1st INTERNATIONAL CONGRESS ON **ALGAE BIOTECHNOLOGY**

9 - 11 APRIL 2025 • LISBON • PORTUGAL

# Book of Abstracts

## Sustainability and Innovation in the Global Algae Industry


Organization

PROALGA
ASSOCIAÇÃO PORTUGUESA DOS PRODUTORES DE ALGAS

GreenCoLab
Joining the pieces in algal biotechnology.

Financing

PRR Plano de Recuperação e Resiliência

REPÚBLICA PORTUGUESA

Financiado pela União Europeia NextGenerationEU

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# WELCOME LETTER GREENCOLAB & PROALGA

Dear Participants,

On behalf of the Organizing Committee and the Scientific Committee, it was with great pleasure and challenge that we welcomed all the participants to the 1st International Congress on Algae Biotechnology, held in the wonderful Portuguese city of Lisbon.

This congress marked an aggregating and enriching moment for the algae sector, which brought together around 300 participants from 22 countries, demonstrating the growing global focus on algae biotechnology and its transformative applications for the industry. The enthusiasm of the scientific and industrial community was clearly evident in the submission of 140 abstracts, accepted for oral or poster presentation, reflecting the excellent scientific quality and thematic diversity presented.

The congress program has been carefully designed to reflect the latest advances and emerging trends in algae research and application, and to evoke an open spirit of exchange of ideas and reflections in an international ecosystem.

The agenda consisted of 14 sessions and 3 opening moments, made up of key and recognized renowned figures from academia and industry, as well as 2 round tables and interactive moments that promote the sharing of experiences, constructive debate and collaboration between different actors in the algae value chain.

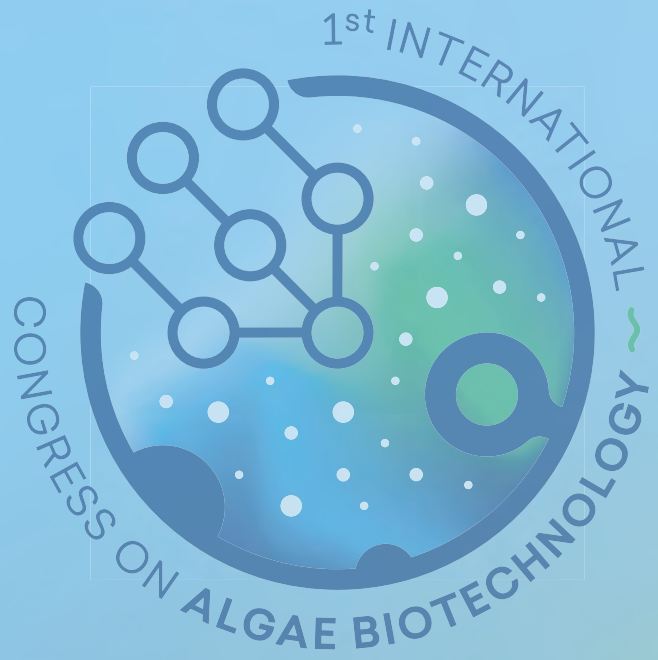
With a total of 107 lectures and oral interventions, topics ranging from laboratory and large-scale cultivation, biotechnology and genetic engineering, application of high-value products, human and animal nutrition, biorefinery, wastewater treatment, LCA, to the largest Portuguese project in the algae sector: Vertical Algae, were covered.

One of the highlights of this edition are the sessions dedicated to industry, a frequent request from the sector, which aims to promote dialogue between science and the market. Complementing the programme, unique social events were organized, including a technical visit to Allmicroalgae (Leiria), a congress dinner (Beer Museum), a tasting day with algae food products (3rd day) and two book launches.

We would like to thank our partners who have made this event possible in various ways, from providing products and stands to logistical support.

Finally, we hope that these three intensive days of congress will not only provide knowledge and scientific updates, but also networking opportunities, moments of conviviality and, above all, the beginning of new collaborations that will contribute to the sustainable advancement of algae biotechnology.

The Organizing Committee




# ORGANISERS
# SPONSORS
# PARTNERS

# ORGANISERS

**GreenCoLab — Associação Oceano Verde**
Collaborative Laboratory, a non-profit organisation, bridges academia and industry for research and innovation focused on algae's sustainable applications.

