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The utilization of gadung (*dioscorea hispida dennst*) starch for edible coating making and its tomato packaging

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Abstract. An edible coating is one method that could be utilized in preserving and coating on fruits. The utilization of gadung (*Dioscorea hispida* Dennst) starch as a raw material in edible coating making can be used as an alternative renewable raw material due to of high starch content and its potential still not been utilized optimally. This study has been evaluated the influences of hydrocolloids and plasticizers contents of the mixture to produce proper tensile strength and elongation of the coating produced. The quality and characterization of edible coating have been evaluated using weight loss test, thickness test, elongation test, tensile strength test and oxygen permeability test. The gadung starch edible coating was shown to be effective in tomato fruit preserved until 21 days. Mechanical properties of edible coating were obtained the tensile strength ranging from 5.76 to 7.03 kgf.mm⁻², elongation ranging from 13.57 - 38.56%, thickness ranging from 0.01 - 0.05 mm and optimum oxygen permeability of 3.739 g.m⁻².h⁻¹ by adding of the CMC of 1% and glycerol of 10%.

1. Introduction

Fruit is an important source of nutrients and energy for human life. The problems faced by fruit traders and consumers is on how to maintain longer its freshness and quality [1]. The decreasing of fruits quality can be affected by oxygen and water content, light exposure and storage time. To overcome the degradation of fruit quality in order to prolong its shelf life before consumption can be carry out by cooling, packaging with plastic and storage in atmospheric conditions [2]. Among disadvantages of packaging with plastic would damage the fruits due to its characteristic might could entrap water vapor and instable if excessive exposed to heat [3]. The best way to maintain the quality of fruits is to use edible coating [4, 5].

An edible coating is a method used to extend shelf life and maintaining the quality of fruits at room temperature. An edible coating is a thin layer that aims to provide a selective resistant of mass transfer so that fruits can maintain weight loss [6]. Edible coatings can be made from three different types of materials: hydrocolloids, lipids, and composites. Edible coating layer provides an alternative as a packaging material that lesser impact on environmental pollution due to its safer and biodegradable materials and low cost [4].

One of the most effective ways to retain fruit shelf life is to packaging the fruits with edible coating [7]. The edible coating is safe for consumption. In this study the edible coating layer is made from starch of gadung (*Dioscorea hispida* Dennst) due to of its starch is easily biodegraded into harmless



compounds. In Indonesia there are various plants producing starch such as cassava, gadung, taro, rice, potato, sorghum, banana and others [5]. Therefore, this research utilizes gadung as raw material for edible coating production because gadung contains starch is rarely consumed and by society due to complicated processing process. The utilization of hydrophilic plasticizers could increase edible coating solubility. The most widely used plasticizer in edible coating making is glycerol. This study proposed the preparation of edible coating from gadung starch to study the potential utilization of gadung starch as edible coating in order to maintain the shelf life and the quality of fruits.

2. Experimental section

2.1. Materials

The material used in this research is gadung starch tubes, liquid glycerol, aquadest, silica gel and Carboxymethyl Cellulose (CMC). The tool used in this research is 250 ml glass, 50 ml measuring cup, blender, spatula, hot plate, mercury thermometer, oven dryer, magnetic stirrer, knife, spatula and stopwatch.

2.2. Preparation of gadung starch

Methodology This study used a complete randomized design (RAL) experimental design method. The variables evaluated were variation of hydrocolloid concentration of CMC (A) consisting of 4 levels i.e 1, 3, 5 and 7% (b/v) and concentration factor of plasticizer ie glycerol (B) consisting of 4 levels ie 10, 15, 20 and 25% (w/v). So the combination of treatment is $4 \times 4 = 16$ by using 2 replications, so that in 32 units obtained the experiment. Gadung starch was extracted from a local variety gadung which is a commonly grown in forest in Aceh Province, Indonesia. Freshly harvested tomato (*Solanum lycopersicum* L.) fruit at the mature-green stage of ripening were purchased from local market of Banda Aceh. The fruits were chosen for uniformity in color, size, and absence of blemishes, mechanical damages and fungal infection. Before coating, tomatoes were thoroughly washed with a 0.05% sodium hypochlorite solution (Product Code: 425044 Sigma-Aldrich) and air-dried. Sorbitol (Product Code: S1876), glycerol (Product Code: G9012), and all other chemicals used were of analytical reagent grade and purchased from Sigma (Sigma-Aldrich GmbH, Sternheim, Germany).

