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The Effect of *Aloe vera* and Glycerol Addition on Edible Film of Lesser Yam Starch (*Dioscorea esculenta* L. Burkill)

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Abstract. *Edible films are thin layers made from hydrocolloids, lipids, and their combinations, functioning as a barrier to mass transfer. The hydrocolloid source that commonly used for edible film is starch. Lesser yam has the potential to be developed into food packaging products. It has a high starch yield (21.4%). The starch properties, which usually obstruct the edible film production are not resistant to high temperature, it produces a starch suspension with viscosity and ability to form a gel is not uniform, cannot stand in acidic conditions, does not resist stirring, limited solubility in water, and starch gel is easy to syneresis and brittle. This study aimed to investigate the effect of glycerol and Aloe veraconcentrations on the physical and mechanical edible film. Randomized complete block design (RCBD) factorial with two factors was adopted. The first factor was Aloe vera concentration (0, 1%, 0.2% and 0.3% w/v), and the second factor wasglycerol concentration (17.5, 22.5 and 27.5% v/w). The parameters tested included thickness, tensile strength, elongation, solubility, transparency, and water vapor transmission rate (WVTR). The results showed an interaction between the addition of glycerol and Aloe vera to thickness, tensile strength, elongation, solubility, transparency, and WVTR. The best characteristics of edible film were produced by the addition of glycerol 17.5% and Aloe vera 0.1% with thickness (0.08 mm), transparency (1.72 mm^{-1}), tensile strength (0.156 MPa), elongation (17.25%), solubility (53.89%), and WVTR (4.09 g m^{-2} 24 h^{-1}).*

Keywords: *edible film, lesser yams, glycerol, Aloe vera*

INTRODUCTION

Food packaging is important to protect food from damage. Lately, almost all food packaging materials are made on plastic. Therefore, it needs to develop food packaging materials that are biodegradable with characteristics similar to plastic. One type of packaging that is environmentally friendly (biodegradable) and the characteristics are almost like plastic is edible film. The main ingredients for forming edible films are biopolymers such as proteins, carbohydrates, and lipids (Bourtoom, 2009). Tubers that have great potential to be developed as raw material for food packaging formation is lesser yam (*Dioscorea esculenta* L. Burkill). According to Suhardi (2002), lesser yams has the highest yield of starch and starch flour (24.28% and 21.4%) compared to other tubers.

Natural starch produces a starch suspension with viscosity and gel forming ability are inconsistent, cannot stand in acidic conditions, does not resist stirring, limited solubility in water, then starch gel easily undergoes syneresis and brittle (Jouki et al., 2013; Siskawardani, et al., 2020). Chemical modification using the cross-linking agent, *Aloe vera* has expanded. The monophosphate starch formation will make dispersions that have higher viscosity, and better clarity, as well stability. This is due to monophosphate group presence, which can significantly reduce the starch gelatinization temperature. The edible coating from *Aloe vera* gel has been used for mangoes (Dang et al., 2008), apples (Ergun and Satici, 2012), and grapes (Serrano et al., 2006).

Glycerol is used effectively as a plasticizer in hydrophilic films, such as pectin, starch, gelatin, as well as in protein-based biodegradable films formation (Araujo-Farro et al., 2010). Glycerol molecules will interfere the compactness of basic polymer materials by decreasing intermolecular interactions and increasing polymer mobility thereby improving the flexibility and extensibility of edible films (Ghasemlou et al., 2011). The purpose of this study was to determine the interaction between glycerol and *Aloe vera* on the physical and mechanical characteristics of edible film.

MATERIAL AND METHOD

Material

The main materials included lesser yams (*Dioscorea esculenta* L.Burkill) obtained from Paciran Sub district, Lamongan Regency, East Java, Indonesia with a harvest age of 9 months.

Equipment

The equipment consisted of glass plates (20 cm x 20 cm), baking sheets (20 cm x 20 cm x 2 cm), analytical scales, thermometers, cabinet dryer, WVTR glass, screw micrometer, texture analyzer, and spectrophotometer.