**PROALGA — Associação Portuguesa dos Produtores de Algas** — is a private, non-profit association with legal personality whose purpose is to promote, defend and stimulate the interests of seaweed producers (microalgae and macroalgae) and to represent them before decision-making bodies, public agencies and other public and private institutions, whether national, EU or foreign.

# SPONSORS

**Necton** - is one of the leading companies in producing and cultivating microalgae, specialising in freshwater and marine cultures. Located in the south of Portugal, it stands out for its mastery of various cultivation systems, from open to closed, guaranteeing innovation and quality at every stage of the process.

**Allmicroalgae** - is looking to expand microalgae's benefits to various industries, such as food, nutrition, agriculture, and cosmetics. With a production and innovation unit in Leiria, Portugal, the company is only at the beginning of its journey to explore microalgae's potential.

**CellDEG** GmbH is a Berlin-based biotech company that specializes in ultra-high-density cultivation systems for microalgae. Our patented technology utilizes thin-layer membrane photobioreactors that integrate highly efficient membrane-mediated $CO_2$ supply with optimal light intensities and nutrient-enriched HD-media. This innovative approach enables us to achieve cell densities exceeding 30 g DW $L^{-1}$ and productivities of up to 10 g DW $L^{-1}$ $d^{-1}$ in batch mode using numerous established model strains.

Designed for axenic cultivation, CellDEG's systems are suitable to both research and industrial applications. Our versatile control unit allows for the use of interchangeable cultivation platforms, ranging from 10 mL to 4 L, significantly reducing both time and costs while enhancing flexibility. These systems effectively eliminate $CO_2$ limitations at high densities under strong light, facilitate efficient oxygen removal, and minimize water vapor loss, positioning them as the ideal choice for rapid microalgae bioproduction.

Committed to delivering standardized, high-performance solutions, CellDEG serves institutions and biomass producers around the globe.

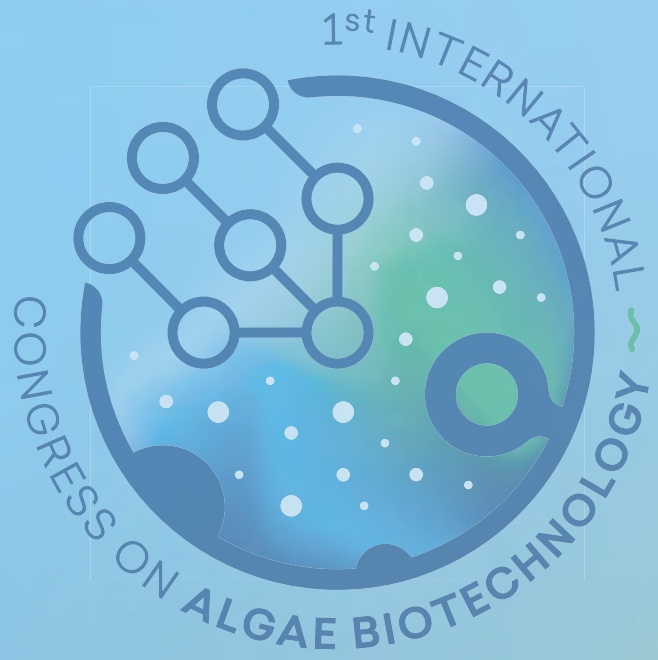
# PARTNERS

**Colab4Food** - is a non-profit association bridging academia and industry to develop sustainable, nutritious, and market-oriented food solutions through collaboration.

**SUMOL+COMPAL** - rooted in nature, excels in Portuguese non-alcoholic beverages and packaged vegetables, with innovative brands recognized globally.

The **CHECK-In** Faro Restaurant, led by starred chef Leonel Pereira, offers a gastronomic experience inspired by travelling, combining reinvented classics, innovation and research, with a strong focus on seasonality, sustainability and a special emphasis on fish and sea derivatives, such as algae's.

**ISA** - part of the University of Lisbon, focuses on higher research, technology transfer in agriculture, forestry, and related fields. It hosts three research centers and engages in various projects.




