Lipidomics tools for the valorization of lipids from microalgae for biotechnological applications

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Objectives:

The demand for sustainable food sources and food ingredients is increasing, and microalgae have been emerging as a sustainable source of bioactive lipids, with high levels of omega-3 fatty acids (ω-3 FA) mainly esterified in polar lipids. Microalgae grown under different growth conditions can adapt their FA and polar lipid profiles, but little is still known about the plasticity of polar lipidome[1], hindering their full biotechnological potential. The work ongoing in the Marine Lipidomic Lab, MBA-CESAM, aims to (1) characterize the FA profile and polar lipid (phospholipids, glycolipids) signatures of different commercial microalgae; (2) Unveil the impact of microalgae growth conditions in polar lipidome and in production of healthy and bioactive lipids fostering valorization of microalgae and their application in new biotechnological fields.

Methods:

Allmicroalgae natural products

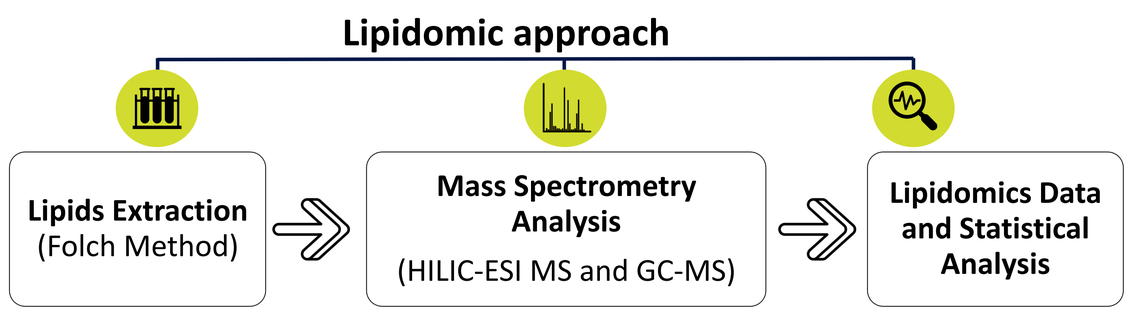
microalgae samples

Chlorophyta
***Chlorella vulgaris* (C.v)**
Chlorococcum amblystomatis (C)
Scenedesmus obliquus (SC)
Tetraselmis chui (T.C)

Bacillariophyta
Phaeodactylum tricornutum (Phae)

Ochrophyta
Nannochloropsis oceânica (N.O)

Cyanobacteria
Spirulina sp. (SP)



Results:

(1) Microalgae fatty acid profiling

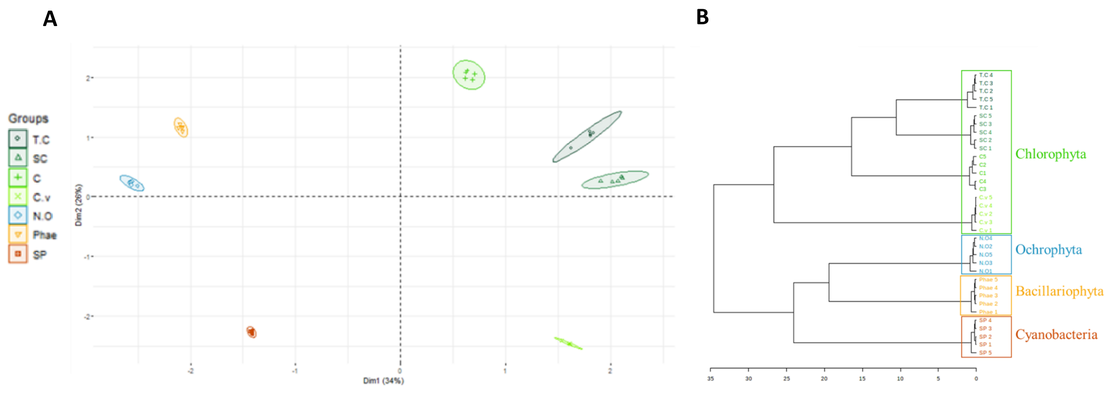


Figure 1. (**A**) PCA scores and (**B**) hierarchical clustering plot of FA profiles identified by GC–MS from all microalgae surveyed.

Table 1. Fatty acid (FA) indicators of all microalgae surveyed.

