BIOMASS AND BIOENERGY 35 (2011) 3241–3246

Available at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Short communication

A novel use for sugarcane bagasse hemicellulosic fraction: Xylitol enzymatic production

Ricardo de Freitas Branco, Julio C. dos Santos, Silvio S. da Silva*

Grupo de Microbiologia Aplicada e Bioprocessos, Departamento de Biotecnologia, Universidade de São Paulo, Escola de Engenharia de Lorena, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 11 January 2010
Received in revised form
10 January 2011
Accepted 10 February 2011
Available online 5 April 2011

Keywords:
Lignocellulosic residues
Sugarcane bagasse
Hemicellulose
Xylitol
Enzymatic process
Sustainability

ABSTRACT

The excess of sugarcane bagasse (SCB) from the sugar-alcohol industry is considered a -by-product with great potential for many bioproducts production. This work had as objective to verify the performance of sugarcane bagasse hemicellulosic hydrolysate (SCBHH) as source of sugars for enzymatic or *in vitro* xylitol production. For this purpose, xylitol enzymatic production was evaluated using different concentrations of treated SCBHH in the commercial reaction media. The weak acid hydrolysis of SCB provided a hydrolysate with 18 g L^{-1} and 6 g L^{-1} of xylose and glucose, respectively. Considering the reactions, changes at xylose–xylitol conversion efficiency and volumetric productivity in xylitol were not observed for the control experiment and using 20 and 40% $v.v^{-1}$ of SCBHH in the reaction media. The conversion efficiency achieved 100% in all the experiments tested. The results showed that treated SCBHH is suitable as xylose and glucose source for the enzymatic xylitol production and that this process has potential as an alternative for traditional xylitol production ways.

1. Introduction

Lignocellulosic materials like straw, stover and bagasse are considered residues after vegetal biomass processing and disposal by industrial, agricultural and forestry activities. However, they represent abundant source of organic compounds that are potential raw material for industrial bioprocessing [1–3]. In Brazil, the largest lignocellulosic residue is the sugarcane bagasse (SCB) originated at sugar-alcohol industry. Table 1 presents 2009 sugarcane production estimative for the whole Brazilian territory and regions. The 2009 Brazilian sugarcane harvest is estimated in 629.0 mill tons, this value is 10.0% higher than 2008 (572.0). The southwest region stands out with 63% of the total national production, being only the state of São Paulo responsible for 342.9 mill tons (55.0%). From the total produced, 347.8 mill tons (55.3%) will be designated to produce ethanol and the rest to sugar (sucrose) [4]. From one ton of sugarcane processed 135 kg (dry mass) of SBC is formed [5]. According to Frollini and Pimenta [6] half of this SCB has to be burned to match the plant energy demand, actually, Brazilian sugar-alcohol industries burn about 75–90% of sugarcane bagasse in order to sell electricity for immediacy cities. This means that only in this year, in Brazil, 84.9 mill tons of SBC was formed and, at least, 21.2 mill tons were disposed directly on nature. Besides energy generation, SCB can be used for paper, paperboard, animal feed and fertilizer production [7],

* *Corresponding author*. Estrada municipal do campinho, P.O.Box 116 Lorena, SP, Brazil. Tel.: +55 12 31595000/5188; fax: +55 12 315333165.
E-mail address: ricardo@debiq.eel.usp.br (R. de F. de Freitas Branco).
0961-9534/$ – see front matter © 2011 Published by Elsevier Ltd.
doi:10.1016/j.biombioe.2011.02.014

Table 1 – Sugarcane 2008 and 2009 estimated production divided by regions and states of the southeast of Brazil.

REGION/State	Production (mill tons)	
	2008	2009
NORTH	1.468	1.555
NORTHEAST	64.416	61.904
CENTER-WEST	66.510	88.442
SOUTH	44.320	53.768
SOUTHEAST	395.094	423.353
São Paulo	342.910	364.132
Rio de Janeiro	3.556	3.556
MinasGerais	44.208	51.321
Espirito Santo	4.419	4.343
BRAZIL	571.809	629.024

Source: CONAB 3°Survey, September 2009.

although these products do not contribute significantly to the use of this waste. This SBC excess is considered to be an environmental problem, its accumulation for long periods can even trigger spontaneous combustion [3]. It is known that SBC is rich in polymeric compounds like cellulose, hemicellulose and lignin. Table 2 presents the average composition of SBC *in natura* [8]. According to Table 2 almost one third of SBC is hemicellulose, an L-arabino-(4-O-methyl-D-glucurono)-D-xylan which is basically a xylose chain. Therefore, it is important to develop green technologies for its use to produce useful goods for mankind and, with this objective, biotechnological processes have been studied [9–12].