# AGENDA

# DAY 1 | 9 APRIL 2025

| | | |
|---|---|---|
| **8h00 - 9h10** | **REGISTRATION** | |
| | **MAIN AUDITORIUM** | |
| **9h10 - 9h30** | **OPENING CEREMONY** | |
| | Host<br>9h10 - 9h15 | **João Navalho (President)**<br>Necton S.A. \| Algae Vertical Promoter Leader |
| | Host<br>9h15 - 9h30 | **Lídia Bulcão (Secretary of State for Maritime Affairs)**<br>Portuguese Republic |
| **9h30 - 11h15** | **SESSION** | **ADVANCES IN MICROALGAE PRODUCTION & R&D** |
| | Chair (5 min)<br>9h30 – 9h35 | **Rosário Domingues (Associate Professor with Habilitation)**<br>University of Aveiro |
| | Keynote Speaker<br>9h35 – 10h05 | **"Hypes, hopes and the way forward for microalgal biotechnology"**<br>**Maria Barbosa** (Professor \| Director) \|\| Wageningen University & Research \| AlgaePARC |
| | Guest Speaker<br>10h05 – 10h25 | **"Strategies and advancements in the identification and mitigation of culture-collapsing biological contaminants"**<br>**João Varela** (Associate Professor \| Coordinator) \|\| University of Algarve \| CCMAR MarBiotech Group |
| | Talk 1<br>10h25 – 10h35 | **"Engineering, cultivation and application of the fast-growing cyanobacteria Synechococcus sp. PCC 11901, engineered for the synthesis of astaxanthin"**<br>**Nico Betterle** \| University of Verona |
| | Talk 2<br>10h35 – 10h45 | **"Investigating Calvin Cycle Regulation in Chlamydomonas reinhardtii through Heterologous Expression of Cyanobacterial FBP/SBPase"**<br>**Martina Bussola** \| University of Verona |
| | Talk 3<br>10h45 – 10h55 | **"Airborne Transport and Characterization of Microalgal Bioaerosols"**<br>**César Marina Montes** \| University of Almeria |
| | Talk 4<br>10h45 – 10h55 | **"Cheese-whey as an alternative growth medium for white Chlorella sorokiniana"**<br>**Filipe Maciel** \| University of Minho |
| | Talk 5<br>11h05 – 11h15 | **CO2-nanobubble optimisation of biomass productivity in micro-algal cultivation: towards large-scale productivity**<br>**Niall English** \| University College Dublin |
| **11h15 – 11h40** | **Coffee break \| Poster Session [1–25]** | **PARALLEL AUDITORIUM*** |
| **11h40 - 13h25** | **SESSION** | **ADVANCES IN MICROALGAE PRODUCTION & R&D** / **ADVANCES IN MICROALGAE PRODUCTION & R&D (PART II)** |
| | Chair<br>11h40 – 11h45 | **Isabel Costa (Assistant Researcher)**<br>CIIMAR |
| | Keynote Speaker<br>11h45 – 12h15 | **"Progress in seaweed-based product applications cultivated in Europe and the US"**<br>**Urd Grandorf Bak** (Head of R&D Europe) \| Ocean Rainforest Sp/F |
| | Guest Speaker<br>12h15 – 12h35 | **"Macroalgae Production in Europe: The Contribution of Land-Based Precision Phyconomy"**<br>**Rui Pereira** (Head of Seaweed Division) \| IAF – Algae For Future |
| | Talk 1<br>12h35 – 12h45 | **"From Ocean to Innovation: Unlocking the Full Potential of Codium tomentosum"**<br>**Inês Oliveira** \| ALGAPLUS |
| | Talk 2<br>12h45 – 12h55 | **"Advancing Sustainable Cultivation of Atlantic Nori: Strain Selection for Enhanced Growth and Quality"**<br>**Madalena Carla Mendes** \| GreenCoLab |
| | Talk 3<br>12h55 – 13h05 | **"From sea to land: A way to produce macroalgae in terrestrial areas and the use as biostimulants"**<br>**Victor Alonso Robles Carnero** \| University of Almeria |
| | Talk 4<br>13h05 – 13h15 | **"Adaptive Changes in the Fatty Acid Profile of Ulva spp. in Response to Iron and Copper Short-term Exposure"**<br>**Catarina D. Freire** \| MARE-IPL |
| | Talk 5<br>13h15 – 13h25 | **"Advancing Macro and Microalgae Identification Through Molecular Tools"**<br>**Iris Silva** \| S2AQUAcoLAB |
| | | **Marta Batista de Sá (Lead AlgaeHub)**<br>Lgem \| Synalgae |
