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Isolation and Characterization of Hemicellulose from Empty Oil Palm Fruit Bunches

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ABSTRACT

Isolation and characterization of hemicellulose from empty oil palm bunches have been carried out. The method used in the isolation is alkali extraction with NaOH solvent. Hemicellulose isolated from empty oil palm bunches was analyzed by organoleptic and solubility tests. Functional group analysis was carried out using FTIR, and morphology was performed using SEM. The highest yield of 12.84% was obtained from the variation of 0.5 N NaOH solvent. Organoleptic and solubility tests showed that the characteristics of hemicellulose isolated from empty oil palm bunches were by the characteristics of hemicellulose in general. The FTIR results of hemicellulose showed the specific absorption peaks of O-H stretching, C-H stretching, C=O bending, C-OH bending, and C-C stretching. SEM photos show the rough and fibrous shape of the hemicellulose powder surface.

Keywords: hemicellulose, empty oil palm fruit bunches, green chemistry

1. INTRODUCTION

Indonesia is one of the largest palm oil-producing countries in the world. Palm oil is one of the plantation commodities that play an important role in the Indonesian economy because of its ability to produce crude palm oil (CPO) and palm kernel oil (PKO), which are needed as raw materials for the food and non-food industries. However, along with the increase in palm oil processing, there has been an increase in by-product waste in the form of empty oil palm bunches that have not been widely utilized. Untreated empty oil palm bunch waste will cause environmental pollution.

Empty oil palm bunches are waste from oil palm processing that contains lignocellulose. The lignocellulose content of empty oil palm bunches consists of 45.95% cellulose, 22.84% hemicellulose, and 16.49% lignin[1]. Lignocellulose has the potential to be used as a raw material in the pharmaceutical industry, such as an additive in the manufacture of medicines. As part of lignocellulose, hemicellulose has been used as a source of bioethanol, ligands for toxic metals, antioxidants, and media for microbiology. In the

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pharmaceutical field, hemicellulose has been used as xylitol hydrolyzed from xylan, as a binder, disintegrant, thickener, and stabilizer in drug formulation, and as dietary fiber[2].

Various methods can separate hemicellulose derived from lignocellulosic biomass [3–6]. Of the many previously carried out, the alkali extraction method has proven to be the most efficient for isolating hemicellulose polysaccharides in large quantities[7]. The isolation of hemicellulose from corn cobs using the alkali extraction method carried out by Muchlisyam (2014) has been proven to follow the principles of green chemistry, where chemical solvents are less and more environmentally friendly. The characteristics of the hemicellulose produced can be used as a capsule shell[8]. Meanwhile, the isolation of hemicellulose from empty oil palm bunches using the alkali extraction method that applies the principles of green chemistry has not been previously reported. Therefore, this study aims to isolate hemicellulose from empty oil palm bunches using the alkali extraction method.

2. EXPERIMENTAL

2.1. Chemicals, Equipment and Instrumentation

The materials used were empty oil palm bunches taken from Tanjung Seumantoh, Aceh Tamiang Regency, distilled water, CO_2-free distilled water, NaOH (Merck), and ethanol. The equipment used were glassware, analytical scales, a blender, mortar and pestle, a hotplate, a 100 mesh sieve, a metal spatula, a horn spoon, and parchment paper. The instruments used were Fourier Transform Infrared (FTIR SHIMADZU IRSpirit) and Scanning Electron Microscope (SEM TM3000 Hitachi).

2.2. Research Procedure

2.2.1 Preparation of oil palm empty bunches

A total of 5.000 g of empty oil palm bunches obtained from the remaining palm oil mill production were wet sorted and washed with running water. Furthermore, the fiber of the empty oil palm bunches obtained was cut and dried in a drying cabinet at 50ºC. The coarse fiber of the empty oil palm bunches was ground with a grinding machine and then sieved with a size of 100 mesh to obtain empty oil palm bunch powder.

2.2.2 Hemicellulose isolation of empty oil palm fruit bunches

Isolation of hemicellulose from empty oil palm bunches was done by modifying the method used by Muchlisyam (2014). 250 g of empty oil palm bunch powder was put into 3000 ml of NaOH with various concentrations of 0.05 N, 0.10 N, 0.20 N, 0.3 N, and 0.5 N. The mixture was stirred until homogeneous, left for 6 hours, and poured off. Then, the filtrate from the separation was added with 70% ethanol (1:3), went for 3 hours, and poured off again. The residue was washed with distilled water and then dried at 50ºC. The dried powder was then ground and weighed.

