Extraction of Pectin from Banana Peels (Musa Paradisica Fomatypica) for Biodegradable Plastic Films

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Abstract. The main goal of this research is to determine the effect of banana peels pectin on the characteristics of biodegradable film plastic, especially thickness, water resistance, tensile strength, and elongation. With the addition of citric acid, extract of banana peel starch as filler, and glycerol as plasticizer. The results showed that the use of citric acid could reduce the browning effect of pectin with the characteristics of water content of 11.56%, ash content of 3.060%, low methoxyl content of 3.906% (<7%), characteristics of the best biodegradable plastic film on the addition of pectin 5 grams with thickness characteristics 0.00387 cm, water resistance 63.63%, tensile strength of 10.5620 MPa, and elongation of 58.33%.

1. Introduction

The use of bioplastic films for food products and technology is still limited. Therefore, more intensive research needs to be developed, because bioplastics film is very potential to be used as packaging and coating for food, industrial, pharmaceutical and fresh agricultural products. Edible film is a packaging that is able to act as an inhibitor of water vapor transfer and gas exchange (CO$_2$ and O$_2$), maintain the integration of material structure, hold young flavor components evaporate, and can also be used as food additives such as antimicrobial agents, antioxidants, and so on [1]. With its capabilities, biodegradable film / edible film has been widely used to increase the shelf life of fruits and vegetables. Another advantage of edible packaging film is its ability to be degraded easily so that it does not cause environmental problems such as plastic waste that can pollute the environment [2].

Pectin from kepok banana peels as a raw material of biodegradable plastic film has own challenges. The challenge is the reduce a browning effect that causes brown starch from banana peels. The browning effect is a brown color change from fruits and vegetables as a result of the oxidation of phenolic substrates by polyphenol oxidase [3]. The level of brown discoloration in banana peels, after cutting, correlates with polyphenol oxidase activity and free phenolic substrate concentration [4]. To limit the oxidation process of various chemicals used in the literature. The selection of chemicals used depends on the function and ability of each ingredient, such as antioxidant agents, chelating agents, firmness agents and acidifying agents. Stated that the ingredients used to inhibit the browning effect on fruits and vegetables, one of the ingredients used is citric acid. The addition of citric acid can inhibit oxidation so that the resulting pectin of banana peel is brighter when compared to banana peel...
pectin without the addition of citric acid [3]. Banana peels pectin produced by the addition of citric acid was used as a raw material for making biodegradable plastic films in this study. This study aims to see the best pectin concentration for edible film and the characteristics of the film produced.

2. Experimental Procedure

2.1. Materials
Kepok banana peels, citrate acid, acetate acid, chitosan, glycerol, aquadest

2.2. Equipments
Hotplate, magnetic stirrer, thermometer, beaker glass, filter paper, measuring pipette, tensile strength test equipment, plastic printing equipment

2.3. Methods
2.3.1. Pectin Extraction
Clean banana peels weighed 500 grams for each treatment and blending. Then filtered and the filtrate results are extracted by boiling in 2% citric acid solution (20 grams of citric acid / liter of water) at 90°C for 3 hours. Then filtered, the extracted liquid is added to ethanol (1: 1) and filtered again. The pectin obtained was dried in an oven at 50°C for 8 hours. Then packaged, analyzed and applied for making bioplastics. Observation and analysis parameter is moisture content, ash content and a methoxyl content.

2.3.2. Making Plastic Film Biodegradable
Pectin extracted with various variations was dissolved in distilled water and added with 5 grams of kepok banana peel extract and then heated at 60°C. At the same time chitosan is dissolved with 3% citric acid, then the pectin solution is mixed with chitosan and stirred until homogeneous. Then 2% sorbitol was added, the solution was heated to a temperature of 80°C and maintained for 10 minutes. The mixture is put into a mold and dried at a temperature of 50-60°C. Observation and analysis parameter is thickness, swelling, tensile strength and elongation.