| | | **"Productivity and carbon dioxide loss monitoring in large-scale microalgal photobioreactors"**<br>**Luca Buscaglia** \| AlgaePARC (Wageningen University & Research) |
| | | **"Innovative and Sustainable Approaches for the gentle disruption of Microalgae Cells to extract valuable Compounds using Pulsed Electric Fields"**<br>**Sofie Schröder** \| Elea Technology GmbH |
| | | **"Modification of the biochemical composition of Pavlova gyrans through in situ electric field application throughout growth"**<br>**Mariana Barreiros** \| Centre of Biological Engineering (University of Minho) |
| | | **"Enabling geraniol production in Chlamydomonas reinhardtii via heterologous CrGES expression"**<br>**Edoardo Ceschi** \| University of Verona |
| | | **"A novel, fast and reliable alternative for microalgal growth assessment in scalable cultivation systems"**<br>**José Ignacio Gayo Pelaez** \| Swansea University |
| **13h25 – 14h50** | **Lunch** | |
| **14h50 – 16h20** | **ROUND TABLE** | **WHY ARE WE STILL SO FAR FROM THE MASS MARKET?** |
| | Moderator<br>14h50 – 15h00 | **João Navalho (President)**<br>Necton S.A. \| Algae Vertical Promoter Leader |
| | Guest speaker<br>15h00 – 15h10 | **"Algae as food: trends and consumer patterns"**<br>**Marlos Silva** (R&D and Innovation Director) \| MC Sonae |
| | Guest speaker<br>15h10 – 15h20 | **"Algae as the Future of Sustainable Nutrition: Overcoming Market Barriers and Offering Solutions to Current Global Challenges"**<br>**Jesús P. Kaufmann** (CEO and Founder) \| PureRaw – Kaufmann GmbH and Hochschule Anhalt University of Applied Science |
| | Guest speaker<br>15h20 – 15h30 | **"From the Microalgae Stone Age to an Advanced Microalgae Biotechnology and Agri-Aquaculture"**<br>**Jörg Ullmann** (Managing Director and Scientific Project Manager) \| Algenfarm Klötze GmbH & Co. KG |
| | Guest speaker<br>15h30 – 15h40 | **"High hopes, Low Scale: Seaweeds Struggle to go mainstream?"**<br>**Helena Abreu** (Independent Seaweed Consultant) |
| | Discussion + Q&A<br>15h40 – 16h20 | |
| **16h20 – 16h50** | **Coffee break \| Poster Session [26–50]** | |
| **16h50 – 18h30** | **SESSION** | **TOWARDS ALGAE INDUSTRY AUTOMATION: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS** |
| | Chair<br>16h50 – 16h55 | **Mariana Carneiro (Innovation Manager)**<br>Necton S.A. |
| | Keynote Speaker<br>16h55 – 17h20 | **"Smart Microalgae Production: Innovations in Automation and Optimization Strategies"**<br>**José Luis Guzmán** (Professor) \| University of Almeria |
| | Guest speaker<br>17h20 – 17h40 | **"Harmful algal bloom detection with machine learning and satellite imagery"**<br>**Emily Dane** (Lead Data Scientist) \| DrivenData |
| | Talk 1<br>17h40 – 17h50 | **"Machine Learning Models for Estimating Nutrient Demands in Microalgae Cultivation Systems: A Classification Approach"**<br>**Geovanni Freitas** \| Faculty of Engineering (University of Porto) \| NOVA de Lisboa \| IAF |
| | Talk 2<br>17h50 – 18h00 | **"Digital twin-based optimization of Crocosphaera chwakensis cultivation for efficient cyanobacterial production"**<br>**Daniela Wüst** \| acib GmbH \| BOKU University |
| | Talk 3<br>18h00 – 18h10 | **"Evaluating the sustainability of heterotrophic alternative proteins: the Chlorella spp. case study"**<br>**Lais Speranza** \| GreenCoLab |
| | Talk 4<br>18h10 – 18h20 | **"Energizing a Circular Economy Model Integrating Agri-Voltaics, Microalgae Production, and Agro-Industrial Synergies"**<br>**Antonio Idd** \| SIPA |
| | Talk 5<br>18h20 – 18h30 | **"Continuous hydrogen production under illumination by Synechocystis sp. PCC6803 using oxygen absorber"**<br>**Gergely Erno Lakatos** \| National Research Council of Italy |