Research Procedure

This research consisted of two main step. (i) Leser yam starch production started with sorted process, peeled to remove the skin, and washed thoroughly. Then Leser yam was soaked using a saline solution to remove mucus and calcium oxalate for 2 h, followed with washed and grated. The addition of water ratio was 4:1 of Leser yam, then filtered for separating the filtrate and pulp. The filtrate was precipitated for 24 h, washed 3 times, then dried using a cabinet dryer for 12 h at 60 °C. After drying, the precipitate was blended and sieved using 80 mesh size. (ii) The edible film making, started with weighed starch 3.5% w/v. *Aloe vera* addition comprised of 3 concentration (0, 1%, 0.2% and 0.3% w/v). Glycerol was measured at concentrations of 17.5%, 22.5%, 27.5% (v/ leser yam). Leser yam starch, *Aloe vera* and glycerol made suspension with the addition of Aquades 150 mL, then heated using a hot plate at 80 °C for 10 min. The suspension heated was cooled at 30 °C, then poured onto a glass plate. The edible film solution was dried at ± 50 °C for 18 h to 24 h, and cooled at room temperature for 15 min.

Reserach Parameter

The edible film ready to be analyzed thickness (micrometer), tensile strength and elongation (texture analyzer), transparency (spectrophotometer at 560 nm), solubility and water vapor transmission rate (WVTR) (Siskawardani, et al., 2020; Warkoyo, et al., 2014).

Research Method and Data Analysis

The randomized complete block design factorial (RCBD) with two factors and 3 replications was adopted. First factor was *Aloe vera* concentration (P) that comprised of 3 levels (0, 1%, 0.2% and 0.3% b/v), while second factor was glycerol (G) which consisted of 3 levels (17.5%, 22.5%, and 27.5% v/b starch). The Analysis of Variance (ANOVA) was used and continued with the comparative test of DMRT (Duncan's Multiple Range Test) with a significance level of 5%.

RESULTS AND DISCUSSION

Thickness and Transparency of Edible Film

There was an interaction between glycerol and *Aloe vera* on thickness and transparency of the edible film produced, and the thickness and transparency value can be seen in Table 1. The glycerol and *Aloe vera* had a significant effect on the thickness. The glycerol ability to bind water is the main factor, when glycerol concentration is higher, the water evaporation rate become lower. As the results, some water in the film solution bound by glycerol, and the edible film produced is thicker. This is in accordance with the opinion of Ahmadi et al.(2012) reported increased thickness in edible films from psyllium hydrocolloid in response to the enhancement of glycerol concentration. According to Dick et al., (2015), the films with high glycerol concentration adsorbed more moisture resulting in increased thickness because of swelling. The glycerol properties of being easily soluble in water, increasing the viscosity and water binding of solution. According to Wahyudi (2009), when heating process, there are many broken starch granules, *Aloe vera* addition will make the broken granules become lesser, thus producing a compact paste due to the water molecules trapped inside the starch granules. As the result, the polymers that compiler the film matrix are also greater. Compared to edible film from banana starch, the thickness value was below 0.22 mm (Wulansari, 2016).

The combination of glycerol and *Aloe vera* gave significant effect on the transparency. The increasing glycerol concentration and *Aloe vera* produced transparency levels was higher. Increased transparency values indicate the brightness of edible films. Transparency will be directly proportional to the thickness and materials concentration. When the thickness or concentration of material passed increases, so the light quantity will be more absorbed. In addition, the factors that influence transparency are the raw materials characteristics (Wiryawan, 2007). In addition, it may due to in polyethylene glycol consisted high molecular weight and low content of hydroxyl groups (Hafnimardiyanti and Armin, 2016).

Elongation of Edible Film

The addition of plasticizers is very important to solve the fragility and improve flexibility of edible film (Barreto, et al., 2003). The glycerol and *Aloe vera* concentrations separately gave significant effect on the edible film elongation (Table 1.). The plasticizers addition can decrease the intermolecular force of the polymer chain length, but increase the flexibility. *Aloe vera* addition causes a reaction among starch molecules, as the result the monophosphate starch formed. Monophosphate starch can prevent the expansion and rupture of starch granules due to heating, because it can reduce starch gelatinization temperature. Wahyudi (2009) stated that, during heating process, many starch granules were broken, *Aloe vera* addition resulted broken granule smaller. Thus producing a compact paste due to the presence of water molecules trapped inside starch granule, and it would increase the edible film mobility and elongation. The elongation value was upper than edible film based on banana 8.2% (Wulansari, 2016)

Table 1. Thickness, Transparency and Elongation of Edible Film

Treatment	Thickness (mm)	Transparency	Elongation (%)
P1G1	0.08[a]	1.72[a]	17.25[ab]
P1G2	0.09[b]	1.74[a]	15.55[ab]
P1G3	0.11[c]	1.80[b]	8.6[a]
P2G1	0.12[d]	2.13[c]	50.85[c]
P2G2	0.13[e]	2.19[d]	25.09[b]
P2G3	0.14[f]	2.23[d]	22.69[b]
P3G1	0.17[g]	2.31[e]	3.12[a]
P3G2	0.18[h]	2.37[f]	4.11[a]
P3G3	0.20[i]	2.38[f]	6.6[a]

The numbers followed by the same letter in each column shows insignificant differences according to Duncan's test α 5%.