2.3. Isolation of starch

Gadung starch was extracted by blending with 0.16% sodium metabisulphite solution and the resultant slurry was screened through 100 mesh sieve followed by 300 mesh sieve. The supernatant was decanted and the starch layer was resuspended in distilled water and then centrifuged at 8000 rpm for 5 min. The brownish layer was discarded; the under layer was resuspended in distilled water and recentrifuged at 8000 rpm for 5 min. The resultant starch was finally air dried at 45 °C for 12 h and then pulverized. The extracted starch had approximately 98.5% purity (fat 0.22%, fiber 0.53%, protein 0.42%).

2.4. Coating application

The selected tomatoes were divided into four groups each contained thirty fruits and dipped in ascorbic acid and citric acid for 5 m. The coating slurry was prepared by gelatinizing the gadung starch (4.0 g/100 mL solution) in distilled water with constant stirring on hot plate. Glycerol was then added in the gelatinized slurry and again stirred for 30 min. Tomatoes were dipped separately in coating slurry for 30 s, air dried and finally stored at 25 °C and 60% RH for 20 days in a controlled atmosphere chamber. The uncoated fruits were used as control. Quality assessment of each sample was evaluated after every 4 days.

2.5. Film preparation

Gadung starch films were prepared by casting technique. Aqueous suspension of 2% gadung starch was gelatinized at 85°C for 30 min on a hot plate followed by adding of Carboxymethyl Cellulose

(CMC) with continuous stirring. Glycerol as plasticizer was added (10, 15, 20, and 25% of starch weight) to the gelatinized suspensions and again stirred for 30 min. The concentration of plasticizers was selected based on preliminary trials to obtain smooth and flexible films. The air bubbles formed during heating were removed by means of sonication at reduced pressure. The slurries were then casted on acrylic trays and dried overnight at 55°C for 12 h. Films were removed carefully from trays and conditioned in a desiccator at 58% relative humidity (RH) for 48 h prior to further testing.

2.6. Edible Film Testing

Analysis of tomato fruit is weight loss, and organoleptic test. While the characterization test of Edible Coating includes film thickness, elongation, tensile strength, and oxygen permeability.

3. Results and discussion

3.1. Weight loss

All coated and uncoated tomato samples were weighed at the beginning of the experiment and after every 3 days for upto 21 days. In this study tomato coated edible coating with different concentrations of CMC and Glycerol and observed tomatoes for 21 days. Weight loss was determined by taking their initial and final weights differences and expressed as percentage. It can be seen in Figure 1 the decrease in weight loss that occurs with different levels of CMC and Glycerol.

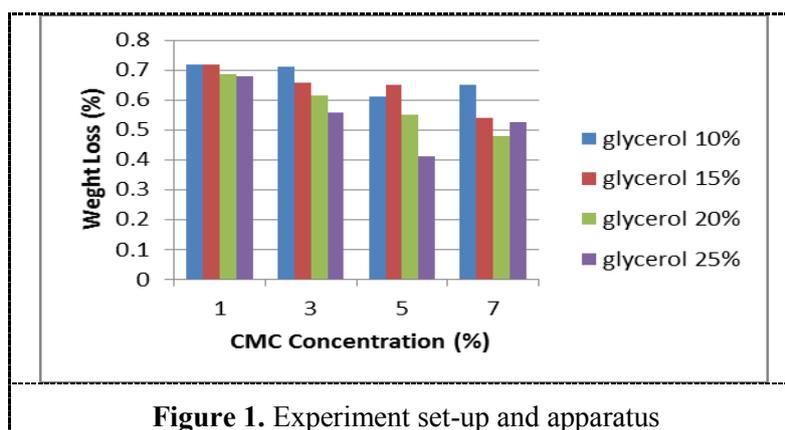


Figure 1. Experiment set-up and apparatus

Figure 1 shows that the greater concentration of glycerol causes less weight loss value. Weight loss with a concentration of 25% glycerol is greater than weight loss with a concentration of 10%. As well as on the increase in glycerol concentration, Figure 1 also shows an increase in CMC concentration causing decreasing weight shrinkage values. The shrinkage value of successive weights decreases with the addition of glycerol. The highest shrinkage value at 10%, second and third concentrations of glycerol at concentrations of 15% and 20%, and the smallest at 25% concentration. The shrinkage value of the higher weights indicates the weight loss in the tomato fruit is greater which means the loss is also greater. With the addition of fruit glycerol will be coated so that the inhibition of the greater microbial and fruit rotation will be longer [8]. According to Nawab et al., the shrinkage of tomato weight will increase during storage, this is because tomato is a climacteric fruit that has a level of respiration that continues to increase along with the maturation of fruit [9].

