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Domesticated Populations of *Codium tomentosum* Display Lipid Extracts with Lower Seasonal Shifts than Conspecifics from the Wild—Relevance for Biotechnological Applications of this Green Seaweed

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Abstract: In the last decades, the use of algae in biotechnology and food industries has experienced an exponential growth. *Codium tomentosum* is a green macroalgae with high biotechnological potential, due to its rich lipidome, although few studies have addressed it. This study aimed to investigate the seasonal changes in lipid and pigment profiles of *C. tomentosum*, as well as to screen its antioxidant activity, in order to evaluate its natural plasticity. Samples of *C. tomentosum* were collected in two different seasons, early-autumn (September/October) and spring (May), in the Portuguese coast (wild samples), and in a land-based integrated multitrophic aquaculture (IMTA) system (IMTA samples). Total lipid extracts were analysed by LC–MS, GC–MS, and HPLC, and antioxidant activity was screened through free radical scavenging potential against DPPH and 2,20-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radicals. Wild samples showed a high seasonal variability, modifying their lipidome and pigment profiles according to environmental shifts, while IMTA samples showed a relatively stable composition due to early-stage culturing in controlled conditions. The lipids that contributed the most to seasonal discrimination were glycolipids (monogalactosyl diacylglycerol - MGDG and digalactosyl diacylglycerol - DGDG) and the lyso forms of phospholipids and glycolipids. Lipid extracts showed antioxidant activity ranging from 61 ± 2 to 115 ± 35 μmol Trolox g^{-1} of lipid extract in DPPH assay and from 532 ± 73 to 927 ± 92 μmol Trolox g^{-1} of lipid extract in ABTS assay, with a more intense antioxidant activity in wild spring samples. This study revealed that wild specimens of *C. tomentosum* presented a higher plasticity to cope with seasonal environmental changes, adjusting their lipid, pigment, and bioactivity profiles, while IMTA samples, cultured under controlled conditions, displayed more stable lipidome and pigment compositions.

Keywords: antioxidant activity; bioactivity; fatty acids; glycolipids; IMTA; lipidomics; macroalgae; mass spectrometry; phospholipids; photosynthetic pigments