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ORIGINAL PAPER

Evaluation of waste products in the synthesis of surfactants by yeasts[‡]

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The highest yields of biosurfactants were obtained by: (i) *Pseudozyma antarctica* (107.2 g L^{-1}) cultivated in a medium containing post-refining waste; (ii) *Pseudozyma aphidis* (77.7 g L^{-1}); and (iii) *Starmerella bombicola* (93.8 g L^{-1}) both cultivated in a medium with soapstock; (iv)*Pichia jadinii* (67.3 g L^{-1}) cultivated in a medium supplemented with waste frying oil. It was found that the biosurfactant synthesis yield increased in all strains when the cell surface hydrophobicity reached 70–80 %, enabling the microbial cells to make good contact with hydrophobic substrates. The lowest surface tension of the post-cultivation medium was from 32.0 mN m^{-1} to 37.8 mN m^{-1}. However, this parameter (which was also determined by a drop collapse assay) was of limited use in monitoring biosurfactant synthesis in this study. The crude glycerol was not a good substrate for biosurfactant synthesis although, in the case of *P. aphidis*, 67.4 g L^{-1} of biosurfactants were obtained after cultivation in the medium supplemented with glycerol fraction (GF2). In a low-cost medium containing soapstock and whey permeate or molasses, about 90 g L^{-1} of mannosylerythritol lipids were synthesised by *P. aphidis* and approximately 40 g L^{-1} by *P. antarctica*.

Keywords: biosurfactants, waste lipids, glycerol, glycolipids, surface tension

Introduction

Transparency Market Research valued the global biosurfactant market at $ 1735.5 million in 2011; in 2018 it is expected to reach $ 2210.5 million, growing at a compound annual growth rate (CAGR) of 3.5 % from 2011 to 2018. In the overall global market, the European region is expected to maintain its leading position in terms of volume and revenue up to 2018. Europe is expected to achieve 53.3 % of global biosurfactant market revenue share in 2018, followed by North America (Transparency Market Research, 2012).

Biosurfactants can play an important role in industry because of their many valuable physico–chemical properties and biological activities (Cameotra & Makkar, 2004). These biological compounds can be used in the agricultural, cosmetic, detergent, pharmacological, medical, food, and paint industries (Rodrigues et al., 2006, Singh et al., 2007). Furthermore, biosurfactants have their uses in agriculture, especially in the formulation of herbicides and pesticides (adjuvants) to disperse active compounds in an aqueous solution. Biosurfactant applications in the environmental industries associated with environmental protection and waste management have received more attention owing to their biodegradability, low toxicity, and effectiveness in enhancing the biodegradation and solubility of hydrophobic compounds (Calvo et al., 2009).

Surfactants synthesised by microorganisms can be classified by their location in cells, chemical structure, and molecular mass (Rosenberg & Ron, 1999). The biochemical pathways of biosurfactant synthesis are diverse and generally can be divided into either de novo or carbon substrate-dependent synthesis. In the latter case, changes in the medium composition in-

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