Characterization Properties of Banana Peel as a Promising Alternative for Bioplastic

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Abstract. The increasing use of conventional plastic has been creating some big problems, ranging from the oil crisis as a raw material for plastic production and the accumulation of unbiodegradable plastic waste on the earth. One of the promising measures to handle the problem is the use of environmentally–friendly biodegradable plastic, made from renewable materials. The aim of this project is to characterize the properties of bio-plastic from banana peel. The process begins with the extraction of pectin from banana peel with hydrochloric acid and followed by the addition of water, $CaSO_4$, tapioca starch, acetic acid, glycerin to form plastic. The analysis of pectin extract gave 8.3 % pectin yield, 29 % water content, 10 % ash content, 4.9 % metoxyl content, 50 % galacturonic acid content,and 13.8 % degree of esterification. The plastic obtained after the following process had the thickness of 0.28 mm, the water absorption capability of 53.8 %, and it was biodegradable with certain characteristics.

Keywords: Biodegradable, conventional plastic, environmentally–friendly, pectin, waste utilization.

1 Introduction

Banana (*Musa paradisiaca* L.) is a fruit that is consumed a lot by people in the world but its peel is just used as an animal feed and even thrown away as waste [1]. Some have used banana peel as an industrial material, such as for ethanol production and chicken feed. The banana peel contains pectin, ranging from 5 % to 12 %, which has the potential to be used as a bioplastic source [2, 3].

Pectin is a polysaccharide having high molecular weight dan acidic properties. It is a polygalacturonic acid is composed of galacturonic acid molecules and several neutral sug-

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ars (L–arabinose, and D–galactose) connected by α–(1–4)–glycoside bond. Some part of esterified carboxyl pectin form ester methyl [4] (Figure 1).

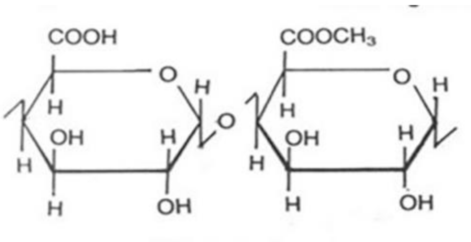

Fig. 1. Pectin structure

Pectin compounds can be classified into pectic acid with no ester methyl, pectic acid with ester methyl, dan protopectin that is insoluble in water. Pectin is fine white powder, yellow, grey or brown, insoluble in alcohol, soluble in water to form coloid [4]. Characteritics and specifications of pectin based on the quality standard of International Pectin Producers Association (IPPA) [2] are as follow:

No.	Quality factor	Percentage
1.	Water content	Max. 12 %
2.	Ash content	Max. 10 %
3.	Equivalent weight	600 mg to 800 mg
4.	Methoxyl content: – Pectin with high metoxyl content – Pectin with low metoxyl content	 > 7.12 % 2.5 % to 7.12 %
5.	Galacturonic acid content	Min. 35 %
6.	Degree of esterification: – Pectin with high ester content – Pectin with low ester content	 Min. 50 % Max. 50 %
7.	Gel strength	Min. 150 grade
8.	Acetyl number	0.15 % to 0.45 %

This research aims to analyse the characteristics of pectin obtained from banana peel in terms of water content, ash content, methoxyl content, galacturonic acid content, degree of esterification. Water content is related to the shelf life, quality and composition of chemicals. The analysis of ash content is to determine the remaining inorganic content after burning. Methoxyl content is defined as the methanol content in the pectin. Galacturonic acid is the basic structure of pectin and can be used to indicate its degree of purity. The degree of esterification indicates the percentage of galacturonic acid that reacts with ethanol.

Pectin is used in food industry as a gel forming and thickening agent, jam, and low calory food and drink. In pharmacy industry, pectin is used to treat diarrhoea and to lower cholesterol level. Pectin is also used in paper and textile industry as a filling and thickening agent [4–7].

