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Eco Friendly-Microwave Assisted Extraction of Cellulose from Sugarcane Bagasse

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Abstrak-Selulosa merupakan salah satu jenis biopolimer alami yang paling berlimpah dan ditemukan di berbagai biomassa. Selulosa dan turunannya memiliki berbagai karakteristik yang menguntungkan sehingga membuat keduanya memiliki potensi aplikasi yang luas. Menimbang berbagai kelebihan dan potensi aplikasi yang luas, usaha untuk mendapatkan selulosa murni dewasa ini terus dikaji dan dikembangkan. Ampas tebu merupakan salah satu biomassa yang dapat dijadikan sebagai bahan baku produksi selulosa mengingat kandungan selulosa yang tinggi. Tujuan penelitian ini adalah mengkaji proses produksi selulosa dari ampas tebu menggunakan proses ekstraksigelombangmikro yang ramah lingkungan menggunakan pelarut asam asetat. Ekstraksi gelombang mikro selulosa dari ampas tebu dilakukan pada berbagai variasi waktu ekstraksi (30-70 menit) dan rasio solid liquid (1:12-1:20), serta pada konsentrasi asam asetat 5% dan daya mikrowave 39,9W. Produk ekstraksi dianalisa kandungan alpha, beta dan gamma selulosa. Hasil penelitian menunjukkan bahwa alpha selulosa tertinggi diperoleh pada ekstrak yang dihasilkan dari proses ekstraksi gelombang mikro selama 60 menit dengan rasio solid likuid 1:12, konsentrasi asam asetat 5% serta daya mikrowave 39,9W.

Kata kunci*:* ampas tebu, ekstraksi, selulosa

Abstract-Cellulose is widely present in various forms of biomasses. Cellulose and its derivatives have many advantages and have been used for years in a wide variety of applications. Obtaining pure cellulose from lignocellulosic materials is essential due to its potential advantages and applications. Sugarcane bagasse is one of very promising raw materials for cellulose production due to its high cellulose content. The objective of this research was to investigate the microwave assisted extraction of cellulose from sugarcane bagasse by using an eco-friendly solvent, i.e. acetic acid. The microwave assisted extraction of sugarcane bagasse cellulose were conducted in varied extraction time (30-70 minutes) and solid liquid ratio of 1:12-1:20, while the acetic acid concentration was fixed at 5% and the power level of the microwave was set at 39.9 W. The product was analyzed for its alpha, beta and gamma cellulose content. The research showed that 67.56% was the highest alpha cellulose content of the sugarcane bagasse pulp obtained from the eco- friendly microwave assisted extraction conducted at 60 minutes of extraction, solid liquid ratio of 1:12, acetic acid concentration of 5% and microwave power level of 39.9 W.

Keywords**:** sugarcane bagasse, extraction, cellulose

1. Introduction

Cellulose is the most abundant, natural, biodegradable, non-toxic and renewable biopolymer resources on earth. Cellulose is a polydisperse homopolymer, its molecule consisting of regio- and enantioselectivelyβ-1,4-glycosidic linked d-glucopyranose units (so-called anhydroglucose units [AGU]) (Klemm at al., 2005). The nature of the glucose molecules bond allows the polymer to be arranged in long straight and linear chains. The molecular formula of cellulose is $(C_6H_{10}O_5)n$, and its (n) ranging from 10,000 to 15,000 through an acetal oxygen covalently bonding C1 of one glucose ring and C4 of the adjoining ring. The cellulose contains free hydroxyl groups at the C-2, C-3, and C-6 atoms (Klemn et al., 2005; Peng et al, 2011; Zhou and Wu, 2012).

Cellulose is widely present in various forms of biomasses. The primary occurrence of cellulose is the existing lignocellulosic material in forests, agriculture and plantation, with wood as the most important source. Other cellulose-containing materials include agriculture residues, water plants, grasses, and other plant substances, such as algae, tunicate and bacteria. In lignocellulosic material, besides cellulose, they contain hemicelluloses, lignin, and a comparably small amount of extractives (Klemn et al., 2005; Draman et al., 2016).

