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Production of lutein from the microalga *Scenedesmus almeriensis* in an industrial size photobioreactor: Case study.

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A case study about the microalgal production of lutein in an industrial size tubular photobioreactor is presented. The recently identified new microalgal strain *Scenedesmus almeriensis* has been utilized. This strain, isolated within a farmer greenhouse, is characterized by a high content of lutein, mean content of 0.5%d.wt., ten times higher than the commercial source of this compound, *Tagetes* sp. The microalga *S. almeriensis* has been produced in an industrial size tubular photobioreactor (4.0 m^3) designed, built and set up inside a farmer greenhouse. The photobioreactor consists of a single loop of polymethylmethacrylate tubes, 0.10 m diameter and 400 m long, and an airlift system, 4.0 m height, made up of two vertical tubes of 0.10 (riser) and 0.25 m (downcomer) diameter, respectively. The temperature of the culture was kept below 35 ºC by means of a heat exchanger installed within the downcomer, through which tap water from a reservoir was circulated. The pH was controlled by on-demand injection of CO_2 at the beginning of the loop. In spite of a 40% of light attenuation produced by the plastic cover of the greenhouse, the high photosynthetic growth rate existing within the tubes raised dissolved oxygen levels up to 400%Sat. The main problem concerning the operation of the reactor was the excessive accumulation of dissolved oxygen at the end of the loop and the fouling on the inner surface of tubes. To decrease the residence time of the culture on the loop a centrifugal pump was installed. Simultaneously, a self-cleaning system consisting of zero buoyancy small particles was also implemented to avoid fouling. The use of a centrifugal pump increased the liquid velocity from 0.3 m/s (airlift mode) to 0.9 m/s, causing a decrease of the residence time on the loop from 22 min (airlift mode) to only 7 min. The self-cleaning system described effectively avoids fouling and allows continuous operation of the reactor for more than eight months. Moreover, the biomass productivity increased from 0.2 g/L/day when operated the photobioreactor just with airlift pump to 0.6 g/L/day by using the centrifugal pump, with the lowest irradiance conditions of winter. In these conditions the lutein content of the biomass was of 0.45%d.wt., resulting in a lutein productivity of 5.0 $mgL^{-1}day^{-1}$. On the other hand, photosynthetic efficiencies as high as 6.0% of global radiation were obtained. These results show the adequacy of the production system presented, thus being a promising technology for the production of lutein at industrial scale. Based on our economic analysis, the technologies developed in this work can provide algal biomass at 15.5 €/kg; what, taking into account the lutein content, could provide a production cost of the recommended daily doses (6 mg lutein/day) of 0.015 €.