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ORIGINAL ARTICLE

Batch fermentation of succinic acid from cheese whey by *Actinobacillus succinogenes* under variant medium composition

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Abstract

Bio-based succinic acid production has attracted global attention since its consideration as a potential replacement to petroleum-based platform chemicals. This study used three different CO_2 sources, namely $NaHCO_3$, K_2CO_3 and $MgCO_3$ for fermentation of succinic acid (SA) by *Actinobacillus succinogenes* under three distinct substrate conditions i.e. lactose, whey and whey devoid of any supplements. Batch experiments were performed in both anaerobic flasks and 5L benchtop fermenter. SA fermentation in anaerobic flasks was unfettered by supplementary nutrients. However, fermentation in the benchtop fermenter devoid of supplementary nutrients resulted into 42% reduction in SA yield as well as lower SA productivities. Furthermore, a significant reduction of cell growth occurred in anerobic flasks at pH < 6.0, and complete termination of bacterial activity was noted at pH < 5.3. The highest SA titer, yield and productivity of 15.67 g/L, 0.54 g/g and 0.33 g/L/h, respectively, was recorded from whey fermentation with $MgCO_3$. The present study further highlights significant inhibitory effect of K_2CO_3 buffered medium on *Actinobacillus succinogenes*. Thus, we can claim that environmental pollution as well as costs of SA production from whey can be reduced by leveraging on whey residual nutrients to support the activity of *Actinobacillus succinogenes*.

Keywords Succinic acid · Whey · *Actinobacillus succinogenes* · CO_2 sources

Introduction

Succinic acid (butanedioic acid, $CH_2)_2(CO_2H)_2$) has been identified as one of the top ten chemicals with potential to replace petroleum-based platform chemical by the U.S. Department of Energy (Bozell and Petersen 2010; Jansen and van Gulik 2014). Succinic acid (SA) is a crucial compound in the manufacture of degradable biopolymer and could also be used for synthesis of 1, 4-butanediol, N-methyl pyrrolidone and polybutylene succinate (Wang et al. 2011; Huang et al. 2019). Consequently, many investigations have focused on economic viability of bio-based commercial succinic acid production. Different microorganisms such as *Anaerobiospirillum succiniciproducens*, *Actinobacillus succinogenes*, *Mannheimia succiniciproducens*, *Basfia succiniciproducens* and *Escherichia coli* have been assessed for succinic acid production (Olajuyin et al. 2016; Shen et al. 2018). Therein, *Actinobacillus succinogenes,* a Gram-negative, rod-shaped bacterium isolated from the bovine rumen (Guettler et al. 1999), has been identified as one of the most favorable strains for commercial production of succinic acid due to its tolerance to high acid concentration and ability to produce succinic acid at high yields from wide range of carbon sources.

Succinic acid production from renewable feedstocks such as whey, sugarcane molasses, straw hydrolysate, textile waste hydrolysate, duckweed hydrolysate and glycerol have been examined by many researchers with the objective of reducing the feedstock costs involved in SA production (Lee et al. 2003; Wan et al. 2008; Zheng et al. 2009; Shen et al. 2015, 2018). In this study, whey was used for fermentation

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