The materials based on cellulose and its derivatives have been used for more than 150 years in a wide variety of applications, such as construction material, food, textile fibers, paper production, biomaterials and pharmaceuticals. Moreover, cellulose was reported to be a versatile starting material for chemical conversions, aiming at the production of artificial, cellulose-based threads and films (Peng et al., 2011; Draman et al., 2016). Due to its wide variety of applications, obtaining pure cellulose from lignocellulosic materials is essential. Cellulose can be obtained from sugarcane bagasse since it is composed of cellulole (40%), hemicellulose (30%), lignin (20%), and extractives (10%) (Klemn et al., 2005).Meanwhile Guilherme et al. (2011) reported that the cellulose, hemicellulose and liginin content of sugarcane bagasse were reported as high as 38.59%, 27.89%, and 17.79%, respectively.

Commonly, two main steps involved in the extraction of cellulose from various lignocellulosic materials. The two main steps are alkali or acidic treatment and bleaching which widely used by researchers for cellulose extraction. NaOH was used for alkaline treatment, meanwhile sodium chlorite were used as bleaching agents. Acidified sodium chlorite was also widely used as a reagent for the cellulose extraction. The main back draw of the process was the production of chlorine radical which reacts and fragments the lignocellulosic material into highly toxic organochlorine (Nazir et al., 2013; Draman et al., 2016). There are now concerted efforts to go green by using eco-friendly reagents such as acetic acid which is less corrosive, effective and provide more stable medium for monosaccharide in the aguaeous phase compared to the other strong acid solution i.e. sulfuric acid (Nazir et al., 2013).

In this work, sugarcane bagasse cellulose was extracted by applied acetic acid as the solvent and microwave heating.

2. Research Method

Materials

Sugarcane bagasse was provided from local sugarcane industry in Pati, Central Java. Acetic acid, kalium permanganate, sodium thiosulphate, kalium iodide, sulphuric acid, hydrogen peroxide, and amylum were of analytical grade and water was double distilled.

Microwave assisted organosolv pulping

Sugarcane bagasse fiber was dried and then ground by a grinder. The grinded sugarcane bagasse fiber was then sieved to reduce the size. This dried ground EFB fiber was then, kept in a desiccators at 50% relative humidity until use.

The microwave assisted extraction of sugarcane bagasse cellulose was conducted in a varied of the microwave assisted extraction time (30-70 minutes), and solid liquid ratio (1:12-1:20). The microwave power level was set at 10% of its maximum power, 399W and acetic acid concentration of 5%. Once the microwave assisted extraction has completed, the residue was analyzed for its alpha cellulose, beta cellulose and gamma cellulose content.

Alpha, Beta and Gamma Cellulose determination

The alpha, beta and gamma cellulose content were determined in accordance with No 0444:2009 SNI Method. Pulp is extracted consecutively with 17.5% and 9.45% sodium hydroxide solutions at 25^0C. The soluble fraction consisting of beta- and gamma-celluloses, is determined volumetrically by oxidation with potassium dichromate, and the alpha-cellulose, as an insoluble fraction, is derived by difference.

3. Result and Discussion

Cellulose has been extracted from different sources such as sago biomass (Veeramachineni et al., 2016), wheat straw (Saberikhah et al., 2010; Singh et al., 2013), and agave leaves (Rosli et al., 2013).

Different methods, e.g., chemical, mechanical, biological and chemo-mechanical, have been applied in the separation process, but the quality varies widely depending on the source of the cellulose (Veeramachineni et al., 2016). Biological extraction of cellulose was conducted by the advantage of enzymatic action such as in the cellulose separation conducted by Xu et al (2015). They applied protease and pectinase in the cellulose extraction from banana pseudo stem fibers. Biological methods are environmentally friendly but the extraction processing time was long and gave negative effects towards the cellulose fiber's quality. Moreover, chemical methods applied in the cellulose extraction are including the utilization of acid and alkaline solution in the delignification process (Seben and Paula, 2012). Meanwhile the mechanical methods are including mechanical decortication, scrapping, steam explosion and ultrasonic vibration (Xu et al., 2015). Veeramachineni et al. (2016) mentioned that the most expensive method uses biology, whereas a combination of chemical and mechanical methods shows evidence of producing cheaper and efficient methods of extraction.

