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Ability of *Gordonia alkanivorans* strain 1B for high added value carotenoids production

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Currently, carotenoids are valuable bioactive molecules for several industries, such as chemical, pharmaceutical, food and cosmetics, due to their multiple benefits as natural colorants, antioxidants and vitamin precursors. Hence, the increasing interest on these high added-value products has led to the search of alternatives, more cost-effective and with better yields, towards their industrial production. Indeed, microbial metabolism offers a promising option for carotenoids production. Herein it is shown the potential of the dibenzothiophene desulfurizing bacterium *Gordonia alkanivorans* strain 1B as a high carotenoid-producer microorganism. The novel carotenoids, produced under different culture conditions, were extracted with DMSO and then further analyzed both through spectrophotometry and HPLC. When grown in glucose-sulfate-light, strain 1B was able of achieving 2015 μg carotenoids per g DCW in shake-flask assays, with about 60% corresponding to lutein, canthaxanthin and astaxanthin. Further optimization studies open a new focus of research aiming to get a hyper pigment-producer strain that may be applied towards different industrial sectors.

I. Introduction

In last two decades, the actinomycete genus *Gordonia* has attracted much interest. Most species were isolated due to their abilities to degrade xenobiotics; environmental pollutants as polycyclic aromatic hydrocarbons, alkylpyridines, phthalates; or otherwise slowly biodegradable natural polymers, as well as to transform or synthesize organic compounds, such as steroid transformation and carotenoid production. The variety of chemical compounds being transformed, biodegraded, and synthesized by gordoniae makes these bacteria very attractive for environmental and industrial biotechnology.[1–4]

Gordonia alkanivorans strain 1B was isolated by Alves *et al.*[5] from oil contaminated soil samples from Parque das Nações (former Petrogal location, Lisbon, Portugal). It is an aerobic, Gram-positive, catalase-positive, oxidase-negative and pink/orange-pigmented bacterium. Cells were shown to be short branched hyphae, which disintegrated to rods and coccus-like elements when visualized by phase contrast microscopy. They are non-motile cells generally occurring in groups.[5]

In the last decade, several works have demonstrated the great potential of *G. alkanivorans* strain 1B towards fossil fuel biodesulfurization (BDS). This bacterium is able of desulfurize dibenzothiophene (DBT) and its alkylated derivatives, as well as mixtures of these compounds (model oils), using the 4S-pathway.[5,6] The 4S-pathway is the best pathway for the desulfurization of crude oils since it enables the removal of sulfur without compromising the carbon skeleton of the organo-sulfur compound and therefore without affecting its calorific power, making BDS an industrially interesting process. Enhanced desulfurization by strain 1B was obtained when fructose or fructose-rich materials were used as carbon source.[7–10]

Clearly, BDS presents advantages as a complementary technique to the commonly oil industry solution (HDS – hydrodesulfurization) towards the production of ultra low sulfur fuels (ULSF) that meets current environmental regulations. However, one of the drawbacks that still hinder the BDS scale up it is the lack of economic viability of this ecofriendly bioprocess.[11–14] In this context, measures to make BDS economically competitive include the use of a cost-effective culture medium for biocatalysts production (minimal medium using a cheaper C-source) and the exploitation of high-added value byproducts produced by the desulfurizing microorganisms, such as carotenoids or biosurfactants.[8,10,14–16]

Several species of the genus *Gordonia* are known producers of carotenoids, in fact most species present a characteristic color orange/red/pink. Amongst them, the most studied is *G. jacobaea*, which was the first of this genus to be isolated as a good carotenoid producer, and was later genetically improved to achieve maximum productivity.[17,18] *G. alkanivorans* strain SKF120101, has also been described as producing strong pigmentation, associated with carotenoids, when grown under an intense light.[19]

Carotenoids in nature are typically C40 tetraterpenoids, which are formed by eight C5 isoprenoid units joined head to

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