EDIBLE FILM FROM POLYBLEND OF GINGER STARCH, CHITOSAN, AND SORBITOL AS PLASTICIZER

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Abstract. Polyblend ginger starch /chitosan based edible film has been successfully prepared and characterized. The purpose of this research was to produce edible film from polyblend of ginger starch, chitosan, and sorbitol as plasticizer. The resulted edible film were characterized by using FTIR, TGA and UTM. Edible film of ginger starch had OH vibration (3430 cm$^{-1}$). Besides, edible film had elongation up to 15.63%. The thermal degradation of this material reached 208°C indicating high thermal stability. The water uptake of the edible film was 42.85%. It concluded that edible film produce in this research has potential as a packaging.

1. Introduction
Packaging is a required material for food quality maintenance in order to keep it in good condition. Plastic is often used as a type of package. The use of plastic as a material of food packaging gave rises variety of problems to environment due to its inability to be recycled and decomposed naturally by microbes. Based on recent data by Jambeck [1] Indonesia is ranked as the world's second producer of plastic garbage to the sea (187.2 million tons) after China (262.9 million tons), in third place was Philippines (83.4 million tons), followed by Viet Nam (55.9 million tons), and Sri Lanka (14.6 million tons) per year. Each year the production of plastic generates about eight percent the production of the oil world about 12 millions barrels of oil or equivalent to 14 million of tree [2]. To resolve this problem, the alternative to reduce packaging material is with changes the using of plastic with the edible film [3]. The ginger production in Indonesia in 2000 amounted to 115,092 tons with an average 0.31% growth per year [4]. Component of ginger is gingerol, shogaol, zingerone and have effect of pharmacology and physiology as antioxidant [5]. The accumulation of ginger production until 2016 has reached approximately 1,401,435 ons and if the starch amount of ginger according to Hermani [6] reaches 82% then the starch of industry waste results more or less amounted to 1,149,178 tons. Given that the magnitude of ginger starch waste industry in Indonesia has not been used optimally and the existing antioxidant components in the ginger starch [7], research need to be done to process the waste ginger starch becoming a beneficial edible film that can be used as an alternative to reduce plastic waste in Indonesia. The main component of edible film is hydrocolloid, fat, and composite [8].
2. Experimental

2.1 Instruments
Instrument used to characterization physic characteristic of material is TGA- DTA Stanton Redcroft TG-750 and FTIR Merk Shimadzu, Type IRPrestige21. Instrument used to characterization mechanic characteristic is tensile strength test use Universal Testing Machine Merk Time Shijin Type WDW-20-E, morphology test use Scanning Electron Microscopy (SEM) JEOL JSM-6360LA, thickness test used couplers micrometer and water uptake test.

2.2 Materials
The material used to produce edible film is ginger starch, chitosan, sorbitol as a plasticizer, acetic acid 2% (Merck®, 100%) and aquadest.

2.3 Edible Film Preparation
A number of starch and chitosan was weighed in comparison of mass variation between starch and chitosan (b/b) i.e. 5:5, 6:4, 7:3, 8:2, 9:1 with a total mass of ginger starch and chitosan 1 gram. Ginger starch was dissolved using aquadest, while chitosan is dissolved in acetic acid 2% (Merck®, DIXI 25%) under stirring for approximately 30 minutes. Both solution had been mixed. The mixture is heated in temperature 80°C [6]. After 25 minute warm-up, the mixture was added 3.7 mL the sorbitol solution 30% and stirred for 5 minutes. The solution is cooled and the air bubbles or the polluter were then ± 150 grams solution was poured into a mold glass and placed in an open room ± 3 days. The molded dry solution was separated as plastic and ready to be characterize.

2.4 Characterization of edible film
2.4.1 The Thickness Measurement. The thickness measurement of edible films was measured using micrometers with accuracy of 0.0001 mm. The measurement was carried out on at least 5 different places to get the average thickness in accordance with the standard thickness [6].