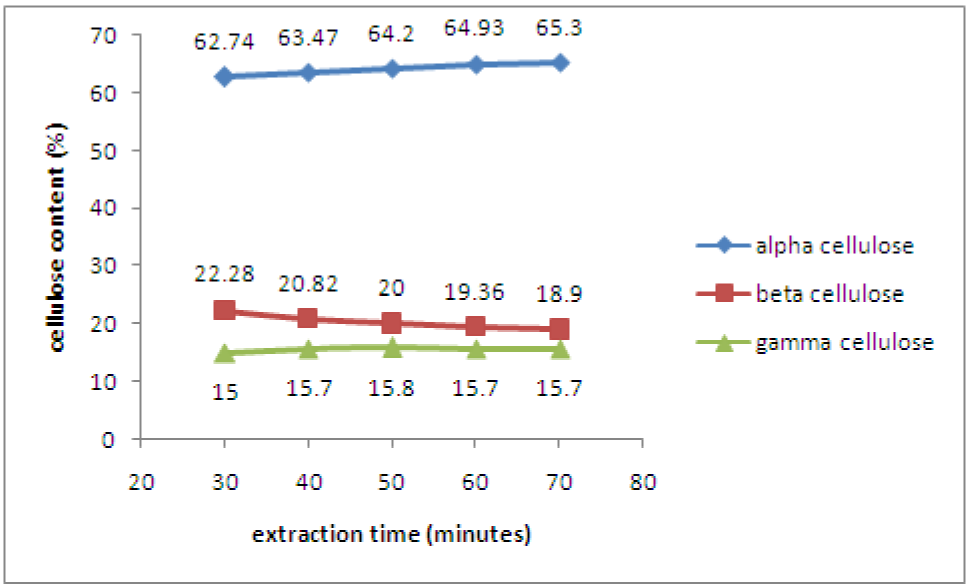

Figure 1. The Cellulose Content of the Eco Friendly-Microwave Assisted Extraction Of Cellulose From Sugarcane Bagasse conducted at solid liquid ratio 1:12, microwave power level of 39.9W and acetic acid concentration of 5%

Furthermore, in this research, acetic acid was used in the microwave assisted extraction of cellulose from sugarcane bagasse. The parameter process investigated was extraction time and solid liquid ratio. The microwave assisted extraction of sugarcane bagasse cellulose was conducted in a varied of the microwave assisted extraction time (30-70 minutes), and solid liquid ratio (1:12-1:20). The microwave power level was set at 10% of its maximum power, 399W and acetic acid concentration of 5%. The cellulose content of the eco-friendly-microwave assisted extraction of cellulose from sugarcane bagasse conducted at solid liquid ratio 1:12, microwave power level of 39.9W and acetic acid concentration of 5% was shown on Fig 1, meanwhile the cellulose content of the eco-friendly-microwave assisted extraction of cellulose from sugarcane bagasse conducted at extraction time of 60 minutes, microwave power level of 39.9W and acetic acid concentration of 5% was shown on Fig 2.

It was show on Fig 1 and 2 that the eco-friendly microwave assisted extraction was able to obtain sugarcane bagasse pulp with high alpha cellulose content. The eco-friendly microwave assisted extraction was able to increase the amount of cellulose content since the alpha cellulose content of the untreated sugarcane bagasse was of 46%, which is lower than the alpha cellulose of 47.4%, found by Samariha and Khakifirooz (2011).