3.2. Edible coating thickness

The film thickness will affect the oxygen permeability /vapor transmission rate and tensile strength of the film's edible. The addition of CMC and glycerol concentrations also affects the thickness of the edible film, wherein the bonds formed between hydrocolloids and glycerol with the starch tuber starch increase the thickness. The relationship between CMC and glycerol concentrations in edible films with the resulting edible film thickness can be seen in Figure 2.

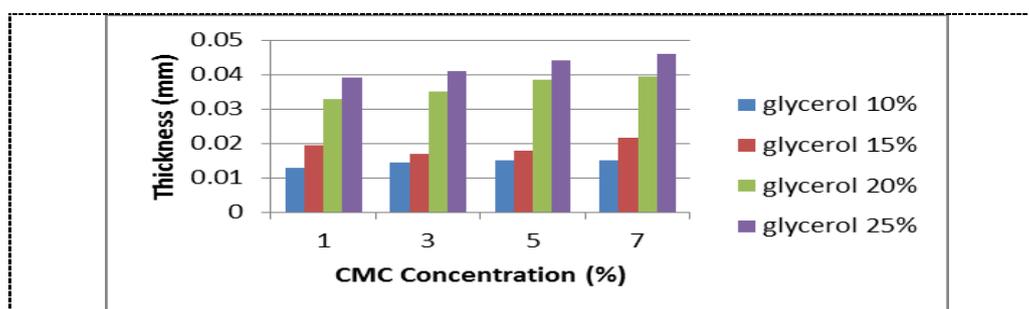


Figure 2. Glycerol and CMC concentration correlation to Elongation of edible film

Figure 2 shows that the addition of CMC and glycerol concentrations tends to produce an average of different thicknesses. The addition of glycerol causes edible films to increase in thickness. The average thickness of edible film with CMC concentration variations were 1, 3, 5 and 7% and the variation of glycerol concentrations were 10, 15, 20 and 25% were between 0.01-0.05 mm. The average standard of edible film thickness is less than 0.25 mm. The thickness of this edible film is relatively thinner than some of the previous studies.

3.3. Elongation

Elongation is the mechanical properties of edible films that are closely related to the physical properties of the film. Elongation shows the maximum length change of the film when it gets tensile until the movie is disconnected [10]. Percent elongation also depends on the ingredients mixed into the edible film mixture. Percent elongation indicates the film's ability to extend before being disconnected. The higher the elongation percentage of a film the better the quality of the film. The data of the test results can be seen graph of the concentration relationship of CMC (carboxyl methyl cellulose) with the concentration of glycerol to elongation on edible film produced can be seen in Figure 3.

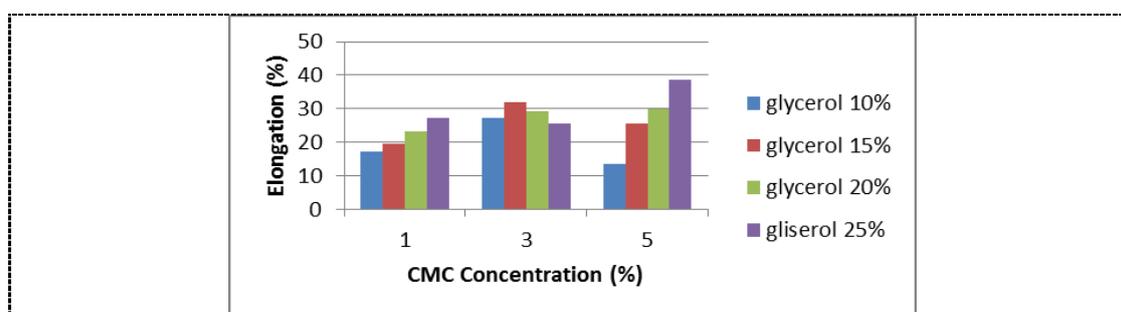


Figure 3. Glycerol and CMC concentration correlation to Elongation of edible film