2.2.3 Characterization of hemicellulose from empty oil palm bunches

Empty oil palm bunch hemicellulose was evaluated using organoleptic and solubility tests. The organoleptic test consists of visual observation, taste, odor, and color. A solubility test was conducted using 0.1 N NaOH alkali solvent, distilled water, ethanol, hot water, and glacial acetic acid. Functional group analysis

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of empty oil palm bunch hemicellulose was conducted using Fourier Transform Infrared (FTIR). Morphology of hemicellulose was conducted using a Scanning Electron Microscope (SEM).

3. RESULTS AND DISCUSSION

3.1 Hemicellulose yield of empty oil palm fruit bunches

Preparation of 5,000 g of raw EOPB sample produced 1,164 g of fine EOPB powder after being cleaned, ground, and sieved. The fine EOPB powder was then added to the NaOH solution with variations of 0.05 N, 0.10 N, 0.20 N, 0.30 N, and 0.50 N to isolate hemicellulose from EOPB. The mixture was left for 6 hours and then separated. The yield of EOPB hemicellulose from various concentrations is presented in Table 1. The results of hemicellulose isolation showed that the higher the concentration of NaOH reagent used, the greater the amount of hemicellulose produced. The highest hemicellulose from EOPB isolation was obtained at a NaOH concentration of 0.5 N, 32.10 g, with a yield of 12.84%. These results align with the findings of Nasir and Saleh (2016), which stated that the yield of hemicellulose increased with increasing KOH concentration.

Table 1. Yield of hemicellulose from isolation of empty oil palm fruit bunches

No	NaOH reagent (N)	Sample (g)	Yield of hemicellulose (g)	Yield (%)
1	0,05	250	1,00	0,40 %
2	0,10	250	7,40	2,96%
3	0,20	250	5,20	2,08%
4	0,30	250	7,00	2,80%
5	0,50	250	32,10	12,84%

Soaking with NaOH will cause lignin molecules to degrade in the crystalline and amorphous parts and some hemicellulose. Hemicellulose has an amorphous structure so that using NaOH solvent can remove lignin while extracting hemicellulose. OH^- ions from NaOH damage the bonds of the lignin structure, namely aryl-ether, carbon-carbon, aryl-aryl, and alkyl bonds. Alkali extraction is the most efficient method for isolating hemicellulose polysaccharides in large quantities [7].

3.2 Organoleptic and solubility test of empty oil palm bunches hemicellulose

Organoleptic testing was conducted to determine the characteristics of hemicellulose obtained from EOPB isolation. The results of the organoleptic test showed that hemicellulose in all variations of NaOH reagents had the same characteristics, namely powder form, distinctive odor, brown color, and tasteless. The characteristics of the hemicellulose obtained were the same as the hemicellulose from the previous isolation [7].

The solubility test of hemicellulose aims to determine its properties in various solvents. The results of the solubility test show that hemicellulose in all variations of NaOH reagents has the same solubility, namely easily soluble in base (0.1 N NaOH), soluble in hot water, difficult to dissolve in aquadest, insoluble in 70% ethanol and insoluble in acid. The solubility of a carbohydrate polymer will decrease with the increasing molecular weight. Hemicellulose is difficult to dissolve in aquadest but soluble in hot water. The solubility properties of

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the EOPB hemicellulose produced are the same as the research results of Muchlisyam's research (2014), namely hemicellulose is also difficult to dissolve in aquadest.

3.3 Analysis of functional groups of hemicellulose in empty oil palm bunches

The hemicellulose functional groups were evaluated from EOPB isolation using Fourier Transform Infrared. The characteristic absorption peaks of hemicellulose functional groups isolated with various NaOH concentrations are presented in Figure 1. The FTIR results of hemicellulose from all NaOH variations showed the same absorption peaks. An absorption peak at a wavelength of 3324.74 cm^{-1} - 3330.48 cm^{-1} indicates the presence of O-H stretching. The absorption peak at a wavelength of 2917.04 cm^{-1} indicates C-H group stretching. An absorption peak indicates the bending of the C=O group at a wavelength of 1630.79 cm^{-1} - 1648.01 cm^{-1}. The appearance of an absorption peak at a wavelength of 1027.86 cm^{-1} - 1159.93 cm^{-1} indicates the presence of C-OH group bending. The absorption peak in the wavelength region of 895.07 cm^{-1} – 895.82 cm^{-1} indicates C-C stretching. The absorption peaks from the FTIR analysis show specific peaks of hemicellulose and are identical to those from corn cobs studied previously [8–10].

