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Original Research Article

Pectin extraction from kepok banana peel waste (*Musa acuminata* balbisiana) based on green chemistry as a natural preservative

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ABSTRACT

The aims of this research are (1) to extract pectin from kepok banana peels with an environmentally friendly solvent, namely tamarind and (2) to use pectin as a fruit and vegetable preservative. The research methods used were (1) extraction (2) Compound identification test using FTIR (3) Test the effectiveness of pectin's ability to preserve fruit and vegetables. The results of the research showed that the percent yield obtained was 26% and the results of compound identification showed that there were wavelengths corresponding to pectin compounds. The results of testing the effectiveness of pectin's ability to preserve the average result showed that pectin can increase the rotting time of fruit and vegetables. The conclusion from the results of this research is that tamarind can be used as a natural solvent in extracting pectin from kepok banana peels and pectin can be used as a natural preservative for fruit and vegetables.

Introduction

Based on data from the Central Statistics Agency (BPS), in 2022 the number of Indonesian fruit imports will reach 750 thousand tons. These fruits have high production value but have the weakness that the fruit is easily damaged and has a shelf life of fruit that rots quickly, this is because the fruit is still undergoing physiological processes after harvest. Fruits and vegetables are a healthy food with a high content of various vitamins, minerals and dietary fiber (Ilfada et al., 2024).

Foodstuffs that spoil quickly are also called perishable commodities (Yasa et al., 2023). Damage to fruit and vegetables can be caused by several factors, including improper post-harvest handling, resulting in scratches or wounds on the fruit, as well as a relatively long distribution process (Rifaldi et al., 2023). If post-harvest handling is incorrect, the quality of the fruit gradually decreases along with the metabolic processes that occur (Indriana et al., 2023). The respiration process, which produces heat, causes the fruit to wilt/decrease in weight, lose water content, and decrease the vitamin C content (Dewi et al., 2023). The low content of natural protective compounds in fruit is one of the factors causing accelerated spoilage. Natural compounds that protect fruit are called pectin compounds (Asrafil, 2022).

Pectin is an important polysaccharide with applications in food, medicine, and a number of other industries (Sarandi et al., 2015). Structurally, pectin is a heteropolysaccharide consisting of three main constituent subunits, namely homogalacturonan (HG), rhamnogalacturonan-I (RG-I) and rhamnogalacturonan-II (RG-II). The overall structure of pectin can be seen in Fig-1.

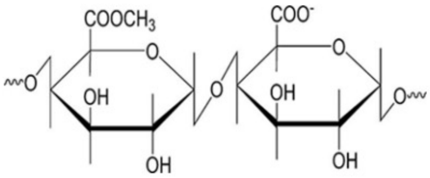

Fig-1. Pectin structure.

Pectin can form structural networks and viscoelastic solutions and is widely used in bread, cheese, jelly, marmalade, marmalade and jam (Husni et al., 2021). The advantage of pectin in the food sector lies in its ability to form gels in the presence of Ca2+ ions or solutes at low pH (Nurlaila et al., 2023). Although the exact mechanism of gel formation is not yet fully known, research progress in this direction has been significant (Begum et al., 2017). Depending on the pectin, coordination bonds with Ca2+ ions or hydrogen bonds and hydrophobic interactions are involved in gel formation (Wang et al., 2018).

Due to the ability of pectin to change the functional properties of products such as viscosity, emulsion properties and gel formation, the research team hypothesized that pectin could potentially be used as a natural preservative for fruit and vegetables. The ability of this pectin to coat the outside of fruit and vegetables so that contact with bacteria is reduced because of which the fruit and vegetables will experience a longer rotting process (Anantami et al., 2023). The ability of pectin compounds to coat fruit and vegetables is called edible films. The antibacterials contained in edible film are bioactive substances that can inhibit the growth of microorganisms, thereby extending the shelf life of food products and reducing the risk of poisoning due to contaminants (Sobarsa et al., 2023).