Based on Figure 3 the addition of CMC with concentrations of 1, 3 and 5% and plasticizers of glycerol at concentrations of 10, 15, 20 and 25% averaged 13.57 - 38.56%. The optimum elongation percentage obtained at the addition of 5% CMC concentration and 25% glycerol concentration is 38.56%, because in this composition the most additions of plasticizer and CMC (carboxyl methyl cellulose) mixture adds moisture to the film causing the film to be elastic. The addition of CMC and plasticizer is needed to overcome the fragility caused by molecular intermolecular forces on the main raw material. Without CMC and plasticizer, films made from starch will be fragile (Thakur et al., 2018). Increased concentrations of glycerol will lead to an increase in elongation percentage rather than the film.

3.4. Tensile strength

Tensile strength is the maximum force that occurs in the edible film during the measurement until the film lasts before breaking or tearing. Measurement of tensile strength is intended to determine the amount of force required to achieve maximum attraction in the area of the film lengthening or stretching.

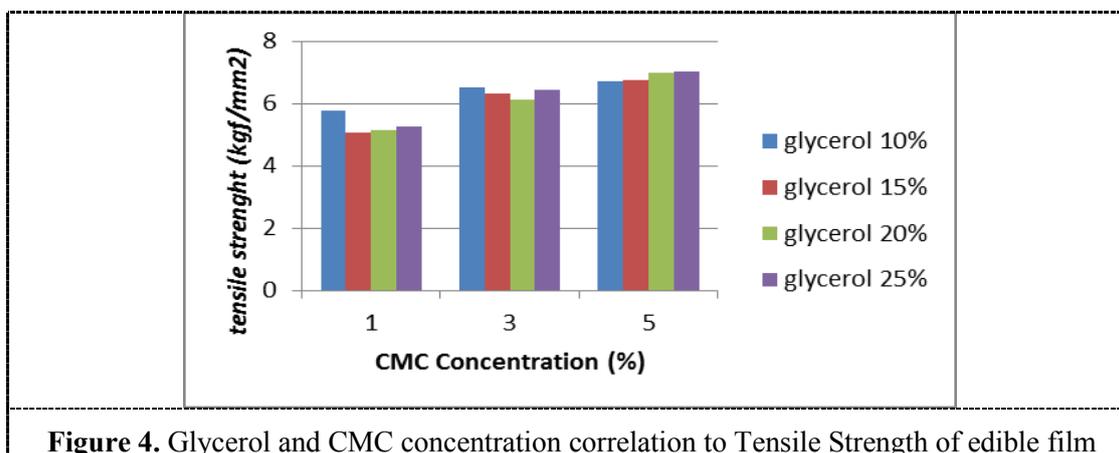


Figure 4. Glycerol and CMC concentration correlation to Tensile Strength of edible film

4. Conclusion

A new non-conventional source of starch from gadung (*Dioscorea hispida* Dennst) starch was used to prepare edible coating films and the influence of different plasticizers on its functional properties was investigated. Gadung films plasticized without glycerol and CMC formed a fragile film indicating that glycerol was appropriate plasticizer for gadung films. The edible films produced with thickness ranging from 0.01 - 0.05 mm plasticized with glycerol has a good mechanical characteristic with a higher elongation, tensile strength and lower oxygen permeability with increasing the concentration of glycerol and CMC. The optimum elongation percentage obtained at 38.56% with the addition of 5% CMC and 25% glycerol concentration. The films plasticized with this amount concentration of CMC (5%) and glycerol (25%) also showed a higher tensile strength, it was 7.03 kgf/mm². Films plasticized with glycerol concentration of 10% combined with CMC 1% gave a lower oxygen permeability values of 3.739 g/m²/h than that of at higher plasticizers concentrations. It could be proved to be a good barrier for water vapors. The findings of this study will facilitate the use of gadung as an alternative starch source for edible coating making. It will also provide foundation for further developments of edible packaging from gadung starch. These results suggest that gadung edible coating can be used effectively to prolong the shelf life of tomato until 21 days.

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