Production of Lactic Acid From Cheese Whey by Batch and Repeated Batch Cultures of *Lactobacillus* sp. RKY2

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Abstract

The fermentative production of lactic acid from cheese whey and corn steep liquor (CSL) as cheap raw materials was investigated by using *Lactobacillus* sp. RKY2 in order to develop a cost-effective fermentation medium. Lactic acid yields based on consumed lactose were obtained at more than 0.98 g/g from the medium containing whey lactose. Lactic acid productivities and yields obtained from whey lactose medium were slightly higher than those obtained from pure lactose medium. The lactic acid productivity gradually decreased with increase in substrate concentration owing to substrate and product inhibitions. The fermentation efficiencies were improved by the addition of more CSL to the medium. Moreover, through the cell-recycle repeated batch fermentation, lactic acid productivity was maximized to 6.34 g/L/h, which was 6.2 times higher than that of the batch fermentation.

Index Entries: Corn steep liquor; lactic acid; *Lactobacillus*; lactose; whey.

Introduction

Lactic acid has numerous applications in food, chemical, textile, pharmaceutical, and other industries (1). Recently, there has been a great demand for lactic acid, because it can be used as a monomer for the production of biodegradable polymer, polylactic acid (PLA), which can be alternative to synthetic polymers derived from petroleum resources (2). In 1999, the annual world production of lactic acid was estimated to be approx 80,000 t produced both by chemical synthesis and by biological fermentation processes (1). However, a number of applications of lactic acid currently resulted in a significant increase in its demand. While the
only racemic DL-lactic acid is produced through a chemical synthesis, a desired stereoisomer, i.e., an optically pure L(+)- or D(-)-lactic acid, could be produced through a fermentative production from renewable resources, if the proper microorganisms would be chosen for lactic acid fermentation (3). The optical purity of lactic acid is important to the physical properties of PLA. Especially, L(+)-lactic acid of high purity is polymerized to a high crystal polymer, that is suitable for fiber and oriented film. Also as an optically active material, L(+)-lactic acid is expected to be useful for the production of liquid crystals (4). However, lactic acid fermentation process generally requires a complex basal medium, which may result in an increased production cost. Nevertheless, many studies on the production of lactic acid by the lactic acid bacteria were mainly focused on producing from the dextrose-based media and/or expensive nutrients such as yeast extract (3,5). Therefore, the studies on alternative and low-cost media for lactic acid fermentation will be needed owing to its industrial feasibility and an economic consideration. The economics of lactic acid fermentation would be typically improved by using cheap raw materials.

Whey is a major byproduct of dairy industry, and it contains approx 60–65% (w/v) of lactose and some moieties of protein, fat, and mineral salts. The worldwide production of whey is approx 120 × 10^6 t/yr and its greater portion remains unutilized, which causes an environmental pollution as a result of high biochemical oxygen demand (BOD, 40,000–60,000 ppm) and chemical oxygen demand (COD, 50,000–80,000 ppm). More than 90% of whey BOD is caused by lactose moiety in the whey. In order to reduce the BOD level and to acquire some useful compounds, this nutrient-rich whey can be utilized for the production of lactic acid by bacteria as a cheap carbohydrate source (6–12). However, lactic acid bacteria have a complex nutrient requirement because they have a limited capacity to synthesize B-vitamin and amino acids (1). Therefore, for complete conversion of lactose to lactic acid, the supplementation of nitrogen sources such as yeast extract or corn steep liquor (CSL) is needed (13).

CSL is a byproduct from corn milling industry, which has been used as an inexpensive nutrient source for several fermentations. In the production of lactic acid, though CSL seems to negatively affect the separation and purification of the produced lactic acid and to reduce the productivity, it should be an attractive source for the economical production of lactic acid as mentioned before (14,15). This study was mainly focused on the utilization of whey lactose as a substrate for the production of lactic acid by batch culture of Lactobacillus sp. RKY2. In addition, the effects of CSL on lactic acid fermentation using cheese whey were also investigated. The cell-recycle repeated batch production of lactic acid using cheese whey and CSL as raw materials was tried in order to further enhance the productivity of lactic acid.

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