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MINI-REVIEW

Integrated microbial processes for biofuels and high value-added products: the way to improve the cost effectiveness of biofuel production

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Abstract The production of microbial biofuels is currently under investigation, as they are alternative sources to fossil fuels, which are diminishing and their use has a negative impact on the environment. However, so far, biofuels derived from microbes are not economically competitive. One way to overcome this bottleneck is the use of microorganisms to transform substrates into biofuels and high value-added products, and simultaneously taking advantage of the various microbial biomass components to produce other products of interest, as an integrated process. In this way, it is possible to maximize the economic value of the whole process, with the desired reduction of the waste streams produced. It is expected that this integrated system makes the biofuel production economically sustainable and competitive in the near future. This review describes the investigation on integrated microbial processes (based on bacteria, yeast, and microalgal cultivations) that have been experimentally developed, highlighting the importance of this approach as a way to optimize microbial biofuel production process.

Keywords Integrated microbial bioprocess · Biomass · Biorefinery · Bacteria · Yeast · Microalga · Biofuel · High value-added products

Introduction

In the midst of the world energy crisis, third-generation biofuels (derived from microbes) have been considered to be viable fuel alternatives (Antoni et al. 2007; Li et al. 2008; Lopes da Silva et al. 2012). Microbial biofuels are a renewable source of energy, do not contain sulfur, and are highly biodegradable (González-Delgado and Kafarov 2011). So far, the major obstacle for commercialization of biofuels obtained from microbes is still the high production cost involved. Therefore, it is crucial to explore approaches to reduce the costs of microbial biofuel production processes, by using low-cost raw materials and/or coproducing high value-added products. However, most of the published studies focusing on microbial biofuels describe the production of only one microbial biofuel. This means that the other available and valuable remaining microbial products or components in the microbial biomass are undervalued and lost.

In fact, some microbial producers may also produce intracellularly high value-added products such as carotenoids, polyunsaturated fatty acids (PUFAs), carbohydrates, and proteins. These products may be recovered and used in a real biorefinery integrated process in diverse industries such as food, pharmaceutical, nutraceutical, cosmetic, and chemical (Fig. 1). Such approach will take advantage of the various products synthesized by the microorganisms and of the microbial biomass, therefore maximizing the value derived from the whole process, with a desired minimal environmental impact. In this way, the economics of the process may be greatly improved, as the high value-added products (such as carotenoids and polyunsaturated fatty acids) may sustain the microbial biofuel production.

This review will focus on the integrated microbial processes involving bacteria, yeast, and microalgae, aiming at the coproduction of two (or more) products. At least, one of the microbial products is a biofuel (biodiesel, bioethanol, biomethane, biohydrogen, or bioelectricity) and the other(s) are high value-added products directed to a wide range of applications and markets.

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