# DAY 2 | 10 APRIL 2025

| | | | |
|---|---|---|---|
| 8h30 – 9h00 | **REGISTRATION** | | |
| | **MAIN AUDITORIUM** | | **PARALLEL AUDITORIUM*** |
| 9h00 – 9h30 | Guest speaker<br>9h00 – 9h10 | **Helena Vieira** (Coordinator Researcher and ERA CHAIR Holder)<br>University of Aveiro | **ADVANCES IN MICROALGAE PRODUCTION & R&D (PART II)** |
| | Keynote speaker<br>9h10 – 9h30 | **Jorge Dias** (Co-Founder, CEO and Production Manager)<br>SPAROS | |
| 9h30 – 11h35 | **SESSION** | **SESSION — ALGAE APPLICATIONS (PART I)** | **ALGAE APPLICATIONS: ENVIRONMENTAL SOLUTIONS AND CIRCULAR ECONOMY** |
| | Chair<br>9h30 – 9h35 | **Maria Barbosa** (Professor \| Director)<br>Wageningen University & Research \| AlgaePARC | **João Varela** (Associate Professor \| Coordinator)<br>University of Algarve \| CCMAR MarBiotech Group |
| | Keynote Speaker<br>9h35 – 10h05 | **"Microalgae Biorefinery: Advances, Challenges, and Emerging Pathways"**<br>**Qiang Hu** (Full Professor and Director) \|\| Shenzhen University of Advanced Technology (SIAT) | |
| | Guest Speaker<br>10h05 – 10h25 | **"Microalgae in Human Nutrition and Health: Opportunities and Challenge"**<br>**Fengzheng Gao** (Established Researcher and Team Leader) \| ETH Zurich | |
| | Talk 1<br>10h25 – 10h35 | **"Lipidomics meets algae: A blueprint for future foods and biotechnological applications of algae lipids"**<br>**Rosário Domingues** \| University of Aveiro | **"Locality: an algae-based circular initiative in the North and Baltic Seas"**<br>**Margarida Costa** \| Norwegian Institute for Water Research (NIVA) |
| | Talk 2<br>10h35 – 10h45 | **"50 shades of yellow: establishing beta-xanthin pigment biosynthesis in cyanobacteria"**<br>**Sayali Hanamghar** \| Friedrich Schiller University Jena, Matthias Schleiden Institute | **"Microalgal blooms: A sustainable approach for marine aquaculture wastewater treatment"**<br>**Bethany Louise Short** \| University of Cádiz |
| | Talk 3<br>10h45 – 10h55 | **"Exploring microalgae biomass for vegan scrambled egg formulations"**<br>**Krielle Demarci** \| GreenCoLab | **"Sustainable production and valorization of microalgal biomass from unfiltered livestock digestate"**<br>**Tea Miotti** \| University of Verona |
| | Talk 4<br>10h55 – 11h05 | **"Microalgae-Derived Bioactives for Skin Regeneration: A Multifunctional Approach to Inflammation, Microbiome Modulation, and Aging"**<br>**Duarte Toubart** \| University of Azores | **"Engineering of a microalgal-bacterial consortium for the removal of organic pollutants from petrochemical industry"**<br>**Antonio Leon-Vaz** \| University of Valladolid |
| | Talk 5<br>11h05 – 11h15 | **"Cyanoflan: the innovative polymer ingredient for the cosmetic industry"**<br>**Rita Mota** \| acib GmbH | **"Tertiary wastewater treatment with microalgae consortia"**<br>**Sofia Vaz** \| IAF – Algae For Future |
| | Talk 6<br>11h15 – 11h25 | **"Tailored Haptophytes for Aquafeeds and Efficient Industrial Production"**<br>**Daniel Figueiredo** \| GreenCoLab | **"Integrating Microalgae Cultivation with Wastewater Treatment: The FRONTSHIP Project's Technological Innovations"**<br>**Alice Ferreira** \| LNEG |
