Diluted Sulphuric Acid Hydrolysis of Destarched Sago Fibre assisted with Selected Pre-treatments for Glucose and Xylose Production

Barji Isfaniza and Awang Adeni Dayang Salwani*
Resource Biotechnology Programme, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, MALAYSIA
*adsalwa@unimas.my

Abstract
In Sarawak, Malaysia, approximately 7 t of sago fibre waste is produced daily from a single sago starch processing mill and it is currently disposed of either directly into a river nearby or in open spaces. On a dry basis, sago fibre contains 58% starch, 23% cellulose, 9.2% hemicellulose and 4% lignin. Our previous study used the trapped starch of sago fibre as a substrate for producing glucose through an enzymatic hydrolysis process in which the destarched fibre (DSF) remained unused. This study represents an attempt to utilise destarched sago fibre (DSF) as a raw material for glucose and xylose production. The DSF initially underwent a pre-treatment process via dilute sulphuric acid hydrolysis to liberate xylose for which four parameters were studied: the solid-to-liquid ratio (5:100-40:100), the dilute sulphuric acid concentration (0% (v/v) - 9% (v/v)), reaction time (30, 60 and 90 minutes) and the effects of steaming and microwave pre-treatment.

Steaming pre-treatment led to the highest xylose (28.19 ± 0.78 g/L) and glucose (78.63 g/L ± 0.22 g/L) production, for which the dilute sulphuric acid concentration was set at 2% (v/v), reaction time was set at 60 minutes. The solid-to-liquid ratio was 30:100. Overall, this work indicates that the optimal pre-treatment of DSF can yield glucose and xylose which can be used to produce bioethanol and xylitol. The study also suggests that DSF can be an alternative raw material for xylitol production.

Keywords: Destarched sago fibre, dilute sulphuric acid pre-treatment, steaming, microwave, mild hydrothermal, glucose, xylose.

Introduction

Biomass resources from agricultural waste are abundant in Malaysia. This type of waste accounts for more than 70 million t annually. Its volume continuously increases each year due to the rapid development in Malaysia[1]. In Sarawak, the sago palm plantation land in the Mukah division contributes one type of agricultural waste. This state, most notably the Mukah division, contains the largest area of sago palm plantation. Sago fibre, bark and wastewater are all waste products of the sago business. Starch and lignocellulosic substances comprise most of this waste such as lignin, cellulose and hemicellulose. Several studies have utilised sago waste to yield valuable sugar products such as glucose[1,19,20]. However, the literature shows that limited studies have been attempted to use sago fibre to produce xylose.

Various processes can be used to perform the hydrolysis pre-treatment of lignocellulosic waste. Dilute acid is one of the most effective in selectively releasing hemicellulosic sugars (xylose and arabinose), leaving a residue containing the cellulose and lignin fractions almost unaltered[18]. Acid hydrolysis is one of the most commonly used methods due to its simplicity, effectiveness and economic feasibility[24]. It was reported that acid hydrolysis pre-treatment removed nearly 35% of the hemicellulose in corncob[25].

Several studies have recently been conducted using different types of lignocellulosic waste as the substrate, all of which underwent dilute sulphuric acid pre-treatment to produce xylose hydrolysate. The pre-treatment was performed using steaming, the reaction times ranged from 1 hour to 1.5 hours and the dilute sulphuric acid ranged from 1% to 2.5% [6,18,23]. However, studies have not been undertaken using sago waste with these selected parameters.

Microwave heating is used as an efficient way to perform the thermal pre-treatment of biomass. It is an alternative to traditional heating due to its high heating rate and ease of preparation[10]. The structure of cellulose, hemicellulose and lignin can be altered by microwave irradiation. Microwave pre-treatment helps to degrade the hemicellulose and lignin. It disrupts the silicified waxy surface, enhancing the enzymatic sensitivity of reducing sugar[14]. The pre-treatment of switchgrass using a microwave helped to raise the sugar yield by around 58%.

Furthermore, pre-treatment using microwave irradiation produced a 56% increment of glucose yield from rape straw[16]. The main benefit of using microwave irradiation is that it aids in cellulosic disintegration. The main advantages of this method over traditional heating are its high uniformity and selectivity, short process time and lower energy requirements. Previous researchers used six seconds of microwave pre-treatment and six minutes of reaction time to produce 88% glucose and 76.5% xylose yields using sago pith waste[28]. Dilute acid with hydrothermal pre-treatment conducted at relatively low temperatures can optimise the xylose released from the hemicellulose[22]. The pre-treatment of wheat straw which utilised a maximum temperature of 140 °C and pH 1, produced 197 g/kg of xylose.