Solubility and Tensile Strength of Edible Film

There was an interaction between glycerol and *Aloe vera* on the solubility and tensile strength of edible film (Table 2.). The solubility values (28.15%-56.65%), were very higher from previous research (17.18%) (Krisna, 2011). The solubility value had positive correlation to the glycerol and *Aloe vera* concentrations. The glycerol diminishes interactions between biopolymer molecules, in result increasing solubility because of its hydrophilic nature (Dick et al., 2015). Solubility become higher as the hydrophilic component of edible film, as the result water absorbed increased (Mehyar and Han, 2004; Hafnimardiyanti and Armin, 2016). In addition, the increasing number of hydroxyl groups affect to the enhancing water level is getting easier and faster into the polymer matrix and creates more mobile area with greater interchain distances (Dick, et al., 2015; Saibuatong and Phisalapong, 2010). Based on Guiterrez and Alvarez, (2016) the edible film with high solubility, it was perfect to applied in candy because it's easy to melt in mouth.

The tensile strength had positive correlation with increasing concentration of glycerol and *Aloe vera*. This result was consistent to the edible film based on modified arrowroot starch (Hafnimardiyanti and Armin, 2016). This is caused *Aloe vera* ability to bind with fibril tissue, therefore it able to increase the tensile strength (Saibuatong and Phisalapong, 2010; Miranda et al., 2018). In accordance to Park, et al., (1995) and Siskawardani, et al., (2020) reported that the addition of glycerol reduced the force among molecules through polysaccharides chain, so that the edible film structure become finer and more flexible. Glycerol is able to enter into the polymer chain, it will disrupt the starch compactness, reduce the intermolecular interactions and increase polymer mobility, so the film becomes elastic, but tensile strength become stronger (Warkoyo, et al., 2014).

Table 2. WVTR, Solubility, and Tensile Strength of Edible Film

Treatment	WVTR	Solubility (%)	Tensile Strength (MPa)
P1G1	4.09^{e}	53.89^{ef}	0.156^{a}
P1G2	3.85^{de}	54.93^{f}	0.237^{b}
P1G3	3.71^{d}	56.65^{f}	0.353^{c}
P2G1	3.40^{c}	41.03^{d}	0.555^{d}
P2G2	3.26^{c}	46.43^{e}	0.722^{e}
P2G3	2.98^{b}	49.20^{e}	0.875^{f}
P3G1	2.92^{b}	28.15^{a}	1.114^{g}
P3G2	2.88^{b}	31.48^{b}	1.376^{h}
P3G3	2.61^{a}	53.89^{ef}	1.522^{i}

The numbers followed by the same letter in each column shows insignificant differences according to Duncan's test α 5%.

WVTR of Edible Film

There was an interaction between glycerol and *Aloe vera* significantly on WVTR edible films produced. The glycerol and *Aloe vera* interaction significantly affected edible film WVTR (Table 2.). Enhancement of glycerol and *Aloe vera* concentration produce transmission of water vapor become lower. In accordance to the Pinzon et al., (2018) the presence of *Aloe vera* reduced the hydrophilic groups availability in starch and decreased the WVTR by a crosslinking effect with the starch molecules. The height of water vapor transmission rate indicates the component that can pass through the edible film also greater. Conversely, if the WVTR value gets lower then the ability of edible film in order to resist water evaporation will be lower. In addition it's related to the high water content of *Aloe vera* 98.6 % (Monzon-Ortega et al., 2018). Glycerol also contributed, due to has hydrophilic which add polar properties in the film that increase intermolecular distance. Therefore internal hydrogen bonds and intermolecular stresses of edible film matrix decreased, and the distance caused moisture to penetrate and enhanched permeability (Yuliastiani et al., 2020).

CONCLUSION

It can be concluded that there is significantly interaction between concentration of glycerol and *Aloe vera* on thickness, transparency, solubility, tensile strength, elongation and water vapor transmission rate (WVTR) of edible starch. The best treatment is G1S1 (17.5% glycerol and 0.1% *Aloe vera*) with thickness (0.08 mm), transparency (1.72 A_{546}/mm), solubility (53.89 %), tensile strength (0.156 MPa), elongation (17.25 %) and WVTR (4.09 g m^{-2} 24 h^{-1}).

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