Bananas are the tropical fruit most widely produced and utilized by Indonesian people (Nurhayati et al., 2015). Banana production is ranked first in agricultural products in Indonesia. Utilizing large bananas for various types of food will produce waste in the form of banana peels. Banana peels are waste that is always abundant, causing environmental problems. To increase the use value, banana peels, which are known to contain pectin compounds, are used as the main ingredient for making fruit & vegetable preservatives (Azis et al., 2020). One type of banana that contains the highest pectin compounds is the kepok banana (*Musa acuminata*) (Harahap et al., 2023). The pectin content of Kepok bananas found in the peel is 52.1% (Hanum et al., 2012). Research on the extraction of pectin compounds in kepok banana peels has been widely carried out.

The results of research (Nadir et al., 2018) that have been carried out generally use methods that use hydrochloric acid (HCl), acetic acid (CH_3COOH) and similar acids in the extraction process. The use of these solvents can cause hazardous waste if disposed of into the environment. It has been suggested that the use of acidic solvents be replaced with natural solvents that can be reprocessed and are not harmful to the environment. So, there is a need for methods that use natural ingredients in the research process.

The innovation carried out is to make a natural preservative from Kepok banana peel waste based on green chemistry, namely using *T. indica* as a substitute for hydrochloric acid (HCl) in the extraction process. Green chemistry is the application of the principles of removal and reduction of hazardous compounds in the design, manufacture and application of chemical products. Aspects of green chemistry are minimizing hazardous substances, using reaction catalysts and chemical processes, using non-toxic reagents, using renewable resources, increasing atomic efficiency, using environmentally friendly and recyclable solvents (Prabawati et al., 2015).

Much research has been carried out regarding pectin from Kepok banana peels. The results of previous research that has been carried out generally use hydrochloric acid (HCl) as a solvent in the pectin compound extraction process. The novelty of this research is that it innovates a method in the extraction process, namely replacing the hydrochloric acid (HCl) solution with *T. indica* solution and making pectin as a fruit & vegetable preservative.

Materials and Methods

The method used in this research is a green chemistry-based extraction method. The process used in this research does not produce chemical waste that damages the environment. The method developed was to replace the hydrochloric acid (HCl) solvent by using tamarind solution. Briefly, the research method is presented in the following Fig-2.

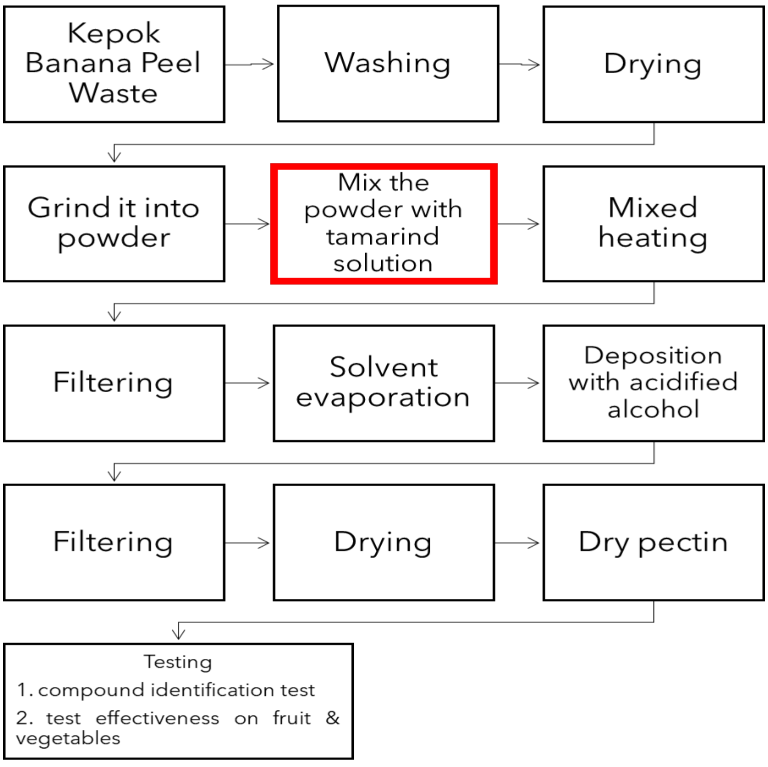

Fig-2. Research method flow scheme.

Materials and tools

The materials needed in this research are: kepok banana peel waste, tamarind, 96% alcohol, and filter paper. The tools needed in this research are: blender, oven, hot plate, rotary evaporator, fourier- transform infrared spectroscopy (FTIR), glass equipment (beaker, funnel, stir bar), vacuum, and hot plate.

