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Investigating the potential of using coconut husk as substrate for bioethanol production

Ding, Teck-Yuan[1], Hii, Siew-Ling[1+], Ong, Lisa-Gaik-Ai[2], Ling, Tau-Chuan[3]

[1] Department of Chemical Engineering, Faculty of Engineering and Science,
Universiti Tunku Abdul Rahman, Jalan Genting Kelang,
53300 Kuala Lumpur, Malaysia.

[2]Department of Biological Science, Faculty of Science,
Universiti Tunku Abdul Rahman, 31900 Kampar, Perak, Malaysia.

[3]Institute of Biological Sciences, Faculty of Science Building,
University of Malaya, 50603 Kuala Lumpur, Malaysia

Abstract. In the present study, the feasibility of using microwave-assisted-alkaline pretreated coconut husks as carbon source for batch ethanol fermentation was investigated. From our study, the maximum concentration of reducing sugar obtained after enzymatic hydrolysis of pretreated coconut husks is 2.90 g/L. By using pretreated coconut husk, approximately 0.09% w/w of ethanol was recorded through simultaneous saccharification and fermentation process. The ethanol yield attained from the current study is lower as compared to the theoretical ethanol yield. Nonetheless, the results indicated that the agricultural waste, i.e., coconut husk, could be considered as a potential lignocellulosic material for production of fermentable sugars related to bioethanol production.

Keywords: Bioethanol, Microwave-assisted-alkaline pretreatment, Simultaneous saccharification and fermentation, *Saccharomyces cerevisiae*

1. Introduction

Worldwide high demand for energy and concerns about global climatic changes has led to the resurgence in the development of alternative fuels such as bioethanol. Bioethanol which can be produced through the fermentation of various lignocellulosic resources, has the advantages of increasing energy availability, decreasing air pollution, and diminishing atmospheric CO_2 accumulation (Prasad, 2007).

Lignocellulosic biomass refers to plant biomass that is composed of carbohydrate polymers (cellulose and hemicellulose) and lignin. Pretreatment is a necessary step in order to alter or remove structural and compositional impediments in lignocelluloses. The goals of pretreatment are to improve the rate of subsequent enzyme hydrolysis and increase yields of fermentable sugars from carbohydrate polymers that are trapped by lignin (Mosier et al., 2005; Alvira et al., 2010).

The pretreatment of lignocellulosic biomass prior to fermentation can be physical, chemical, physic-chemical and etc. Each type of pretreatment has its own advantages and disadvantages. Some have been stated to be effective in disrupting lignin-carbohydrate complex, while others are reported to be effective in breaking down the highly ordered cellulose crystalline structure, which is a prerequisite for enzymatic saccharification. In the present study, microwave-assisted-alkaline treatment was applied to pre-treat the

[+] Corresponding author. Tel.: + 60341079802; fax: +60341079803
E-mail address: yvonne_hii@ymail.com

coconut husks and the conversion of pretreated coconut husk to bioethanol through simultaneous saccharification and fermentation (SSaF) process was examined.

2. Materials and Methods

2.1. Raw Material

The coconut husks were collected from coconut farm in Perak, Malaysia. The grinded coconut husks with particle size range in between 850 to 1500 µm were used as raw material. The coconut husks were then washed and oven dried at 40^{O}C until constant weight.

2.2. Pretreatment of Coconut Husks by Combination of Microwave and Alkaline Technique

Pretreatment of coconut husks particles was conducted in a Sharp/R-218H(S) domestic microwave oven at a frequency of 2450 MHz. The coconut husks particles were pre-soaked in NaOH solution prior to microwave treatment. Following the treatment process, the mixture was removed from the microwave and rinsed with distilled water through a double rings filter paper to separate the residues and the liquid. The filtered residues were then oven dried at 40^{O}C for subsequent use.

2.3. Simultaneous Saccharification and Fermentation (SSaF)

The SSaF experiments were conducted by using 25 g/L of treated coconut husks in Erlenmeyer flask containing 100 mL basal medium (yeast extract, 10 g/L; peptone, 20 g/L). Two commercial enzymes, Celluclast 1.5L and Pextinex Ultra SP-L, were added prior to inoculation of yeast cells (*Saccharomyces cerevisiae* ATCC 36858). Following inoculation process, the flasks were incubated at 30^{O}C in an orbital shaker at 150 rpm.

2.4. Analytical Procedures

Sampling was done at pre-determined time interval for analysis of reducing sugar and ethanol concentration. The content of reducing sugars was determined using 3,5-dinitrosalicylic acid method (Miller, 1959) by measuring absorbance at 540 nm. Ethanol concentration was determined by HPLC on a Rezex ROA-Organic Acid H + (8%) column at 60 ^{O}C at 0.4 ml/min with 0.01 N sulfuric acid as the eluent.