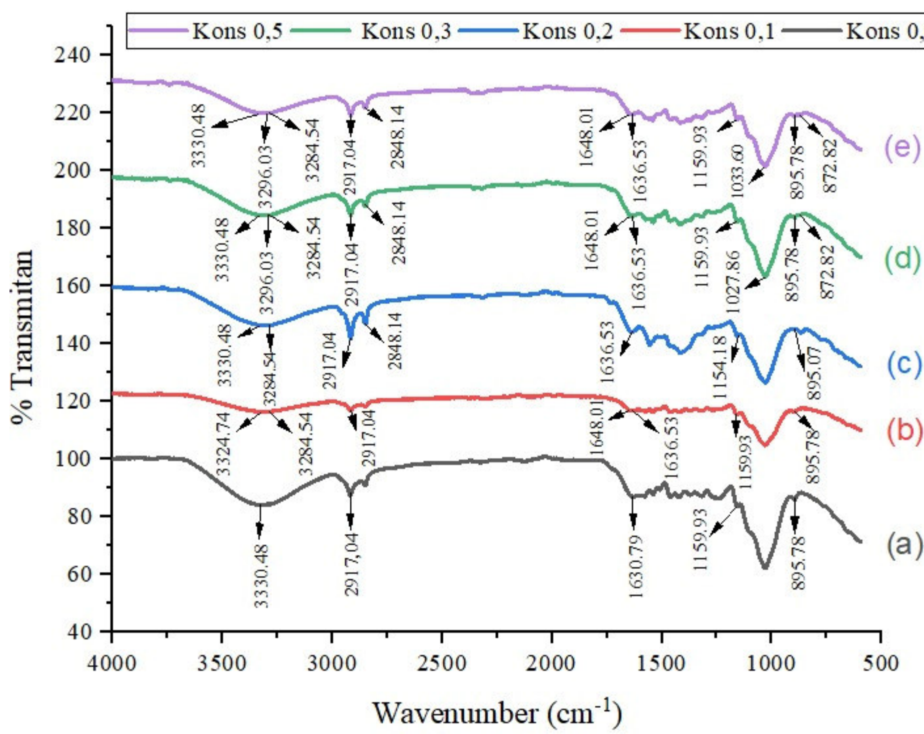

Figure 1. FTIR graph of hemicellulose of empty oil palm bunches with various NaOH concentrations

3.4 Morphological analysis of hemicellulose of empty oil palm bunches

Morphological analysis of hemicellulose was carried out using SEM, which aims to see the morphological structure of the hemicellulose surface in high magnification using a high-energy electron beam. Based on the SEM analysis, the hemicellulose surface of empty oil palm bunches was obtained in various magnification

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sizes in Figure 2. SEM photos show the rough and fibrous shape of the hemicellulose powder surface. At a magnification of 1000 times, the shape of the particle cavities and irregularities is increasingly visible. At a magnification of 2000 times, the cavities of hemicellulose are increasingly visible. The literature states that hemicellulose has hydrophilic properties and is easily soluble in alkali[11,12].

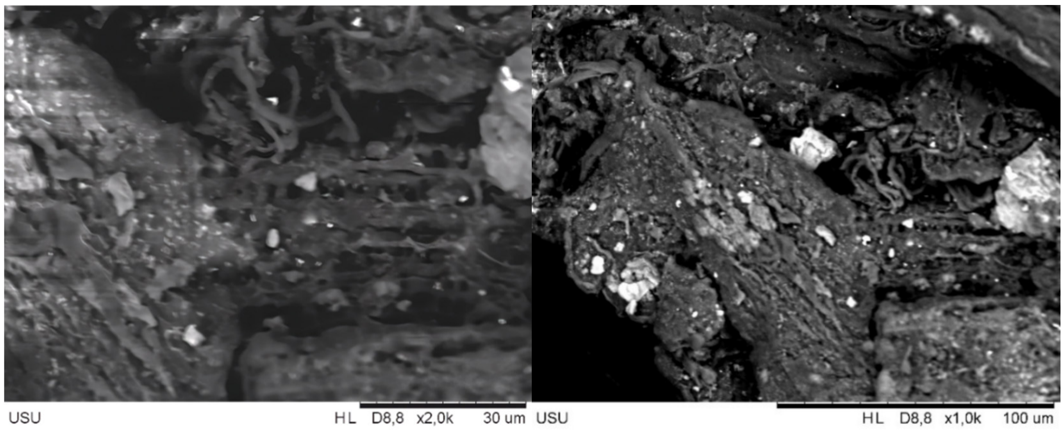

Figure 2. Morphology of hemicellulose from isolated empty oil palm bunches with magnification of (a) 1000 times and (b) 2000 times

4. CONCLUSION

Hemicellulose has been successfully isolated from empty oil palm bunches by alkali extraction method using NaOH solvent. The highest yield of 12.84% was obtained from the 0.5 N NaOH solvent variation. Organoleptic and solubility tests showed that the characteristics of hemicellulose isolated from empty oil palm bunches were by the characteristics of hemicellulose in general. Functional group analysis with FTIR and morphology with SEM confirmed the obtained hemicellulose.

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