2.4.2 Mechanic Test (Tensile Strength). Tensile strength test was done using Mesdan Lab strength by means the tip of sample was clipped in tensile testing machine. Next, recording the thickness and length of the initial sample. Start button on the computer was pressed would make the tool draw samples with speed of 100 mm/min until the sample is broken. Tensile strength test was conducted 3 times on different samples and the average was measured. Tensile strength edible film is calculated with the following equation

$$\tau = \frac{F_{\text{max}}}{A}$$  \hspace{1cm} (1)

Based on equation above, \(\tau\) indicated tensile strength (MPa), \(F_{\text{max}}\) showed voltage (N), and \(A\) showed broad cross-section transverse (mm\(^2\)). Measurement of at the broken elongation was done the same way with powerful pull test. The extension is expressed in percentage with calculation:

$$\text{Elongasi (\%)} = \frac{\text{Length maximum (mm)}}{\text{first length (mm)}} \times 100\%$$  \hspace{1cm} (2)

2.4.3 FTIR Analysis (Fourier Transform Infrared Spectroscopy). FTIR analysis of functional groups was aimed to find the process that followed the mixing procedures on samples, whether physically or chemically in each process of making edible film. The sample is placed into a holder set, then the corresponding spectrum was set. The results would be obtained by diffractogram in the relation between
the wave numbers and intensity. FTIR spectra was recorded using spectrophotometer at room temperature [9].

2.4.4 Water Uptake Test. Water resistance test procedure was done with water absorption test by weighing the initial weight of sample that would be tested (Wo), sample was put into a container that contains aquadest for 10 seconds. Sample was lifted out from the container and the water in the surface of sample was removed with tissue paper, next the weight was measured again. Sample was put back into the container for 10 seconds. Then the sample was lifted from the container and weighed again. Soaking and weighing procedure carried out back until a constant weight was obtained [10]. The absorbed water by the sample were calculated through equation

\[
\text{Water (\%)} = \frac{W - W_o}{W_o} \times 100\%
\]  

(3)

Based on the equation above, Wo showed the initial weight of edible films and W is the final weight after water uptake test.

2.4.5 Thermal Analysis (TGA-DTA). TGA-DTA was thermal analysis method in a polymerization. This method was dynamically recorded the weight of sample in heated or cooled conditions in a controlled ratio as a time or temperature function. The sample was placed into a specific place, heated and sought the spectrum that showed a reduced weight of polymer against temperature or time changes due to dehydration or decomposition process. The results would be obtained by diffractogram in relation between the wave number and intensity.

2.4.6 Scanning Electron Microscope Analysis. The morphological analysis of edible film is done by using SEM (Scanning Electron Microscopy). Edible film samples are affixed to the set of holder with double adhesive, then coated with gold medal in a vacuum. After that, the sample is put in place in the SEM, then the topographic image is observed and 5000 times magnified [9].

2.4.7 Antibacterial Test. Antibacterial test on edible film was done by diffusion method in Agar. The diffusion method was often used for testing an antibacterial properties. E. coli bacteria was used for gram negative. Antibacterial activity of edible film was showed with the emergence of a clear zone in the vicinity of edible film. The clear zone was calculated every 24 hours during the period of 96 hours.
3. Results and Discussion

The edible film ginger starch has been successfully prepared and characterized. The data of water uptake test, mechanic test, the thickness test shown in Table 1. The data shown are data from 5 variations with composition ratio of ginger starch and chitosan is 5:5, 6:4, 7:3, 8:2, 9:1.

| Starch : chitosan | Water Content (%) | Average thickness (mm) | Elongation (%) | Maximum Drag (N) |
|------------------|-------------------|------------------------|----------------|-----------------|
| 0.5 g : 0.5 g    | 50.00 %           | 0.01                   | 2.63           | 13.5            |
| 0.6 g : 0.4 g    | 50.00 %           | 0.01                   | 1.59           | 14.6            |
| 0.7 g : 0.3 g    | 50.00 %           | 0.02                   | 4.09           | 17.4            |
| 0.8 g : 0.2 g    | 42.85 %           | 0.02                   | 5.35           | 18              |
| 0.9 g : 0.1 g    | 52.38 %           | 0.03                   | 15.63          | 24.5            |