3. Results and Discussion

The complex structure of lignocellulosic biomass, which include coconut husk, limits the biomass utilization for energy production (Zaldivar et al., 2001). Hence, pretreatment step is necessary in improving the saccharification efficiency for ethanol production (Zhu et al., 2006). In the present study, the microwave-assisted-alkaline pretreated coconut husks were used as sugar source for bioethanol production through simultaneous saccharification and fermentation (SSaF) process. Simultaneous saccharification and fermentation (SSaF) is defined as a process which combines enzymatic saccharification and yeast (*Saccharomyces cerevisiae*) fermentation (Sun and Cheng, 2002). As can be observed from Figure 1 A, reducing sugar was detected in the fermentation medium and the maximum concentration of 2.90 g/L was achieved after 1 day of cultivation. The gradual decrease of sugars level in the medium thereafter was found associated with the production of bioethanol, as shown in Figure 1 B. The bioethanol level in the medium increased exponentially during the first 36-h of cultivation and attained maximum concentration of 0.087% (w/w) after 48-h of incubation. In conclusion, the current study offers an opportunity in exploring the potential of using a locally available agricultural waste as biomass feedstock for production of bioethanol as alternative energy source.

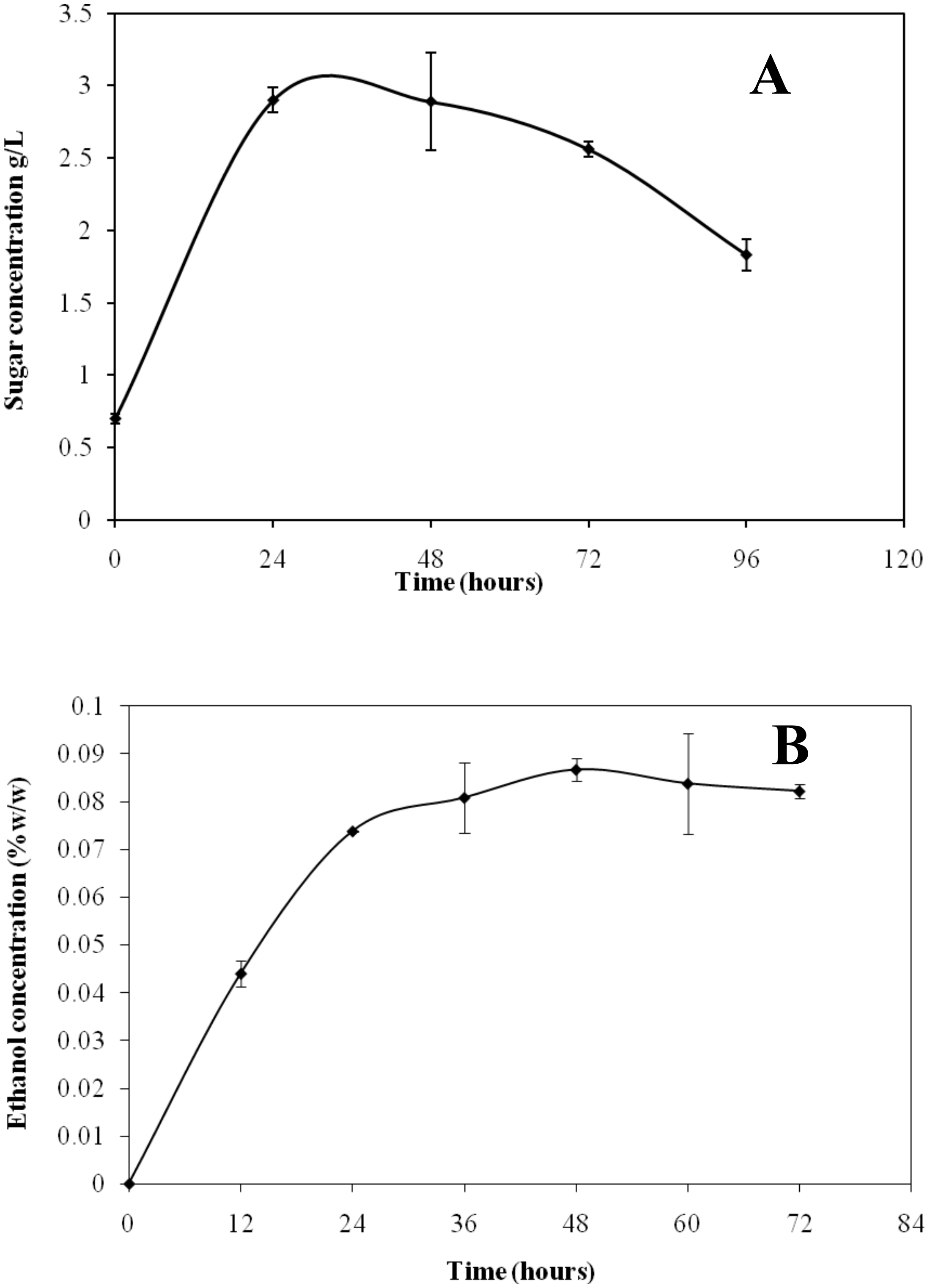

Figure 1: Time course for SSaF of the microwave-assisted-alkaline pretreated coconut husk to ethanol. Symbols: A – reducing sugar; B – ethanol. Error bars indicate the mean ± standard deviation of three experiments. For data points without error bars, the errors were smaller than the size of the symbols.

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