Pectin is found in various plants, such as banana, orange, mango, and guava. To seperate pectin from other compounds, extraction is used by firstly conducting acid, base, or enzyme hydrolisis. In practice, pectin is firstly extracted by hot water acidified with HCl or HNO3, pH 1.3 to pH 3, 60 °C to 100 °C for 20 min to 360 min [5]. Afterwards, ethanol is added to coagulate pectin.To purify pectin, it is further washed by ethanol [7]. And drying is done by low pressure to avoid pectin degradation.

Pectin has ability to form gel, hence it can be used in plastic production [4, 8]. The use of synthetic plastic from petroleum has given negative impact for environment and health. Therefore, bioplastic that is renewable and environmentally–friendly, is needed for its replacement [9, 10].

Bioplastic is a renewable plastic from plants (starch, celulose, pectin), animal (kitin and lignin) and microorganisms [11]. Several researchs have successfully produce bioplastic from sweet potato (*Ipomoea batatas* (L.) Lam.), sago (*Metroxylon sagu* Rottb) starch, cassava (*Manihot esculenta* Crantz) starch and starch from banana peel (*M. paradisiaca*) from other growing place. In this project, we use banana growing in a Timor Leste Distrik [12, 13]. Bioplastic can be naturally degraded by microorganisms or certain environment such as soil, climate, humidity, sun radiation or water [14].

Bioplastic is made from polimerization process, in which pectin molecules by the addition of starch and plasticizer are heated to produce gel, for instance in the form of pieces [15]. Plasticizer, such as glycerin, sorbitol, isopropyl palmitat, can increase the elasticity of a substance [16]. Plasticizer diffuses into the pectin polymer chains and starchs in the polymerization solution to form colloidal dispersion. As the solvent is evaporated, pieces of bioplastic.

There are two basic techniques for production of bioplastic, solution casting and liquid polymer. The formation of bioplastic in this research is made by using solution casting technique [14]. In this technique, the raw material of polymer is dissolved in a suitable solvent to form thick solution. This thick solution is then poured and casted in a non–adhesive casting and the solvent is let evaporated to dryness.

Parameters examined in this project are the thickness, solubility, water absorption, and biodegradability. The thickness of bioplastic will influence the absorption rate of water vapor, gas, and volatile compounds.

Percentage of bioplastic solubility is a percentage of bioplastic dry weight dissolved when immersed in water for 24 h. The analisis of water absorption is conducted to measure the capability of the bioplastic in absorbing water when it comes into contact with water. Biodegradability is a measure of the user–friendliness of bioplastic.

The aim of this research is to produce bioplastic from extracted pectin of banana peel and to analyse the characteristics of the pectin and bioplastic yielded.

2 Materials and methods

Materials used in this project are ripe yellow banana peel, HCl 0.05 N, HCl 0.25 N, NaOH 0.1 N, NaOH 0.25 N, glycerin, distilled water, starch, alcohol 96 %, phenolphtalein 1 % and NaCl 1 %.

The banana peel is washed with distilled water and choped, the dried in sunlight for 2 wk to 3 wk. The dried peel is pulverised and sieved with 300–mesh sieve. The pectin in the powder is hydrolised with 100 mL HCl 0.05 N at 90 °C while stirred for 90 min, and the hot–filtered. Alcohol 96 % is then added to the filtrate (volume ratio of 1:1) while stirred until the pectin is precipitated. The precipitate is washed with alcohol 96 % several times, and dried afterwards in oven at 50 °C for 2 h. Analyses are conducted to measure % pectin yield, water content, ash content, methoxil content, galacturonate content, and degree of esterification [2].

The production of bioplastic from pectin is initiated by preparing first solution containing 0.6 g pectin and 0.06 g $CaSO_4$ in 25 mL distilled water, and second solution containing 2 g starch also in 25 mL distilled water at 40 °C. The two solutions are mixed and into it, 0.5 mL glacial acetic acid 5 % and 0.5 mL glycerin are added. The mixture is then heated while stirred rigorously at 85 °C for 5 min. The heating is continued while stirring until the temperature reachs 90 °C to 95 °C for 10 min and gel formation initiated. The solution is kept in closed container for 24 h and then molded and dried in oven at 60 °C for 4 h. The produced bioplastic is analysed for pectin yield, water content, ash content, methoxyl content, galacturonic acid content, and degree of esterification. Further analyses of the produced bioplastic include thickness, water solubility, water absorption capability, and biodegradability.

