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ORIGINAL PAPER

Production of nisin Z using *Lactococcus lactis* IO-1 from hydrolyzed sago starch

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Abstract A membrane bioreactor for production of nisin Z was constructed using *Lactococcus lactis* IO-1 in continuous culture using hydrolyzed sago starch as carbon source. A strategy used to enhance the productivity of nisin Z was to maintain the cells in a continuous growth at high cell concentration. This resulted in a volumetric productivity of nisin Z, as 50,000 IU l^{-1} h^{-1} using a cell concentration of 15 g l^{-1}, 30°C, pH 5.5 and a dilution rate of 1.24 h^{-1}. Adding 10 g l^{-1} YE and 2 g l^{-1} polypeptone, other inducers were unnecessary to maintain production of nisin. The operating conditions of the reactor removed nisin and lactate, thus minimizing their effects which allowed the maintenance of cells in continuous exponential growth phase mode with high metabolic activity.

Keywords Nisin Z · Bacteriocin · Sago starch · Membrane bioreactor · *Lactococcus lactis IO-1*

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Introduction

It has been demonstrated that *Lactococcus lactis* IO-1 is not only characterized by its high capacity in production of lactic acid (LA), but also for its production of a bacteriocin, which has been identified as nisin Z [12, 14]. The bactericidal effect that bacteriocins have on Gram-positive bacteria, including foodborne pathogens such as *Listeria monocytogenes* and *Bacillus cereus,* and the inhibition of bacterial spore outgrowth enhance the importance of this compound for the food industries. Nisin Z production kinetics in *L.lactic* IO-1 has been widely studied [5, 6, 14, 15, 18]. In order to improve the productivity of nisin Z, a continuous bioreactor with immobilized *L. lactis* IO-1 supported by different materials, both natural and synthetic has been reported [18]. Among the supports tested, ENTG-3800 (polyethylene glycol/polypropylene glycol at 4:1 w/w) gave the best results. Based on this support material and a dilution rate of 0.1 h^{-1}, productivity in the range of 1,500–2,900 AU ml^{-1} was obtained. The highest titers for nisin production employing *L. Lactis* IO-1 have been obtained performing continuous fermentation with a cell recycling system using a ceramic membrane [5]. At a dilution rate of 0.3 h^{-1}, a volumetric productivity of 6×10^5 AU l^{-1} h^{-1} was obtained, corresponding to a bacteriocin titer of 5,860 IU l^{-1}. The use of chemostat cultures to enhance production of bacteriocins has been widely established [3, 4, 7, 8]. Bhugaloo et al. [3] reported on production of the bacteriocin divercin from *Carnobacterium divergens* V41, employing high cell density bioreactors. The productivity was compared in continuous culture with free cells, immobilized cells in alginate beads packed in a plug-flow bioreactor and a membrane reactor. Immobilized cells presented the best results being as high as 100,000 AU l^{-1} h^{-1}. However, the membrane bioreactor failed to be efficient due