3. Results and Discussion
3.1. Characteristics Pectin From Kepok Banana Peels

| Parameter         | Analysis Results | IPPA               |
|-------------------|------------------|--------------------|
| Water Content     | 11.55%           | Max 12             |
| Ash Content       | 3.060%           | Max 10%            |
| Methoxyl Levels   | 3.906% (low)     | 2.5 – 7.12% (low)  |
|                   |                  | >7.12% (high)      |

In this study the extraction process was carried out at 90°C for 3 hours, obtained with water content is 11.55%, Ash content obtained is 3.060%, methoxyl levels is 3.906 %. It still meets the IPPA standard.

Methoxyl levels are defined as the number of moles ethanol contained in 100 moles of galacturonic acid. Methoxyl level test was carried out to determine whether pectin powder from this study was included in high or low methoxyl pectin. Methoxyl levels are used to determine whether the product can be directly used or carried out methylated first. Methoxyl levels obtained in this study were 3.096% classified as low methoxyl pectin according to IPPA quality standards because the methoxyl...
content was less than 7.12%. This is more advantageous because low methoxyl pectin can be directly produced without going through the process of demethylation. Methylation is a process that involves 5-methylcytosine glycosylase through DNA correction pathways by cutting bases.

Testing of pectin functional groups was carried out with an Infrared (FT-IR) spectrophotometer. This analysis aims to find out the functional group changes of material or matrix produced. The spectrum of FT-IR analysis can be seen in Figure 1.

![FT-IR Spectrum](image)

In the infrared spectrum of pectin, the absorption band at 3249.67 cm\(^{-1}\) shows the presence of O-H bond vibration, the absorption band 2936.80 cm\(^{-1}\) shows the aliphatic C-H stretch vibration, the typical absorption of pectin is seen in the wave number 1732.42 cm\(^{-1}\) and 1637.36 cm\(^{-1}\) which is a C = O bond vibration. The absorption band at 1047.42 - 1093.99 cm\(^{-1}\) shows the vibration of C - O and the bending vibration of C - H in the FT - IR spectrum shows that pectin contains O-H, C-H aliphatic groups, carbonic C = O and C-O

3.2. Characteristics of Film Plastic Biodegradable

The mechanical test results from bioplastic pectin film of kepok banana peels include thickness test, solubility test, tensile strength test, and percent elongation. Determination of tensile strength is carried out by giving a certain load to the specimen so that there is a change in length (stretching) until the specimen breaks. The results of the test obtained the price of tensile force (kg) and specimen length (mm). The results of this test were reprocessed to obtain the price of tensile strength (MPa) and percent elongation (%). The value of tensile strength and percent elongation of film bioplastic was measured based on the size of the test object.

| Table 2. Results of Mechanical Physical Properties of Bioplastics from Banana Peels |
|-------------|-------------------|-----------------|-------------------|-------------------|-------------------|
| No | Pectin (Gram) | Extract Banana Peels (Gram) | Thickness (cm) | Swelling (%) | Tensile Strength (MPa) | Elongation (%) |
|-----|---------------|-------------------------------|----------------|--------------|-----------------------|--------------|
| 1   | 1             | 5                             | 0.00311        | 35,30        | 2.6286                | 16,66        |
| 2   | 2             | 5                             | 0.00324        | 47,82        | 5.0462                | 23,33        |
| 3   | 3             | 5                             | 0.00344        | 50,00        | 5.9411                | 27,5         |
| 4   | 4             | 5                             | 0.00365        | 61,53        | 8.958                 | 45,83        |
3.2.1. Thickness Test Result Bioplastic from Banana Peels

The results of the influence of the addition of kepok banana peel pectin to the thickness of bioplastic films are presented in Figure 2.

![Figure 2](image)

**Figure 2.** Effect of Kepok Banana Peels Pectin Addition to Film Bioplastic Thickness

In Figure 2 shows that the addition of pectin causes an increase in total dissolved solids in the film solution, thus increasing the thickness of the film. Pectin kepok banana peel at the addition of 5 grams gave the highest thickness value of 0.00311 cm, while the addition of 1 gram pectin gave the lowest thickness value of 0.00387 cm.

3.2.2. Results Kepok Banana Pectin Peels Film to

The effect of adding banana peels pectin to the water resistance of film bioplastics can be seen in Figure 3.

