Production of Xylitol from D-Xylose by Debaryomyces hansenii

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ABSTRACT

Xylitol, a naturally occurring five-carbon sugar alcohol, can be produced from D-xylose through microbial hydrogenation. Xylitol has found increasing use in the food industries, especially in confectionary. It is the only so-called “second-generation polyol sweeteners” that is allowed to have the specific health claims in some world markets. In this study, the effect of cell density on the xylitol production by the yeast Debaryomyces hansenii NRRL Y-7426 from D-xylose under microaerobic conditions was examined. The rate of xylitol production increased with increasing yeast cell density to 3 g/L. Beyond this amount there was no increase in the xylitol production with increasing cell density. The optimal pH range for xylitol production was between 4.5 and 5.5. The optimal temperature was between 28 and 37°C, and the optimal shaking speed was 300 rpm. The rate of xylitol production increased linearly with increasing initial xylose concentration. A high concentration of xylose (279 g/L) was converted rapidly and efficiently to produce xylitol with a product concentration of 221 g/L was reached after 48 h of incubation under optimum conditions.

Index Entries: Debaryomyces hansenii; D-xylose; xylitol; biological hydrogenation; yeast.

INTRODUCTION

Sucrose is one of the most important ingredients of confectionary products, as it provides body, texture, and preservative properties, besides its sweetening effect. However, it is well known that consumption of

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sucrose and fermentable carbohydrates facilitates the development of plaque, dental caries, and periodontal disease. To avoid these problems, noncariogenic polyol sweeteners are increasingly used. One of these, xylitol, may be considered as the best of all nutritive sweeteners because it has anticaries properties (1). Besides, it is tolerated by diabetics and it has a high negative heat of solution. For all these properties, xylitol is desirable for sugar-free confections (2). Unfortunately, it is one of the most expensive polyol sweeteners (3). Availability and cost of production are the obstacles impeding the increased use of xylitol.

Xylitol is a normal metabolic intermediate in animals. The human body produces 5–15 g of xylitol per day during normal metabolism (2). Xylitol occurs naturally in many fruits and vegetables (such as lettuce, cauliflower, strawberries) and constitutes part of the human diet. However, fruits and vegetables contain a small amount, usually less than 900 mg/100 g, rendering its extraction uneconomical. In industrial scale, it can be produced through chemical reduction of xylose derived from hemicellulosic hydrolyzate. This process includes extensive purification and separation steps to remove polymers of other sugars and other by-products present in the raw materials (4).

Xylitol can be formed too, as a metabolic intermediary product of D-xylose fermentation: D-xylose can be converted to xylitol by NADPH-dependent aldehyde reductase, or can be isomerized to D-xylulose by D-xylose isomerase, and then reduced to xylitol by NADH-dependent xylitol dehydrogenase (5). Many yeast strains have the ability to produce xylitol from xylose extracellularly as a normal metabolic activity (6). The prominent strains that produce xylitol include Candida sp. (7), C. guillermondii (8–10), C. boidinii (11), C. tropicalis (12), C. parapsilosis (13), and D. hansenii (14,15). However, D-xylose is an expensive substrate for xylitol production. Recent developments in obtaining xylose-rich hemicellulose hydrolyzates from lignocellulosic materials have identified economic source of xylose availability (16). As a result, xylitol can be produced from such materials as an option for effective utilization of lignocellulosic biomass (17).

In this report, we studied some characteristics of D. hansenii NRRL Y-7426 for xylitol production from xylose.

MATERIALS AND METHODS

Micro-organism

The yeast strain used in this study, D. hansenii NRRL Y-7426, was obtained from the Northern Regional Research Laboratory, (Peoria, IL). The yeast was grown for 3 d at 32°C in an incubator shaker at 200 rpm (New Brunswick), in a liquid media with 1% of glucose, 1% of xylose, 3 g/L of Bacto-yeast extract, 3 g/L of Bacto-malt extract, and 5 g/L of Bacto-peptone.