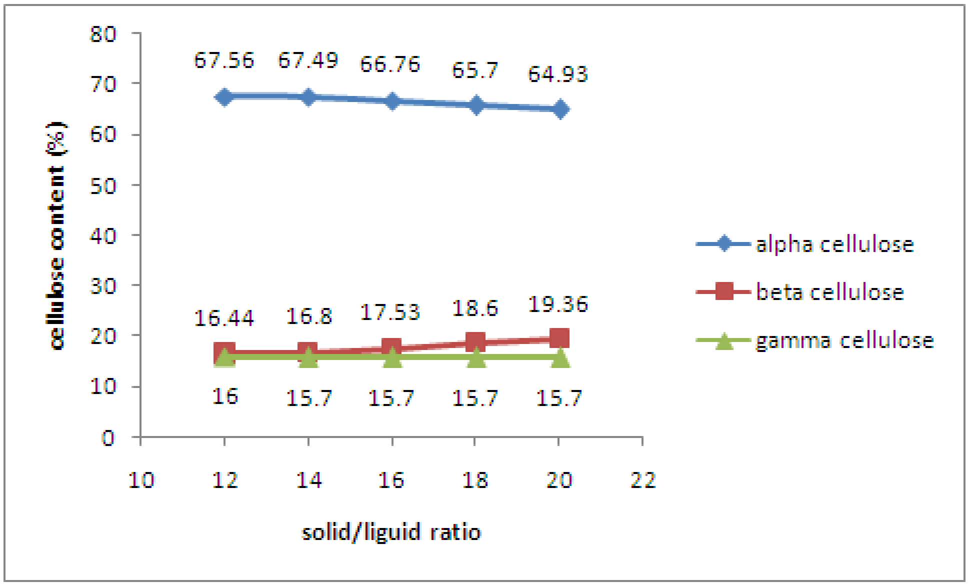

Figure 2. The Cellulose Content of the Eco Friendly-Microwave Assisted Extraction Of Cellulose From Sugarcane Bagasse conducted at extraction time of 60 minutes, microwave power level of 39.9W and acetic acid concentration of 5%

Fig 1 showed us that along with the increasing of the extraction temperature from 30-70 minutes, the alpha cellulose increase from 62.74 to 65.3%. It might be due to along with the increasing time, the microwave heating enhance the extraction process. Fig 2 showed us that 67.56% was the highest alpha cellulose content of the sugarcane bagasse pulp obtained from the eco-friendly microwave assisted extraction conducted at 60 minutes of extraction, solid liquid ratio of 1:12, acetic acid concentration of 5% and microwave power level of 39.9W. This finding was higher than the alpha cellulose content of the sugarcane bagasse pulp obtained by mechanical and biological-mechanical methods applied by Saelee et al. (2014). They investigated the comparation of the alpha cellulose content of the sugarcane bagasse pulp obtained by steam explosion; steam explosion combined with xylanase treatment and bleached fiber of sugarcane bagasse pulp. They conducted steam explotion by utilized exploded steam at a pressure 13 bar (195 °C) for 15 min. Then, the steam exploded SCB was treated with 20 U/g of xylanase using fiber to liquor ratio of 1:10 for 1 h at 50°C under constant agitation. The dried steam exploded SCB treated with xylanase was then to bleached with 0.7% sodium chlorite ($NaClO_2$) adjusted to a pH 4 by the addition of acetic acid at 70 °C for 1 h. The alpha cellulose content of the sugarcane bagasse pulp obtained by steam explosion, steam explosion combined with xylanase treatment and bleached fiber of sugarcane bagasse pulp were 65.7, 66.3 and 89.3%, respectively.

The relatively high alpha cellulose content of the sugarcane bagasse pulp obtained from the eco-friendly microwave assisted extraction might be due to the ability of microwave heating in enhancing the extraction process.

4. Conclusion

The combination of microwave heating and the ecofriendly solvent was proven as a potential technology in the extraction of sugarcane bagasse cellulose. The research showed that 67.56% was the highest alpha cellulose content of the sugarcane bagasse pulp obtained from the eco friendly microwave assisted extraction conducted at 60 minutes of extraction, solid liquid ratio of 1:12, acetic acid concentration of 5% and microwave power level of 39.9 W.

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