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A novel potential source of β-carotene: *Eustigmatos* cf. *polyphem* (Eustigmatophyceae) and pilot β-carotene production in bubble column and flat panel photobioreactors

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HIGHLIGHTS

- Carotenoids profile of *Eustigmatos* cf. *polyphem* was first analyzed by HPLC.
- The microalga was first reported to accumulate large amount of β-carotene and biomass.
- Effects of light intensity and N on β-carotene and biomass accumulation were studied.
- Production of β-carotene in bubble column and large flat panel bioreactors was assessed.

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ABSTRACT

Carotenoids profile of the unicellular *Eustigmatos* cf. *polyphem* (Eustigmatophyceae) and β-carotene production of the microalga in bubble column and large flat panel bioreactors were studied. The microalga which contained β-carotene, violaxanthin and vaucheriaxanthin as the major carotenoids accumulated large amount of β-carotene. The β-carotene production of this microalga in the bubble column bioreactor was considerable, with the maximum intracellular β-carotene content reaching 60.76 mg g^{-1}, biomass reaching 9.2 g L^{-1}, and β-carotene yield up to 470.2 mg L^{-1}. The β-carotene productions in two large flat panel bioreactors were relatively lower, whereas over 100 mg β-carotene L^{-1} was achieved. Besides, high light intensity helped to accumulate intracellular β-carotene and biomass. Deficient nitrate supply inhibited biomass growth, though it helped to accumulate β-carotene. Our results first proved that *E.* cf. *polyphem* was a potential source and producer of β-carotene, making it an interesting subject for further β-carotene study or commercial exploration.

1. Introduction

β-Carotene is a naturally occurring orange-colored pigment synthesized by high plants and microorganisms. Besides its best documented and established function of provitamin A activity (Olson and Hayashi, 1965) and important role played in photosynthesis (Telfer, 2002), this compound also has diverse significant physiological effects, for example, it functions as scavenger of peroxyl radicals (Burton and Ingold, 1984), stimulant of immune response (Williams et al., 2000) and enhancer of gap-junction communication (Stahl and Sies, 1997). Nowadays, *β*-carotene is of increasing demand and extensive applications: as colorant, feed additive, antioxidant, anti-cancer agent and heart disease preventive in the food, aquaculture, cosmetics and pharmaceutical industries (Prieto et al., 2011).

Although a large portion of commercially available *β*-carotene is chemically synthesized (Gómez and González, 2005), yet there has been considerable interest in the production of natural *β*-carotene from living organisms owning to the superior bioavailability, antioxidant capacity and physiological effects over its synthetic counterpart (Becker, 1994). Presently, the most common method for the commercial production of natural *β*-carotene is the massive cultivation of the unicellular biflagellate microalga *Dunaliella salina* (Borowitzka, 1995), which yielded a high intracellular *β*-carotene content up to 10% of dry weight (Ben-Amotz, 1999). However, such a high concentration of *β*-carotene in this microalga had to be achieved under numerous harsh cultivation conditions, such as high salinity, high light intensity (≧500 μmol photons m^{-2} s^{-1}) and low growth temperature (Borowitzka et al., 1984; Brown et al., 1997; Abdullaev and Semenenko, 1975). Besides, *β*-carotene production of this microalga is greatly restricted by low biomass yield, which was generally less than 1.5 g L^{-1} (Gómez et al., 2003; Hejazi et al., 2004; García-González et al., 2005). Hence, looking for novel sources of natural *β*-carotene is necessary.

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