| | Talk 7<br>11h25 – 11h35 | **"From Sea to Fork: Merging Algae and Vegetables for Next-Generation Meals"**<br>**João Dias** \| SPAROS | **"Life cycle assessment of photoautotrophic production of Limnospira platensis (Spirulina) in an industrial facility"**<br>**Sofia Navalho** \| SPAROS |
| 11h35 – 12h00 | **Coffee break \| Poster Session [51–75]** | | |
| 12h00 – 13h00 | **ROUND TABLE**<br>Discussion + Q&A | **THE FUTURE OF ALGAE IN GLOBAL POLICY AND ECONOMICS** | |
| | Moderator | **Catarina Pinto Correia** (Environment & Climate Change Co-head Partner \| Executive Board Member)<br>VdA Partner \| BlueBio Alliance | |
| | Guest speaker | **Helena Vieira** (Senior Coordinator Researcher and ERA CHAIR Holder)<br>University of Aveiro | |
| | Guest speaker | **Gabriel Acien** (Vice-President)<br>European Algae Biomass Association (EABA) | |
| | Guest speaker | **Laura Maranha** (EABA Project Manager)<br>EABA | |
| | Guest speaker | **Helena Abreu** (President)<br>International Seaweed Association (ISA) | |
| 13h00 – 14h25 | **Lunch** | | **PARALLEL AUDITORIUM*** |
| 14h25 – 16h20 | **SESSION** | **BIOREFINERY** | **ALGAE APPLICATIONS (PART II)** |
| | Chair<br>14h25 – 14h30 | **Iago Teles** (Research Manager)<br>Wageningen University & Research | **Margarida Costa** (Research Manager) [Microalgae section]<br>Norsk institutt for vannforskning (NIVA) |
| | Keynote Speaker<br>14h30 – 15h00 | **"Seaweed biorefinery applications and environmental impacts"**<br>**Pi Nyvall** (Scientific Director) \| Olmix Group | |
| | Guest Speaker<br>15h00 – 15h20 | **"Seaweed as a Solution"**<br>**Antoinette Rabar** (Assistant Professor) \| Wageningen University & Research | |
| | Talk 1<br>15h20 – 15h30 | **"Adaptation of the microalgae Scenedesmus almeriensis to seawater: Effect on morphological and physiological attributes"**<br>**Tomas Lafarga** \| University of Almeria | **"Microalgae as a main ingredient in mayonnaise – steps to achieve a clean label prototype"**<br>**Pedro Coelho** \| EAF (Instituto Superior de Agronomia) |
| | Talk 2<br>15h30 – 15h40 | **"Unlocking the potential of algae with the ALGAREFINE platform for sustainable biorefinery innovations"**<br>**Mariam Kholany** \| GreenCoLab | **"Edible coatings: From seaweeds to food products"**<br>**Gabriela Sousa** \| LEAF (Instituto Superior de Agronomia) |
| | Talk 3<br>15h40 – 15h50 | **"Comparative analysis of protein content and antioxidant capacity in microalgae biomasses extracted with ultrasound-assisted extraction"**<br>**Jiedgian Belluco** \| Universidade Católica Portuguesa | **"Algae biomass as a potential ingredient for seafood analogues"**<br>**Catarina Moreira** \| University of Minho |
| | Talk 4<br>15h50 – 16h00 | **"Enhancing Bioaccessibility of Chlorella Protein Through Physical Processing Techniques"**<br>**Maria Silva** \| Centre of Biological Engineering \| University of Minho | **"Spirulina as the main ingredient of a plant-based animal product alternative"**<br>**Inês Guerra** \| IRT-M \| GreenCoLab \| CCMAR |
| | Talk 5<br>16h00 – 16h10 | **"Sustainable valorization of residual Spirulina platensis biomass: Solid-state fermentation for the production of bioactive compounds and enhanced protein content"**<br>**Estefania Hernandez** \| acib GmbH | **"Antiviral activity in different species of microalgae: a promising approach to discover new high-value molecules"**<br>**Antonio Leon-Vaz** \| University of Valladolid |