From the data, it is known that the best composition of the ginger starch and chitosan in ratio 9:1. In this comparison, the water uptake test shows a good percentage that is equal to 52.38%. This identifies that in the ratio of ginger starch and chitosan 9:1 will be more easily degraded by water, this is because the starch contains more hydroxyl groups (OH), so it will bind more water because of the hydrogen bond. From the water uptake data then it can be seen that this edible film will be digested well by the body. Water content is smaller than previous researchers is 212.98% [9]. Thickness testing aims to know that edible films can be used as well as food packaging. Data from the average thickness indicates that of the five comparisons have a thickness between 0.01 mm to 0.03 mm. Japanese industrial standard states that edible films used as food packaging should not have a thickness above 0.25 mm. Of the data, edible film ginger starch and chitosan meets the standard for use as food packaging. Edible film has the best elongation on composition ratio 9:1 with elongation percentage of 15.63%. According to Krochta (1997) state that the percentage of edible film elongation is said not good if less than 10% [11]. From the data, it can be seen that the edible film has a good elongation on the composition ratio of ginger starch and chitosan is 9:1. The maximum tensile strength of the edible film at a ratio of 9:1 is 24.5 N, from the data it can be seen that edible film can be used for food packaging.

Functional groups of edible film samples with variations of ginger starch: chitosan (5:5), (6:4), (7:3), (8:2), and (9:1) were successfully performed. The FTIR spectra results are shown in Figure 1. Based on the FTIR spectra there is an uptake in the region of 3500-3300 cm⁻¹ indicating the presence of the -OH group. The absorption in the 1700-1600 cm⁻¹ region shows the presence of C=O absorption.
Figure 1. Spectra FTIR edible film (a) spectra of edible film, ginger starch and chitosan, (b) spectra of edible film on five variations of composition.

The spectra of the edible film indicate the absorption of the wave number 2093 cm\(^{-1}\), the absorption of C-C, this absorption is a new absorption that identifies that new compounds have been formed, and from the five variations that FTIR has tested show the same spectra, it shows that the five variations have formed an edible film. The purpose of FTIR testing is simply to know that the edible film has been successfully synthesized and from the FTIR spectra showing that the edible film was successfully synthesized.

The analysis of thermal properties in the edible film sample was determined by thermogravimetric method in which edible film was heated at room temperature up to 900°C with a heating rate of 10°C/min. The TGA-DTA edible film thermogram is shown in Figure 2. The data show that the edible film experiences three times the thermal degradation that occurs in the heating process, at a temperature of about 100°C, 200 - 360°C, and 360 - 600°C. The degradation of the first stage of edible film at a temperature of 100°C indicated that the process of releasing water molecules in the edible film [12]. This degradation is characterized by a reduction in mass directly as the temperature begins to rise. The second degradation occurs at a temperature of about 200 - 360°C. Degradation at this stage was the breaking of the starch bonds. The third degradation occurs at temperatures around 360 - 600°C. Degradation at this stage was the breaking of the main chitosan chain [12].
Figure 2. Thermal analysis results (TGA- DTA) of edible film ginger starch and chitosan

SEM surface morphology analysis of edible film has been successfully performed. The SEM test results are shown in Figure 3 which is a SEM morphological image from edible film ginger starch and chitosan compared to edible film sukun starch chitosan [9].

Figure 3. SEM Analysis (a. SEM analysis from edible film ginger starch and chitosan, b. SEM analysis from sukun starch and chitosan)

Based on the SEM test data, edible film ginger starch and chitosan has a finer surface when compared with edible film sukun starch chitosan. This is identifies that this edible film has better physical properties when compared to edible film sukun starch chitosan. Antibacterial testing, it is known that *e.coli* bacteria can not grow in this edible film, so it can be seen that edible film is bacteriostatic.
4. **Conclusion**

Based on the above data, it can be concluded that:

1. Manufacture of edible films that are strong, elastic, and have antibacterial properties has been successfully synthesized from ginger starch, chitosan, and sorbitol as a plasticizer.

2. Edible film has elongation reach 15.63%. The thermal degradation of this material reaches a temperature of 208°C which indicates good thermal resistance. In addition, the results of water resistance test of edible film was 42.85%.

3. The best comparison between ginger starch and chitosan, which produces edible film with the best mechanical properties, is in the composition ratio of ginger starch and chitosan at 9:1.

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