![Figure 3](image)

**Figure 3.** Effect of Kepok Banana Peels Pectin Addition to Film Bioplastic Swelling

In Figure 3 can be seen the value of water resistance is directly proportional to the value of thickness in bioplastic, the factors that influence is the use of chitosan as supporting material. Chitosan is a compound that is hydrophobic and insoluble in water, which states chitosan modifies starch molecules so that chitosan will be able to reduce the properties of starch which are basically hydrophobic. However, the results obtained are not entirely good because the bioplastics produced still...
tend to absorb water and have not met the SNI value for bioplastic water resistance with a percentage value of 99%. This is also influenced by the presence of -OH groups in the plastic derived from glycerol. This bond causes bioplastics to still have hydrophobic properties.

3.2.3. Results of Tensile Strength Test Pectin Kepok Banana Peel Film Plastic Biodegradable.

Tensile strength is the maximum pull that can be achieved by film bioplastics before tearing. The effect of adding kepok banana peel pectin to bioplastic tensile strength can be seen in Figure 4.

![Figure 4. Effect of Kepok Banana Peels Pectin Addition to Film Bioplastic to Tensile Strength](image)

Figure 4 shows that more pectin kepok banana peels is added the greater tensile strength value. The best tensile strength value in bioplastics of kepok banana skin was shown on the addition of 5 gram pectin with a tensile strength of 10.5620 MPa. At more materials added in the bioplastic, matrix compiler will increase the gel strength and hydrogen bonds produced in making bioplastic so that the chemical bond will be stronger.

3.2.4. Result of Elongation Test Kepok Banana Peels Pectin Film Bioplastics

Elongation is a mechanical property that is closely related to the physical properties of edible films. Elongation shows a change in the maximum edible film length when obtaining tensile force until the edible film breaks. The value of elongation shows the ability of the film to elongate. This property depends on the type of film formation material which will affect the cohesion properties of the film’s bioplastic structure. The effect of adding kepok banana peel pectin to elongation can be seen in Figure 5.

![Figure 5. Effect of Kepok Banana Peels Pectin Addition to Film Bioplastic Elongation](image)
The results of the analysis in Figure 5 show that Kepok Banana Peels Pectin Addition has a significant effect on the elongation, where the more pectin added the percentage of elongation increases. Characteristic bioplastic film more elastic, the function of pectin as an emulsifier increases the intermolecular bond in the film. The results showed that bioplastics of kepok banana peel film had a fairly good level of elongation. Percentage of elongation edible film is good if the value is more than 50% and bad if the value is less than 10%.

4. Conclusion
From this research, we can conclude that
1. Characteristics of pectin kepok banana peels extracted with citric acid at 90°C for 3 hours which has a water content of 11.55% 3.060% ash content, methoxyl content 3.966%.
2. Characteristics of bioplastics of pectin film produced from kepok banana peels which have a film thickness ranging between 0.00311 - 0.00387 cm, water resistance 35.30 - 63.63%, with a tensile strength of 2.6286 - 10.5620 MPa, elongation value 16.66 - 58.33%.
3. The best pectin film bioplastic was produced on the addition of 5 gram pectin with a film thickness of 0.00387 cm, water resistance of 63.63%, the tensile strength value of 10.562 MPa, elongation value of 58.33%

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References
[1] Baldwin, E.A, Krochta, J. M., dan M.O. Nisperos-Carriedo. 1994. Edible coatings and film to improve food quality. Technomic Publ.Co., Inc., USA.
[2] Lestari, Retno Budi dan Yohana S. K. Dewi. 2008. Technology of Biodegradable Film from Aloe Vera And Its Application for Packaging Duku. Jurnal Penelitian Universitas Tanjungpura, Volume X No.2 April 2008.
[3] Suharti, Profiyanti Hermien, Nanik Hendrawati, and Arief Suharti. "Preliminary Study of Utilization of Kepok Banana Skin Waste (Musa acuminata balbisiana Colla) as a Biodegradable Film Raw Material." Jurnal Teknik: Ilmu dan Aplikasi, 2015
[4] Nguyen, Thi Bich Thuy, Saichol Ketsa, and Wouter G. van Doorn. "Relationship between browning and the activities of polyphenol oxidase and phenylalanine ammonia lyase in banana peel during low temperature storage." Postharvest Biology and Technology 30, 2003: 187-193