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1,3-Propanediol production from glycerol with *Lactobacillus diolivorans*

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HIGHLIGHTS

- *Lactobacillus diolivorans* efficiently converts glycerol to 1,3-propanediol.
- Anaerobic fed-batch processes lead to 1,3-propanediol concentrations up to 85 g/l.
- 0.1 mol glucose/mol glycerol is optimal for production in a fed-batch process.
- Vitamin B_{12} addition enhances production of 1,3-propanediol significantly.

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ABSTRACT

The aim of this study was to evaluate the natural producer *Lactobacillus diolivorans* as potential production organism of 1,3-propanediol from glycerol. Different cultivation parameters, such as oxygen supply, feeding-strategy, or medium composition have been tested in batch and fed-batch cultivations. The 1,3-propanediol concentration obtained in batch cultivations was 41.7 g/l. This could be increased to 73.7 g/l in a fed-batch co-feeding glucose and glycerol with a molar ratio of 0.1. Yeast extract as part of the MRS cultivation medium could be replaced by nicotinic acid and riboflavin. Furthermore, the addition of Vitamin B_{12} to the culture medium increased production by 15% to a final titer of 84.5 g/l 1,3-propanediol.

1. Introduction

1,3-Propanediol has long been considered a specialty chemical due to the high costs connected to its production and the narrow application spectrum. About a decade ago, the application as a monomer in a polymerization process producing polytrimethylene terephthalate (PTT) led to an increased demand for 1,3-propanediol. 1,3-Propanediol can replace classic glycols for the production of polyurethanes, polyesters and polyethers (Kaur et al., 2012; Johnson and Taconi, 2007).

The increased requirement for 1,3-propanediol has also enhanced efforts to produce the substance biotechnologically. Currently, 1,3-propanediol is mainly produced with recombinant *Escherichia coli* strains, using glucose as the sole carbon source, which is usually derived from corn (Nakamura and Whited, 2003). However, the natural carbon source for the production of 1,3-propanediol is glycerol, and the ability of microorganisms to convert glycerol into 1,3-propanediol has first been described over a century ago (Freund, 1881).

Much of the glycerol available today originates as the by-product of oleochemical processes such as biodiesel, soap, fatty acid and fatty alcohol production. For 100 kg biodiesel produced 10–12 kg of crude glycerol are obtained (Sheedlo, 2008; Vasudevan and Briggs, 2008). Since biodiesel production has been increased dramatically over the past few years, also the availability of glycerol increased. Basically, the majority of the market for glycerol requires a value adding and cleaning step in order to establish an economically sound biorefinery process (Posada et al., 2012). However, impurities in crude glycerol may affect product formation and biomass formation during fermentation (Johnson and Taconi, 2007; Jensen et al., 2012).

Quite a large number of microorganisms are capable of converting glycerol into 1,3-propanediol (Sauer et al., 2008; Tokumoto and Tanaka, 2012). For example, the ability of *Klebsiella pneumoniae* to produce 1,3-propanediol has been studied quite extensively (Oh et al., 2011; Cheng et al., 2007; Huang et al., 2012). Mutant strains of this organism obtain titers up to 103 g/l, whereas with wildtype strains in a larger scale typically concentrations of only

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