Conversion of coffee residue waste into bioethanol with using popping pretreatment

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HIGHLIGHTS

Popping pretreatment conducted bioethanol production from coffee residue waste.
Simultaneous saccharification and fermentation applied with optimal enzyme dosage.
High hydrolysis efficiency (85.6%) and fermentation efficiency (87.2%) were obtained.

ABSTRACT

Coffee residue waste (CRW), which is produced after coffee extraction for coffee powder and instant coffee preparation, is a primary industrial waste. In this study, the use of CRW for bioethanol production was evaluated. The carbohydrate content of CRW was analyzed for fermentable sugars such as glucose, galactose, and mannose, which can be fermented by \textit{Saccharomyces cerevisiae}. Pretreatment at a pressure of 1.47 MPa for 10 min with popping pretreatment was required to increase enzymatic hydrolysis. CRW was well hydrolyzed following popping pretreatment at 1.47 MPa. The enzymatic conversion rate of CRW to fermentable sugars was 85.6%. Ethanol concentration and yield (based on sugar content) following enzymatic hydrolysis after simultaneous saccharification and fermentation were 15.3 g/L and 87.2%, respectively.

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1. Introduction

Alternative energy resources such as bioethanol are required to sustain economic growth with the environment. Bioethanol can be used to reduce carbon dioxide emissions and is a promising alternative to fossil fuels because it can be produced from renewable biomass. It is a liquid fuel that can be adapted to existing fuel supply systems, ultimately replacing fossil fuels in the transportation sector (Carroll and Someville, 2009), and it is currently produced from starch-based food crops. However, the use of starch-based or sugar-rich feedstock has directly increased food prices due to the high price of raw materials, which account for 40–75% of the total expenses of ethanol production (Eisentraut, 2010). Therefore, cheap and abundant nonfood materials are required as alternative biomass sources, e.g., agricultural by-products, forest residues, or energy crops (Henry, 2010; Demirbas, 2011).

Coffee residue waste (CRW) is a promising alternative biomass resource for bioethanol production, and coffee is one of the most widely consumed beverages globally. Based on USDA data (2011), global coffee production during 2010/2011 is estimated to be over 8.2 million tons. The extraction process generates large amounts of CRW during the treatment of coffee powder and instant coffee preparation. CRW contains toxic compounds, which are typically disposed of into the environment and cause environmental problems (Leifa et al., 2000). However, CRW is rich in fermentable sugars, accounting for approximately 37–42% of the waste (Oosterveld et al., 2003), which can be utilized as a carbohydrate source for bioethanol production. Despite the high carbohydrate content compared to other biomasses, information on the use of CRW in ethanol production is limited, excluding previous studies regarding their use as antioxidants (Yen et al., 2005) or as an activated carbon resource (Nunes et al., 2009).

Efficient utilization of lignocellulose requires an initial pretreatment step to minimize lignin and hemicellulose for effective enzymatic hydrolysis. A pretreatment process is also necessary because CRW contains high concentrations of hemicellulose and lignin (Redgwell et al., 2002). Most pretreatment methods are based on either chemical or physical approaches (Alvira et al., 2010; Gírio...