| | Talk 6<br>16h10 – 16h20 | **"Extracting sustainability in phycoscience: amino acids from microalgae to create pioneering natural solutions for cosmetic applications"**<br>**Barbara M. C. Vaz** \| CICECO (University of Aveiro) | **"The antiviral and anti-angiogenic potential of polysaccharides extracted from red algae Palmaria palmata: chemical and structural characterization"**<br>**Bouchra Benhiyad** \| CNRST-Labeled Research Unit |
| 16h20 – 16h45 | **Coffee break \| Poster Session [76–100]** | | **PARALLEL AUDITORIUM*** |
| 16h45 – 18h30 | **SESSION** | **EMERGING LANDSCAPES IN ALGAE INDUSTRY: PRECISION FERMENTATION, CELLULAR AGRICULTURE AND UNCONVENTIONAL APPLICATIONS** | **APPLICATIONS: BIOREFINERY (SESSION II)** |
| | Chair<br>16h45 – 16h50 | **René Wijffels** (Professor)<br>Wageningen University & Research | **Iulian Boboescu** (Assistant Professor)<br>Wageningen University & Research |
| | Keynote Speaker<br>16h50 – 17h20 | **"Why fermentation? Why not?"**<br>**Huw Griffiths** (Chief Scientific Officer) \| Fermentalg | |
| | Guest Speaker<br>17h20 – 17h40 | **"Harnessing microalgae to enhance sustainability in cell-based food production"**<br>**Júlio S. Franco** (Senior Researcher) \| Research by S2AQUAcoLAB \| CIIMAR | |
| | Talk 1<br>17h40 – 17h50 | **"New genomic techniques (NGT) for sustainable non-transgenic improvement of microalgae capabilities"**<br>**Rosa León** \| University of Huelva | **"Implementation of a transversal scalable multi-product aqueous-based biorefinery pipeline for red algae biomass"**<br>**Pedro Leiras** \| GreenCoLab |
| | Talk 2<br>17h50 – 18h00 | **"Lactobacilli consortium and Corynebacterium glutamicum cultivation in sequential bioreactors to produce single cell proteins (SCP)"**<br>**Diogo Jacinto Marques** \| Instituto Superior Técnico \| Associated Laboratory i4HB | **"Cell disruption of microalgae Nannochloropsis oceanica using bead milling: effect on recovery, composition and bioaccessibility of partially disintegrated biomass"**<br>**Emil Gundersen** \| DTU National Food Institute |
| | Talk 3<br>18h00 – 18h10 | **"Study of PHB production in a continuous culture of Synechocystis sp."**<br>**Javier Garrido Romer** \| University of Almeria | **"Microalgal Auto-PHAs: A Key Step Towards Sustainable Multi-Product Biorefineries"**<br>**Sylwia Khamila** \| Wageningen University & Research |
| | Talk 4<br>18h10 – 18h20 | **"A novel Chlorella vulgaris mutant strain allows for the efficient production of butein and zeaxanthin, pigments required for human health"**<br>**Matteo Ballottari** \| University of Verona | **"Strategies of Stabilization of R-Pigments for Plant-Based Seafood"**<br>**Alexandra Conde** \| University of Aveiro |
| | Talk 5<br>18h20 – 18h30 | **"Potential antioxidant and anti-inflammatory wound healing properties of marine microalgae extracts isolated from Moroccan coastlines"**<br>**Ghita Loubna** \| MASCI \| Université Mohammed V | **"Paving Chlorella with Cost-Effective Bioprocesses to Develop Protein-Rich Food Innovations: Evaluation Properties and Application in Cookies"**<br>**Sheyna Khemiri** \| LEAF (Instituto Superior de Agronomia) |

