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ORIGINAL ARTICLE

Moesziomyces spp. cultivation using cheese whey: new yeast extract-free media, β-galactosidase biosynthesis and mannosylerythritol lipids production

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Abstract
Mannosylerythritol lipids (MELs) are biosurfactants with excellent biochemical properties and a wide range of potential applications. However, high production costs, low productivity and unsatisfactory scale-up production have hampered commercial adoption. Herein, we report for the first time the β-galactosidase production by *Moesziomyces* spp. from different sugars (D-galactose, D-glucose and D-lactose), with D-galactose being the best β-galactosidase inducer, with 11.2 and 63.1 IU/$mg_{biomass}$, for *Moesziomyces aphidis* 5535 ^{T} and *Moesziomyces antarcticus* 5048 ^{T}, respectively. The production of this enzyme allows to break down D-lactose and thus to produce MEL directly from D-lactose or cheese whey (a cheese industry by-product). Remarkably, when CW was used as sole media component (carbon and mineral source), in combination with waste frying oil, MEL productivities were very close (1.40 and 1.31 g_{MEL}/L/day) to the ones obtained with optimized medium containing yeast extract (1.92 and 1.50 $g_{MEL}/g_{susbtrate}$), both for *M. antarcticus* and *M. aphidis*. The low-cost, facile and efficient process which generates large amounts of MELs potentiates its industrialization.

Keywords Manosylerithritol lipids (MELs) · β-galactosidase · Cheese whey · Yeast extract free media · *Moesziomyces* spp

1 Introduction

Since the industrial revolution, the chemical industry has undergone important developments, resulting in a variety of products that are used in a wide range of applications. Within these products, surfactants, molecules capable to stabilize oil–water interfaces and promote self-organized structures [1], are one of the most produced chemicals worldwide, with a market reaching US $40 billion in 2021 [2]. However, most of the surfactants are derived from petrochemicals, and thus contributing to greenhouse gas (GHGs). Moreover, surfactant production generates toxic waste and their use endangers the ecosystem, due to their toxicity and persistence in the environment [3].

In this regard, microbial biosurfactants (mBS) started to be envisioned as an alternative to chemical surfactants, providing a greener solution with faster biodegradability and lower eco-toxicity impacts. Their structural diversity and properties may offer higher efficiency (especially when used in extreme conditions), and new application opportunities, namely as antimicrobials [4], antiviral [5], anticancer [6] and anti-inflammatory agents [7]. Currently, the mBS market is evaluated at US $13 million (2012) and comprises rhamnolipids, sophorolipids and mannosylerythritol lipids (MELs). Nevertheless, the price of the cheapest mBs (US $34/kg of SL) is tenfold higher than chemical surfactants such as sodium lauryl sulphate (~US $1–2/kg) [8]. This indicates that scalable fermentations and downstream processes need to be optimized and technological innovations

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