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Research Article

Recovery of Glucose from Residual Starch of Sago Hampas for Bioethanol Production

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Lower concentration of glucose was often obtained from enzymatic hydrolysis process of agricultural residue due to complexity of the biomass structure and properties. High substrate load feed into the hydrolysis system might solve this problem but has several other drawbacks such as low rate of reaction. In the present study, we have attempted to enhance glucose recovery from agricultural waste, namely, "sago hampas," through three cycles of enzymatic hydrolysis process. The substrate load at 7% (w/v) was seen to be suitable for the hydrolysis process with respect to the gelatinization reaction as well as sufficient mixture of the suspension for saccharification process. However, this study was focused on hydrolyzing starch of sago hampas, and thus to enhance concentration of glucose from 7% substrate load would be impossible. Thus, an alternative method termed as cycles I, II, and III which involved reusing the hydrolysate for subsequent enzymatic hydrolysis process was introduced. Greater improvement of glucose concentration (138.45 g/L) and better conversion yield (52.72%) were achieved with the completion of three cycles of hydrolysis. In comparison, cycle I and cycle II had glucose concentration of 27.79 g/L and 73.00 g/L, respectively. The glucose obtained was subsequently tested as substrate for bioethanol production using commercial baker's yeast. The fermentation process produced 40.30 g/L of ethanol after 16 h, which was equivalent to 93.29% of theoretical yield based on total glucose existing in fermentation media.

1. Introduction

In recent years, there has been an increasing trend towards more efficient utilization of agro-industrial by-products for conversion to a range of value-added bioproducts, including biofuels, biochemicals, and biomaterials [1]. As an initiative, this study was formulated to utilize sago hampas as an alternative substrate for glucose production, which will be used as feedstock for bioethanol production. Sago hampas is a starchy lignocellulosic by-product generated from pith of *Metroxylon sagu* (sago palm) after starch extraction process [2]. *Metroxylon sagu* Rottb. is an increasingly important socioeconomic crop in Southeast Asia whereas New Guinea is believed to be its center of diversity [3]. In Malaysia, the state of Sarawak is recognized as the largest sago-growing areas, which is currently the world's biggest exporter of sago starch, exporting annually about 44,000 t of starch mainly to Peninsular Malaysia, Japan, Singapore, and other countries [4]. The isolation of sago starch involves debarking, rasping, sieving, settling washing, and drying [2]. However, the mechanical process currently employed to extract sago starch is inefficient and often fails to dislodge residual starch embedded in the fibrous portion of the trunks [3]. On dry basis, sago hampas contains 58% starch, 23% cellulose, 9.2% hemicellulose, and 4% lignin [5]. Approximately, 7 t of sago hampas is produced daily from a single sago starch processing mill [6]. Currently, these residues which are mixed together with wastewater are either washed off into nearby streams or deposited in the factory's compound. These circumstances, in time, may potentially lead to serious environmental problems.

Several studies on the utilization of sago hampas as animal feed, compost for mushroom culture, for hydrolysis to confectioners' syrup, particleboard manufacture, and as substrate for local microbes to produce reducing sugars and