^2), waater vapor transmission rate/WVTR (Pineroz-Hernandez, 2017) and color.

Data Analysis

The data obtained were analyzed using analysis of variance and followed by Duncan's New Multiple Range Test (DNMRT) when necessary.

3. Results and Discussion

Physical Characteristics

Transparency describes the clarity of the edible film produced. The analysis of variance shows that the addition of 0.67% to 1.20% does not affect transparency of edible films despite the trend of decreasing transparency as sorbitol concentration increased (Table 1). Similar to this result, previous study by Cao et al (2018) reported that the transparency of edible film decreased with increasing sorbitol concentration.

The solubility of edible film in water is expressed as the percentage of the edible film that dissolves in water after immersion for 24 hours (Ulyarti et al., 2019) and is an important factor in determining usage of edible film. The analysis of variance showed that the concentration of sorbitol does not affect the solubility of edible film (Table 1). Sorbitol has hydrophilic properties and dissolve completely in water so that the higher the concentration of sorbitol, the higher the solubility value. Sobral et al (2001) reported that increasing plasticizer concentration increases the moisture content of the film due to high hygroscopicity between adjacent macro molecules.

The thickness increased with the increase in plasticizer concentration. The highest thickness was obtained in the treatment of sorbitol concentration as a plasticizer of 1.07% (w/b) amounting to 0.17 mm. Marseno (2003) explained that the higher concentration of plasticizer will increase the viscosity and total solids in edible film so that the thickness of the film will increase.

The brightness of edible film may affect the appearance of the packaged product. Edible films can provide a clear or dull color (Pavlath and Orts, 2009). The brighter edible film gives a better the appearance of the packaged product. Based on the anova, it can be seen that the brightness level (L) is not significantly different in each treatment. The level of brightness (L) in the addition of sorbitol concentrations of 0.67%, 0.80%, 0.90%, 1.07% and 1.20% tends to produce the same level of brightness. This is in accordance with the opinion of Bertuzzi, et al. (2007), which states that low plasticizer levels in edible films (<15%) produce high transparency. When plasticizer levels exceed 15% various changes occur and bond mobility increases, and when the plasticizer reaches 30% with increased environmental humidity, the network expands, the intermolecular forces decrease and the polymer matrix absorbs a lot of water, as a result the edible film loses its transparency.

Table 1. Physical characteristics of edible film at different concentration of sorbitol.

[Sorbitol] (w/b)	Transparency (%/mm)	Solubility (%)	Thickness (mm)	Brightness (L*)
0.67	11.87	9.60	0.15	59.525
0.80	11.74	30.05	0.16	59.100
0.93	12.56	20.50	0.15	59.525
1.07	10.71	19.99	0.17	59.100
1.20	10.67	28.06	0.16	58.750

Table 2. Mechanical, barrier and sensory characteristics of edible film at different concentration of sorbitol.

[Sorbitol](w/b)	Compressive Strength (N/m^2)	WVTR (g/m^2h)	Sweetness Score*
0.67	52.150	18.1608 a	1.55 a
0.80	51.800	25.2671 b	1.65 ab
0.93	52.725	19.2136 ab	2.40 c
1.07	57.675	20.2664 ab	2.00 b
1.20	53.100	32.8999 c	2.50 c

Notes: Numbers followed by the same lowercase letter in the same column are not significantly different at the 5% level according to the DNMRT test.
* Score: (4) Much sweeter than R; (3) Sweeter than R; (2) slightly sweeter than R; (1) same as R

Mechanical and Barrier Characteristics

Compressive strength is a parameter which determines how strong the edible film withstands certain loads. As seen in Table 2, the increasing in the concentration of sorbitol does not significantly affect the compressive strength of edible film. However, the trend is that the greater the concentration of sorbitol, the higher the compressive strength. According to Tampubolon (2012), the thickness is also relate to the force needed to press the edible film so that the compressive strength. Therefore the effect of sorbitol concentration on thickness is similar to the effect on compressive strength (Table 1, 2).

Water Vapor Transmission Rate (WVTR) is the most important parameter in assessing the quality of edible film, WVTR is the movement of water vapor in a certain unit of time through a unit area at humidity temperature (Putranto, 2005). This WVTR value will show the ability of edible film to inhibit water vapor. The greater the WVTR value, the worst the quality of edible film as it is unable to inhibit water vapor. In this study, sorbitol concentration affects water vapor transmission rate of edible film. Table 2 shows the value of water vapor transmission rate of edible film increases with increase in sorbitol concentration with an exception on sorbitol concentration 0.8%. This is in accordance with the results reported by Ulyarti et al (2019) and Khwaldia, et al (2004) stating that the water vapor transmission rate increases with the increase of plasticizer concentration. Similar result was also reported by Riyanto et al (2017) using wheat starch and 2.2% sorbitol. Donhowe (1993) and McHugh (1994) added that edible films with sorbitol plasticizers have a greater water vapor permeability value than those with glycerol plasticizers. This is due to a larger molecular size of sorbitol than glycerol. This molecular size will increase the free volume between polymer chains to facilitate the transfer of water molecules.

Sweetness Score

The addition of sorbitol concentration has a very significant effect on the sweetness of the edible film (Table 2). In the production of edible film which mainly aims for packaging, the sweetness should be considered carefully as it may affect the consumer's acceptance. In this point of view, the lowest concentration of sorbitol is preferred.

Conclusion

Sorbitol concentration in the manufacture of edible film from yam starch has a significant effect on the value of water vapor transmission rate and sweetness, but has no significant effect on the characteristics of thickness, transparency, brightness and solubility of edible film. The concentration of sorbitol 0.67 is suggested for edible film production with the thickness 0.15mm, transparency 11.87%/mm, compressive strength 52.150%, solubility 9.60%, water vapor transmission rate 18.1608g/m^{2}h and brightness of 59.525.

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