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Surfactant-assisted pretreatment and enzymatic hydrolysis of spent mushroom compost for the production of sugars

N.U.S. Kapu[a,1], M. Manning[a], T.B. Hurley[a], J. Voigt[a], D.J. Cosgrove[b], C.P. Romaine[c,*]

[a] Expansyn Technologies, Inc., 200 Innovation Boulevard, Suite 258-B, State College, PA 16803, USA
[b] Department of Biology, 208 Mueller Laboratory, The Pennsylvania State University, University Park, PA 16802, USA
[c] Department of Plant Pathology, 211 Buckhout Laboratory, The Pennsylvania State University, University Park, PA 16802, USA

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ABSTRACT

Spent mushroom compost (SMC), a byproduct of commercial mushroom cultivation, poses serious environmental problems that have hampered the growth of this important agro-industry. In an effort to develop new applications for SMC, we explored its use as a feedstock for bioethanol production. SMC constitutes approximately 30% w/w polysaccharides, 66% of which is glucan. Following dilute-acid pretreatment and enzymatic hydrolysis, both in the presence of PEG 6000, 97% of glucan and 44% of xylan in SMC were converted into the corresponding monosaccharides. Incorporation of PEG 6000 reduced the cellulase requirement by 77%. Zwittergent 3–12 and 3–14 also significantly increased the efficacy of acid pretreatment and enzymatic hydrolysis. The use of SMC in bioethanol production represents a potential mitigation solution for the critical environmental issues associated with the stockpiling of the major byproduct of the mushroom industry.

1. Introduction

The conversion of lignocellulosic biomass into biofuel has received considerable scientific and public interest, because biofuels provide an attractive alternative for avoiding the environmental, economic, and political drawbacks associated with petroleum usage (Himmel et al., 2007; Lynd et al., 2008). An alluring aspect of biofuel production is its reliance on low-cost byproducts and residues from a broad range of industries as sources of feedstock. Consequently, there is strong interest in the development of more efficient methods to produce ethanol and other useful chemicals from diverse lignocellulosic substrates.

Spent mushroom compost (SMC) is a lignocellulosic byproduct of the commercial mushroom (*Agaricus bisporus*) industry, where the production of each kilogram of mushroom biomass generates approximately five kilograms of SMC (Finney et al., 2009). The total US production of agaric mushrooms in 2009 was approximately 240,000 tonnes (USDA, 2010), which translates into more than one million tonnes of SMC annually. Commercial mushrooms are cultivated using a substrate consisting of various mixtures of wheat straw, hay, corncobs, seed hulls and meal, horse manure, chicken manure, inorganic fertilizer, calcium sulfate, peat moss, and ground limestone. After mushroom harvest, the residual substrate is pasteurized and either discarded or sold as SMC. The US mushroom industry incurs an estimated cost of US$7 million annually for SMC disposal (pers, commun, Glenn Cote, Laurel Valley Farms). However, the rate of SMC production far exceeds its demand for existing applications. Hence, field storage of SMC leads to significant environmental problems, including the leaching of nitrates and phosphorous that can lead to eutrophication in water resources (Finney et al., 2009) and public health issues associated with the attraction of flies and other insects (Derikx et al., 1990; Kaplan et al., 1995). The lack of sustainable disposal strategies is a major limiting factor in the growth of the mushroom industry (Finney et al., 2009).

To address the daunting disposal issue, SMC has been explored for a diversity of potential commercial applications, including an amendment for plant growth media (Medina et al., 2009; Ribasa et al., 2009) and a bioremediation agent (Chiu et al., 2009). There has been relatively little interest however, in examining the suitability of SMC as a renewable feedstock for fuels and chemicals. Here, one experimental approach entailed the combustion of SMC to generate power (Finney et al., 2009; McCahey et al., 2003; Williams et al., 2001), while another involved an ammonia-based (AFEX) pretreatment combined with enzymatic conversion into fermentable sugars (Balan et al., 2008; Dale et al., 2007). However, to date, none of the above applications has provided a sustainable solution to the stockpiling of SMC.

* Corresponding author. Tel.: +1 814 571 8355; fax: +1 814 863 7217.
E-mail address: cpr2@psu.edu (C.P. Romaine).
[1] Current address: Forest Products Biotechnology/Bioenergy Group, Faculty of Forestry, The University of British Columbia, 2424 Main Mall, Forest Science Ctr., Vancouver, BC, Canada V6T 1Z4.

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