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Lipid dynamics and nutritional value of the estuarine strain *Isochrysis galbana* VLP grown from hypo to hyper salinity

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Abstract

Novel nutritional/functional applications of *Isochrysis* strains are mostly based on their diversified lipid classes. The content of these lipids is modulated by different factors, among which salinity has been comparatively understudied. Since managing salinity is key for optimal microalgae outdoor mass production and most studied *Isochrysis* strains are marine, the lipid response to nearly extreme hypo and hyper salinity in a new estuarine strain is here described. Total lipids in exponentially grown *Isochrysis galbana* VLP gradually decreased from 334 ± 36.6 mg g^{-1} at a salinity of 5 psu to 164.3 ± 24.4 mg g^{-1} at 50 psu. Present is the first report on lipid class (LC) remodeling in response to salinity in any *Isochrysis* strain. Two main storage lipids, steryl esters (SE) and triacylglycerol (TAG), underwent the fastest absolute decrease as salinity increased during both active and halted growth in the estuarine strain *I. galbana* VLP. Alkenones also decreased with salinity although less markedly. Among photosynthetic lipids, galactolipids were more affected by salinity than the anionic lipids. Salinity had minor influence on the relative sterol and betaine lipid proportions. Salinity explained more of total LC variation (34.6%) than culture stage (30.3%), whereas the opposite occurred with fatty acid (FA) variation. The main FA affected by salinity were 20:5n-3, 18:3n-3, 18:5n-3 and 18:2n-6. Nutritional value of *I. galbana* VLP from 5 psu exponential cultures was 1.5-fold to 2-fold higher than under all other conditions. *Isochrysis* production in low salinity waters can be a sustainable procedure compatible with its optimized nutritional value.

Keywords Haptophyta · Fatty acids · Lipid classes · Salinity · Microalgae · Nutritional value

Introduction

Strains of the microalga *Isochrysis* (Haptophyta, Prymnesiophycidae) are commonly used as aquaculture food (Muller-Feuga 2013) and are acquiring increasing interest in other commercial applications thanks to their functional properties (Bonfanti et al. 2018). Despite biomass demand for these species existing for a long time, their specific outdoor mass production systems are less developed than those for other microalgae species. Outdoor mass production in photobioreactors has been described as low and variable in *Isochrysis* species (Zhang and Richmond 2003; van Bergeijk et al. 2010), which exhibited low tolerance to changing culture conditions. Subsequent studies have generated improved designs and operations that allowed more efficient outdoor production of *Isochrysis* strains in closed small-scale experimental photobioreactors (Liu et al. 2013) as well as in a larger pilot-scale photobioreactor (Ippoliti et al. 2016). Regarding open systems, there is an absence of specific published papers on outdoor production following the early work done more than three decades ago by Boussiba et al. (1988) in 100-m^2 tanks. Microalgae production in outdoor open systems depends to a larger extent on external conditions and advancing knowledge on *Isochrysis* response to external factors is essential to achieve efficient mass culture production. Within this context, salinity plays a main role, as has been demonstrated in other species from different taxonomic groups. An adequate salinity control in microalgae mass production is key to compensate pond salinity fluctuations due to local precipitation/evaporation events (Fon-Sing and Borowitzka 2016) and to prevent development of competitors and predators (von

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