3 Results and discussions

3.1 Pectin yield

After drying until the water content below 10 % and pulverising, 3 g of pectin is extracted using 0.05 N HClat 90 °C for 90 min. It yields 0.25 g pectin (8.3 ± 0.1 %). The result is more or less comparable to the yield of previous project of Halifah *et al.*, *i.e.* 22.57 % [2].

Acid–hydrolisis is conducted to break the interaction of pectinate acid–selulose, to convert protopectin into smaller soluble pectin with dark brown colour, and to break the methyl group of pectin ester.

Alcohol 96 % is used as a salting–out agent to separate pectin from solution. The precipitated pectin is then filtered by filter paper, washed with alcohol 96 % several times, and dried at 50 °C.

3.2 Water content

Water content of pectin will influence its shelf–life. The water content of pectin resulted in this project is 29.0 % ± 2.0 %, higher than IPPA standard of maximum 12 %. This water content can be reduced further by longer period of drying.

3.3 Ash content

Ash content represents the inorganic content in sample and will influence gelatinisation process. Ash content in the pectin is 10 % ± 1.6 %. It meets the IPPA standard of maximum 10 % (2002).

3.4 Methoxyl content

Methoxyl content represents the number of methyl ester groups in pectin molecules, i.e. the number of mol of methanol in 100 mol of glucoronic acid. In this project, the methoxyl content in the pectin is low, *i.e.* 4.9 % ± 0.4 %.

3.5 Galacturonic acid content

Galacturonic acid is a product of pectin hydrolysis. The analisis of galacturonic acid content in the pectin is 50.0 % ± 2.0 %. This content meets the IPPA standard, *i.e.* minimum 35 %.

3.6 Degree of esterification

Analysis of degree of esterification is conducted to measure the percentage of carboxyl group in pectin that can be esterified with methanol. The degree of esterification of the pectin in this project is 13.8 % ± 2.1 %. It is categorised as low ester–content pectin, *i.e.* lower than 50 %.

3.7 Further analysis of the bioplastic produced from pectin of banana peel

In this project, bioplastic is made using solution casting technique based on the solubility of pectin in solvent and evaporation of solvent to form bioplastic [14]. The bioplastic production is initiated by the mixing of pectin, distilled water, starch, dan glycerin, followed by the addition of $CaSO_4$, glycerin, and acetic acid. $CaSO_4$ is used to facilitate gelatinisation, starch is used especially as a filling agent and thickening agent. Glycerin is used as a plasticiser. Drying is then conducted to evaporate the solvent so that bioplastic sheet is formed. The properties of bioplastic produced in this project are as follow: Average thickness of 0.28 ± 0.0 mm, water solubility of 20.0 % ± 2.6 %, water absorption capability of 53.8 % ± 2.2 %.

Biodegradability evaluation is conducted by burying the bioplastic in land for 2 wk and the change in bioplastic is observed every week. Being in a good condition initially, in 1 wk the color of bioplastic changes to greenish brown and it begins to tear. In 2 wk the bioplastic sheet is torn into two parts and its surface changes to dark brown. The changes in color and the pulling–apart of the bioplastic are consequences of the growth of microorganism along with their degradation activities. Therefore, this evaluation indicates that the produced bioplastic is biodegradable.

4 Conclusions

The extraction of pectin from banana peel at 90 °C for 90 min results in a pectin rendemen of 8.3 %, water content of 29 %, ash content of 10 %, methoxyl content of 4.9 %, galacturonic acid content of 50 %, and degree of esterification of 13.8 %. The produced bioplastic has a thickness of 0.28 mm, water solubility of 20 %, water absorptivity of 53.8 %, and it is biodegradable. Hence, the produced plastic is biodegradable with certain characteristics.

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