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Bioconversion of volatile fatty acids into lipids by the oleaginous yeast *Yarrowia lipolytica*

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ABSTRACT

The valorization of volatile fatty acids into microbial lipids by the oleaginous yeast *Yarrowia lipolytica* was investigated. Therefore, a two-stage fed-batch strategy was designed: the yeast was initially grown on glucose or glycerol as carbon source, then sequential additions of acetic acid under nitrogen limiting conditions were performed after glucose or glycerol exhaustion. The typical values obtained with an initial 40 g/L concentration of glucose were close to 31 g/L biomass, a lipid concentration of 12.4 g/L, which correspond to a lipid content of the biomass close to 40%. This cultivation strategy was also efficient with other volatile fatty acids (butyric and propionic acids) or with a mixture of these three VFAs. The lipids composition was found quite similar to that of vegetable oils. The study demonstrated the feasibility of simultaneous biovalorization of volatile fatty acids and glycerol, two cheap industrial by-products.

1. Introduction

A few microorganisms have the ability to accumulate lipids in a significant amount. Those that can accumulate lipids up to more than 20% of their biomass come under the category of oleaginous microorganisms. Under the conditions of nutrient (nitrogen, phosphorus or iron) limitation, these microorganisms may accumulate lipids to levels exceeding 70% of their biomass. Examples of oleaginous microorganisms include microalgae, yeasts, moulds and some bacteria (Beopoulos et al., 2009 Certik et al., 1999). It has been found that the fatty acid composition of these microbial lipids is comparable to edible and industrial lipids used for the industrial production of biodiesel. Biodiesel which is defined as a mixture of fatty acid alkyl esters can be obtained from various renewable lipid resources such as vegetable and animal oils or fats and wastes of cooking oils (Ghaly et al., 2010; Liu et al., 2008). With characteristics similar to conventional diesel, biodiesel is a potential alternative fuel for various types of diesel engines and heating systems (Sharma and Singh, 2009; Papanikolaou et al., 2008). The biodegradable, non-toxic and energy efficient properties of biodiesel make its production more attractive.

Lipid bio-fuels, renewable resources, are promising alternatives for partial or total replacement of fossil fuels (Liu et al., 2008). However, the use of edible oils for biodiesel production would lead to the soar of food prices. Therefore, scientists throughout the world are focussing on non-edible lipid sources such as oleaginous organisms. These oleaginous organisms not only accumulate lipids within a short period of time but also can be cultivated on a variety of inexpensive agro-industrial residues. They are considered as interesting alternatives for biodiesel production (Fei et al., 2011a; Zhu et al., 2008; Liang et al., 2010). At present the cost of microbial oil production is higher than those of vegetable and animal oils, but there are various ways to improve the economical process of microbial oil production bioprocesses. One of the reasons for expensive cost of microbial lipid based biodiesel is the high cost of carbon source (usually glucose) used for cultivation of oleaginous microorganisms. It was estimated that the cost of glucose used for biodiesel production from oleaginous organisms is about 80% of the total cost of the medium (Fei et al., 2011b). Current agricultural and industrial practices result in a large amount of nutritionally rich waste material which can be valorized through biotechnological applications such as synthesis of single cell proteins, microbial lipids, organic acids etc.

Volatile fatty acids (VFA) which can be obtained from agro-industrial lignocellulosic wastes, sludge and a variety of biodegradable organic wastes, seem to be alternative carbon sources for lipid production by oleaginous microorganisms (Chang et al., 2010). Bioconversion of these organic acids has not only an economical interest but also an ecological one. For example, acetic acid, which is generated either in the water process of uranium bleaching or as effluent issued from Fischer–Tropsch reaction is considered as an important pollutant (Papanikolaou and Aggelis, 2011).

Although sugars and polysaccharides have been widely used for microbial lipid production by oleaginous microorganisms, the information about lipid accumulation using volatile fatty acids is

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