Preparation of test materials

Collection of raw materials, namely kepok banana peels, from banana processing traders. After the collection is carried out, the next process is washing the Kepok banana peels in running water. The purpose of washing is to remove residue or impurities. Next, the Kepok banana peels that have been washed are then dried using an oven for 7 hours at a temperature of 70-80 0C. Grind the dried banana skin using a blender to make it into powder.

Pectin Extraction

Kepok banana peel powder is soaked in tamarind solution for 20-30 minutes. It is in this process that innovation is carried out. Generally, the soaking process is carried out using a hydrochloric acid (HCl) solution. The innovations carried out can reduce chemical waste in the environment. The tamarind solution is made by dissolving the tamarind in distilled water. After the soaking process, the mixture is then heated on a hot plate for 2 hours at a temperature of 75 0C. After heating, the mixture is filtered using filter paper with the help of a vacuum filter to separate the dregs and filtrate. Strain the heated mixture. The filtrate obtained is called pectin.

Pectin Deposition

Pectin precipitation is carried out by adding alcohol to the filtrate in a ratio of 1 liter of filtrate added to 1.5 liters of acidified alcohol. Deposition time is 10-20 hours. The pectin precipitate formed is then filtered using filter paper with the help of a vacuum filter.

Pectin washing and drying

The pectin precipitate formed is then filtered while washing with 96% alcohol. This is done so that the pectin sediment does not leave an acid residue. The residue-free pectin precipitate will not be red when the indicator phenolphthalein (PP) is added. The wet precipitate is then dried in an oven at a temperature of 40-50oC. The results obtained are dry pectin. Dried pectin is ground into powder.

Pectin testing/analysis

Tests were carried out to determine that the extraction results obtained were pectin and effectiveness testing was limited to several fruits and vegetables. testing and comparison of extracted pectin compounds and standard solutions of pectin compounds using tools and Fourier-transform infrared spectroscopy (FTIR). Testing the effectiveness of pectin is carried out by soaking the analyzed fruit and vegetables for 2-4 minutes. The results of the analysis are the length of time the fruit or vegetable experiences spoilage and shrinkage. The vegetables used are tomatoes, cucumbers and kale.

Results and Discussion

Pectin from Kepok banana peels is extracted using tamarind as a solvent. Tamarind is used to reduce chemical waste and promote green chemistry programs. Kepok banana skins from traders are weighed and dried to obtain dry kepok banana skins. This data can be seen in Table 1.

Table 1. Weight of raw materials

Raw material	Results
The weight of kepok banana peel	10 Kg
Weight after drying	810 gram

Table 2. Yield results

Researcher	Solvent	% Yield	Application
Mada et al. 2021	Etyl alkohol	20.3	No
Arshad et al. 2022	HCl	10.3	No
Mahardiani et al. 2019	HCl	15.16	Fruit Preservative
Pagarra et al. 2019	HCl	22.57	No
Dalimunthe et al. 2023	Calcium Chloride Dihydrate ($CaCl_2.2H_2O$)	9	No
Khamsucharit et al. 2018	Citric Acid	24.08	No
Nurhayati et al. 2016	HCl	5.39	No
This research	Tamarind	26.5	Fruit & Vegetable Preservatives

The pectin extraction results are then calculated to determine the percentage yield to determine the ratio of the dry weight of the resulting product to the weight of the raw material. This data can be seen in Table 2. The calculation results for the extraction of Kepok banana peel using tamarind solvent were 26.5%. This result is better than using chemical solvents which can be harmful to the environment.

FTIR testing

The results of the FT-IR spectrum measurements were carried out to ensure that the kepok banana peel samples contained pectin compounds (Fig-3). The main functional groups in pectin are generally located in the wave number area of 1000 to 2000 cm-1. (Mada et al 2022). Pectin generally has 2 types of carboxyl bonds which are analyzed at wavelengths of 1630-1650 cm-1 for free carboxyl groups and 1740 to 1760 cm-1 for esterified carboxyl groups (Begum et al., 2017). FTIR results can be seen in Table 3.