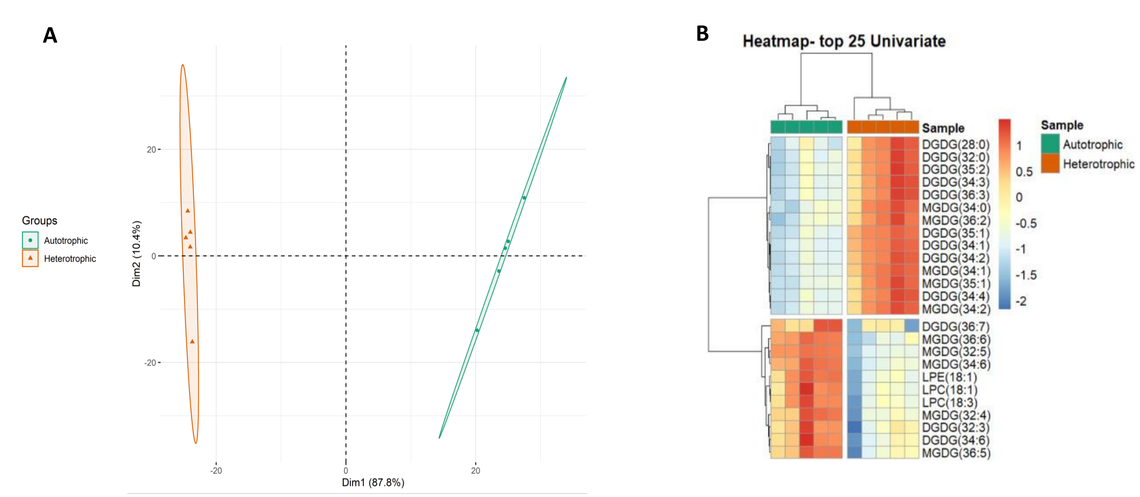
Indicators	Chlorophyta				Bacillariophyta	Cyanobacteria	Ochrophyta
	C.v	***C***	***S.C***	***T.C***	***Phae***	***SP***	***N.O***
∑ SFA	24.9 ± 4.1	27.3 ± 3.3	25.5 ± 5.7	33.6 ± 8.4	23.8 ± 2.4	44.2 ± 1.8	33.0 ± 5.1
∑ MUFA	10.3 ± 0.6	16.1 ± 0.8	14.3 ± 1.1	14.5 ± 1.8	21.9 ± 0.5	10.9 ± 0.3	27.4 ± 1.8
∑ PUFA	**64.6 ± 3.5**	56.7 ± 2.6	60.1 ± 4.8	51.8 ± 6.6	54.3 ± 2.0	44.8 ± 1.5	39.7 ± 3.4
∑ PUFA ω-6	24.3 ± 1.4	6.7 ± 0.4	4.2 ± 0.4	7.3 ± 1.0	4.8 ± 0.3	44.6 ± 1.5	8.9 ± 0.9
∑ PUFA ω-3	40.5 ± 2.2	50.0 ± 2.2	55.9 ± 4.5	44.6 ± 5.7	31.3 ± 1.7	--	30.8 ± 2.4
ω-6/ω-3	0.6 ± 0.0	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.2 ± 0.0	--	0.3 ± 0.0
AI	**0.2 ± 0.0** [a, b, c]	0.4 ± 0.0 [d]	0.2 ± 0.1 [e, f, g]	0.4 ± 0.1	0.5 ± 0.1 [a, f]	0.7 ± 0.0 [b, d, g]	0.6 ± 0.1 [c, e]
TI	0.2 ± 0.0 [b]	0.2 ± 0.0 [h , i]	0.1 ± 0.0 [e, g]	0.2 ± 0.1	0.2 ± 0.2	1.6 ± 0.1 [b, g, h]	0.3 ± 0.1 [e, i]
(h/H)	2.8 ± 0.4 [b, j]	1.7 ± 0.2	2.9 ± 0.5 [g , k]	1.4 ± 0.3 [j , k]	1.8 ± 0.2 [l]	0.6 ± 0.0 [b, g, l]	1.7 ± 0.2

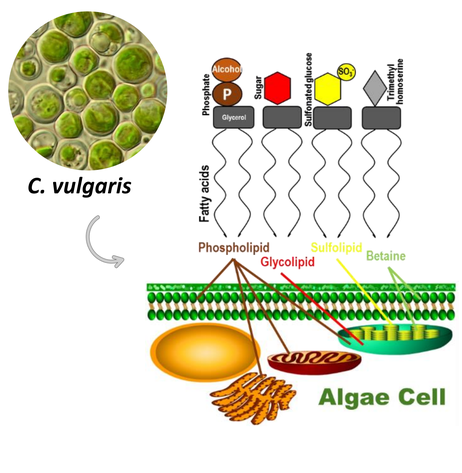
High PUFA

(2) Lipidome plasticity of *C. vulgaris* with growth conditions

✓ *C. vulgaris* were cultivated in autotrophic (**C-Auto**) and heterotrophic (**C-Hetero**) conditions.

✓ Dissimilar polar lipid profile (**phospholipids (PL)**, **glycolipids (GL)** and **Betaines (BL)**) → 173 polar lipids in **C-Auto** and 167 in **C-Hetero**



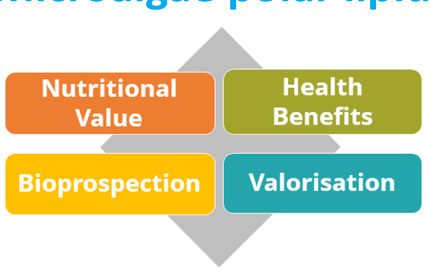


✓ **C-Hetero**
- ↑ **PL**
- ↑ of ***ω*-6** FA and polar lipids

✓ **C-Auto**
- ↑ **GL**
- ↑ Lyso species
- ↑ of ***ω*-3** FA and polar lipids

Figure 2. (**A**) PCA scores plot and (**B**) heat map of polar lipids profiles identified by LC–MS from **C-Hetero** and **C-Auto**.

Microalgae polar lipids



Conclusions:

✓This work has contributed to gathering knowledge on the lipidome of microalgae as a source of ω-3 and ω-6 PUFA with nutritional value and health benefits. Polar lipid composition has phylum and species trend and modulating the health's effect. Nevertheless, lipidome is also dependent of growth conditions as shown for *C. vulgaris*. This knowledge will allow to find the best conditions of cultivation to tune microalgae biomass for specific applications, which is essential to their valorization as a source of bioactive compounds and ingredients for food, feed and other purposes.

References:

[1] Couto, D. et al. Algal Research 2021
[2] Conde, T. et al. Marine Drugs 2021

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