Xylose bioconversion in lactic acid by Lactobacillus pentosus ATCC 8041

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Introduction

Lactic acid (2-hydroxy prop ionic acid) is widely used in food, cosmetic, pharmaceutical, textile and chemicals industries. Recently, the sharply enlarged manufacture of biodegradable plastics, such as PLA, has increased the world production of lactic acid. Lactic acid can be manufactured either by chemical synthesis or microbial fermentation. Chemical synthesis results in racemic DL-lactic acid whereas the fermentation process allows to obtain the stereospecific form [L(+), D(-) and DL mixture]. The search for environmentally sustainable processes is gradually forcing the replacement of a petrochemical platform for a renewable derived one. The production of building blocks can be achieved by allowing by microbial & enzymatic technologies as well chemical transformations. Sugarcane bagasse (mainly composed of cellulose, hemicelluloses and lignin), represents one of the most abundant renewable resources for technological use, that can be used as feedstock for fermentation processes (John *et al.*, 2009; Givry *et al.,* 2008; Reddy *et al.,* 2008; Adsul *et al.*, 2007; John *et al.*, 2007; John *et al.*, 2006). Many studies on the lactic acid production from lignocellulosic materials used mostly the cellulosic fraction, since there are few microorganisms able to ferment hemicellulosics sugars (pentoses) (Bustos *et al.*, 2007; Moldes *et al.*, 2006; Hofvendahl & Hähn-hägerdal, 2000). Often, *Lactobacillus* species fermenting hexoses are not able to ferment xylose as carbon source (Bustos *et al.*, 2004; Zhu *et al.*, 2007). Therefore, it is important to find species more able to ferment pentoses efficiently, in presence of hexoses. The aim of this study is to assess the capability of *Lactobacillus pentosus* ATCC 8041, selected in our laboratory, to convert pentoses in lactic acid.

Results and Conclusions

Fermentation of *Lactobacillus pentosus* ATCC 8041 in synthetic medium MRS without any carbohydrate showed its capability to grow, reaching a biomass concentration of 0.9 gl^{-1} and 1.8 gl^{-1} lactic acid in 17 hours. Lactic acid was consumed after 72 hours (Figure 1), due to limitation of carbon (substrate) in the medium. Acetic acid was the second main product of fermentation 4.91 gl^{-1}, originated from complex nutrients sources (soy peptone, animal peptone, yeast extract, amino acids and vitamins). When bacteria are exposed to a mixture of carbon sources, they choose the substrate that yields the maximum profit for growth or obligatory use non-conventional substrates (Gobbetti *et al.,* 2005).

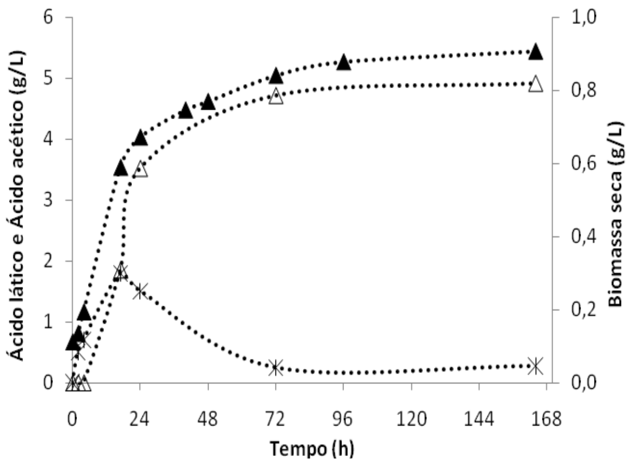

Figure 1. Growth profile, lactic acid and acetic acid production in the fermentation of MRS medium without xylose. (▲) Biomass, (✕) Lactic acid, (Δ) Acetic acid.

When *Lactobacillus pentosus* ATCC 8041 was fermented in a bioreactor with the same MRS synthetic medium, but containing 20 gl^{-1} xylose, biomass concentration reached 1,61 gl^{-1} without inhibition with a maximum volumetric rate of substrate consumption 0.510 $g[l.h]^{-1}$ in 9 hours. The complete xylose depletion was achieved in 48 hours showing that this strain has ability to ferment this pentose for acids production. Lactic acid concentration was 11.68 gl^{-1} after 48 hours of fermentation, representing a volumetric productivity (Q_P) of 0.24 $g[l.h]^{-1}$ and a product yield ($Y_{P/S}$) of 0.58 g/g of xylose. Acetic acid was produced at almost similar concentration as lactic acid, 13.06 gl^{-1} (Figure 2). As the xylose represents only 40% of total carbon fraction of the medium, heterolactic fermentation took place and a maximum theorical yield of lactic acid and acetic acid were achieved (60% and 40%, respectively). Gobbetti *et al.*, (2005) reported that some *Lactobacillus* species showed higher acetic acid production when xylose, ribose and arabinose were used in the culture medium instead maltose. Rivera *et al.*, (2009) reported that *Lactobacillus pentosus* ATCC 8041 in the synthetic medium fermentation supplemented with yeast extract and corn steep liquor and in presence of minerals (Mn, K, Na, Ca and Mg), acetic acid concentration was higher than in the experiments carried out in the absence of minerals. Thus, it was considered that 8.15 gl^{-1} would be produced by substrate and 4.91 gl^{-1} of acetic acid by the other media components, as peptone and yeast extract *Lactobacillus pentosus* ATCC 8041 is considered a facultatively heterofermentative microorganism, degrading hexoses (glucose) via the Embden-Meyerhof pathway e pentoses (xylose and arabinose) via phosphoketolase pathway (Li & Cui, 2010; Rivera *et al.*; 2009; Patel *et al.*, 2006; Moldes *et al.*, 2006; Bustos *et al.*, 2007; Bustos *et al.*, 2005; BustoS *et al.*, 2004; Garde *et al.*, 2002).

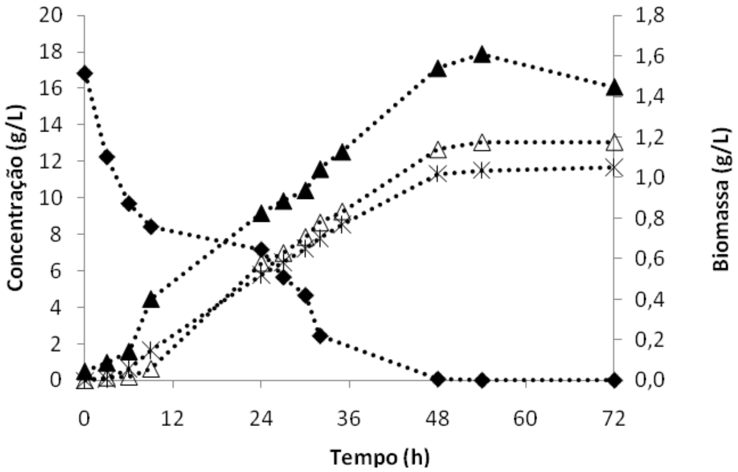

Figure 21. Xylose consumption profile, celular Growth, lactic acid and acetic acid production in the bacth fermentation of MRS_{xylose} medium. (♦) Xylose (▲) Biomass, (✱) Lactic acid, (Δ) Acetic acid.

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