Table 3. FTIR Analysis

Peak Area (Wavelength) cm^{-1}		Information
Standard	Sample	
3446.17	3462.47	bond -OH
2934.16	2926.02	stretch bond $-CH_3$
1698.02	1643.17	bond -C=O
1456.96	1403.52	buckling bonds -C-H
1369	1050.87	stretch bond -C-H
1152	700.97	bond eter (-O-)

Table 4. Application Of Pectin

Vegetable	No Preservatives	Pectin Preservative
Tomato	3 days	4 days
Cucumber	3 days	4 days
spinach	2 days	3 days

The wavelength of the Kepok banana peel sample is 3462.47 with an intensity of 80.62%, which is an indicator of the presence of alcohol bonds. The alcohol bond in question can be primary, tertiary and secondary alcohol (24.25). Spectrum results the wavelength of the sample corresponds to the wavelength of the pectin standard. The absorption wavelength of 2926.02 with an intensity of 97.17% is an indicator of the presence of methyl stretching bonds (CH_3) (Khamsucharit et al., 2018). In the area with a wavelength of 1643.17 with an intensity of 83.61% which is an indicator of the presence of a carboxyl bond (-C=O). At a wavelength of 1403.52 with an intensity of 89.38%, it indicates the presence of a -C-H bending bond. The wavelength 700.97 indicates the presence of ether bonds (Ramandha et al., 2023). The FTIR test results are in accordance with the pectin structure in Fig-1. The pectin structure identified via FTIR shows the presence of alcohol bonds, methyl stretching bonds (CH3), carboxyl bonds (-C=O), -C-H bending bonds and ether bonds.

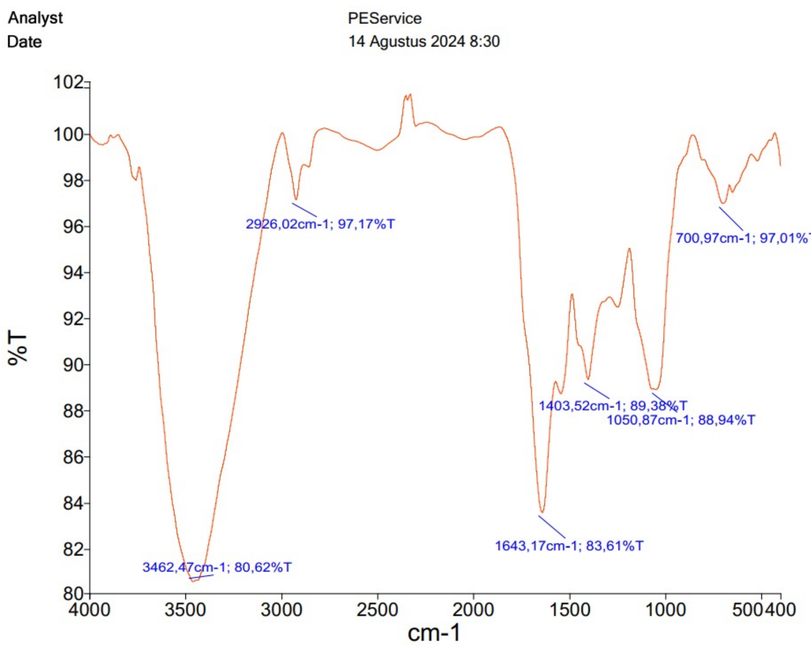

Fig-3. FTIR Test Spectrum

Application of pectin compounds

The resulting pectin compound was then tested for its usefulness as a fruit and vegetable preservative. The fruits and vegetables used are tomatoes, cucumbers and kale. The test was carried out by soaking the fruit and vegetables in a pectin solution and the results were that the fruit and vegetables experienced a longer rotting time than in Table 4. Pectin could act as a vegetable coating to increase the rotting time which is called Edible coating (Anantami et al., 2023). Edible coating can inhibit the rate of water release because the lenticels and cuticles of tomatoes are covered (Rifaldi et al., 2023). Coating with edible coating can reduce oxygen exchange thereby reducing the respiration rate.

Conclusion

Based on the research conducted, it can be concluded that tamarind can be used as an environmentally friendly alternative solvent for extracting pectin compounds. Pectin compounds can also be used as natural preservatives for vegetables. The results of the research showed that pectin compounds were able to increase the rotting time of vegetables on average.

Conflict of Interests

The author declares that there is no conflict of interest in this research and manuscript.

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