Xylitol microbiological production was suggested as an alternative for the use of sugarcane bagasse hemicellulosic hydrolysate (SBCHH) and has been widely reported [13–18]. Xylitol has innumerous interesting properties for food, pharmaceutical and cosmetical products. The largest application of this compound is currently in oral products such as tooth paste, gum, mouthwash, nasal spray among others. Xylitol gives pleasant cool and fresh sensation due to its endothermic solution heat (34.8 cal g^{-1}) which is ideal for gums. The sweetener power is similar to sucrose [19] and amongst all the polyalcohols (sorbitol, arabitol and mannitol), it is the sweetest [20]. Additionally, the most important characteristic, for this area, xylitol does not cause and, actually, combats dental caries [21] and it can also be consumed by diabetics because it does not require insulin for its metabolism [22]. However, researchers have been facing obstacles in xylitol microbiological production, such as low uptake and misuse of sugars by the microorganisms [23,24].

Table 2 – Sugarcane bagasse average composition on dry mass basis.

Fraction/Component	% ($w.w^{-1}$)
Hemicellulose	31.2
Xylose	25.2
Cellulose	42.4
Lignin	19.6
Ashes	1.6
Extractives	4.1

Source: Brienzo et al. [8].

Enzymatic process is a new biotechnological alternative for this microbiological process which can achieve 100% of conversion. This high conversion value is due to the direct transformation of xylose into xylitol which cannot be achieved by the fermentative process because of deviation of xylose to cell maintenance. The enzymatic process consists in the direct reduction of xylose to xylitol by the enzyme xylose reductase (XR, E.C. 1.1.1.21) assisted by the coenzyme nicotinamide adenine dinucleotide phosphate in its reduced form (NADPH). Further, the NADP can be reduced again in a coupling enzymatic reaction to make the process more economically attractive. This work deals with the glucose dehydrogenase system in which glucose is oxidized to gluconic acid (gluconate) mediated by glucose dehydrogenase (GDH, E.C. 1.1.1.119) and NADP is reduced to NADPH. A simple scheme of xylitol enzymatic reaction is shown in Fig. 1.

In this context, this work aimed to evaluate xylitol enzymatic production using, as carbon source, sugarcane bagasse hemicellulosic hydrolysate and to verify technical viability and potential of xylitol enzymatic production as an alternative to the traditional production processes. For this purpose, assays were carried out using different amounts of treated hydrolysate in reaction media. Additionally, the production parameters were compared to reactions without SCBHH and also with data from the microbiological xylitol production reported in literature.

2. Materials and methods

2.1. Materials

All chemicals used in this study were of the highest grade available and were obtained from Aldrich (São Paulo, Brazil) or Sigma (São Paulo, Brazil).

2.2. Raw material

Sugarcane bagasse was kindly donated by the Companhia Açucareira Vale do Rosário (Orlândia, São Paulo, Brazil) and it was collected after the milling process for juice extraction. The SCB used for further treatment was dried until 10% moisture.

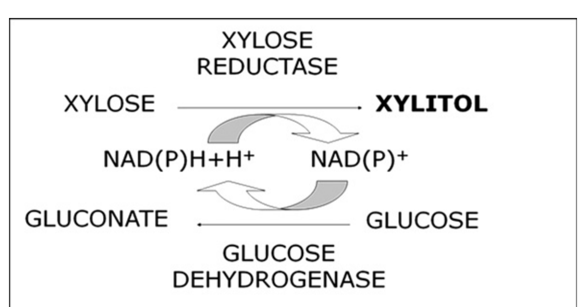

Fig. 1 – Xylitol enzymatic production with a coupling coenzyme *in situ* enzymatic regeneration system.