# DAY 3 | 11 APRIL 2025

| | | |
|---|---|---|
| **8h30 – 9h00** | **REGISTRATION** | |
| | **MAIN AUDITORIUM** | |
| **9h00 – 9h35** | Host<br>9h00 – 9h05 | **João Navalho** (President)<br>Necton S.A. \| Algae Vertical Promoter Leader |
| | Keynote Speaker<br>9h05 – 9h35 | **"Challenges in the development of industrial processes based on microalgae"**<br>**Gabriel Acién** (Professor)<br>Universidad de Almería |
| **9h35 – 10h40** | **SESSION** | **ALGAE VERTICAL PROJECT: PART I** |
| | Chair<br>9h35 – 9h40 | **Alexandre Rodrigues** (Innovation Manager)<br>Necton S.A. |
| | Talk 1<br>9h40 – 9h50 | **"Unveiling the diversity and algal growth promoting features of the microbiome of cultivated Atlantic Nori (Porphyra spp.) at early developmental stages"**<br>**Rodrigo Costa** \| Instituto Superior Técnico |
| | Talk 2<br>9h50 – 10h00 | **"Development of Algae-Based Fish Analogues: Traditional and Non-Traditional Approaches"**<br>**Dalila Vilela** \| Colab4Food |
| | Talk 3<br>10h00 – 10h10 | **"Decoding the Microbiome of Porphyra spp.: A Path to Enhanced Aquaculture Production"**<br>**André C. Pereira** \| Instituto Superior Técnico |
| | Talk 4<br>10h10 – 10h20 | **"InAlgae® AOX: A Sustainable high performance seaweed-based ingredient for Cosmetics"**<br>**Helena Melo Amaro** \| Incita Seaweed Solutions |
| | Talk 5<br>10h20 – 10h30 | **"Exploring sequential protein extraction from Porphyra dioica: structural and functional implications for food applications"**<br>**Cristina Rocha** \| Universidade do Minho |
| | Talk 6<br>10h30 – 10h40 | **"Exploring Cyanobacteria and Microalgae Metabolites for Biotechnological Advances in Diabetes"**<br>**Diogo Ferreira-Martins** \| University of Porto |
| **10h40 – 11h05** | **Thematic "Algae" Coffee break \| Poster Session [101–125]** | |
| **11h05 – 12h00** | **SESSION** | **ALGAE VERTICAL PROJECT: PART II** |
| | Chair<br>11h05 – 11h10 | **Margarida Martins** (Innovation Coordinator)<br>ALGAPLUS |
| | Talk 1<br>11h10 – 11h20 | **"Exploring the Bacteriome Associated with Industrially Produced Microalgae"**<br>**Tamara Santos** \| CCMAR |
| | Talk 2<br>11h20 – 11h30 | **"Enhancing Sustainability and Efficiency in Industrial Microalgae Production: Innovations in Cooling and Harvesting at Necton"**<br>**Alexandre Rodrigues** \| Necton |
| | Talk 3<br>11h30 – 11h40 | **"Modulation of appetite, reduction of lipids and uptake of glucose by extracts from micro- and macroalgae"**<br>**Ralph Urbatka** \| CIIMAR |
| | Talk 4<br>11h40 – 11h50 | **"Public Perception of Algae in Portugal: Insights from a National Survey"**<br>**Margarida Eustáquio** \| PROALGA |
| | Talk 5<br>11h50 – 12h00 | **"Bioactive profile, bioaccessibility and antioxidant activity of Diatoms: a comparative study"**<br>**Helena R. Rocha** \| Faculty of Biotechnology of the Universidade Católica Portuguesa (ESB/UCP) |
| **12h00 – 12h20** | **BOOK LAUNCH SESSION** | **CHILDREN BOOK: THE GREEN OF THE BLUE – DISCOVERING THE WORLD OF ALGAE** |
| | Guest speaker | **Hugo Pereira** (Coordinator) \| GreenCoLab |
| | Guest speaker | **Liliana Silva** (Coordinating Office of the School Libraries Network of the Ministry of Education) |
| **12h20 – 12h40** | **BOOK LAUNCH SESSION** | **ALGAE FOOD BOOK: THE WHOLE OCEAN ON A PLATE – SCIENCE, CUISINE AND ALGAE PRODUCTION** |
| | Guest speaker | **Leonel Pereira** (Chef) \| CheckIn Restaurant |
| | Guest speaker | **João Navalho** (President) \| Necton S.A. \| Algae Vertical Promoter Leader |
| **12h40 – 14h10** | **Thematic "Algae" Lunch** | |
| **14h10 – 14h15** | **YAS SPONSORED GUEST** | **Daniel Figueiredo** (YAS Chair) |
| **14h15 – 15h20** | **SESSION** | **FROM LAB TO MARKET: COMMERCIALIZING ALGAL INNOVATIONS** |
| | Chair<br>14h15 – 14h20 | **Rita Sousa** (Ocean / Climate Tech Fund Partner)<br>Faber |
| | Talk 1<br>14h20 – 14h30 | **"Co-fermentation – broadening the market for microalgae"**<br>**Guido Albanese** \| (Founder & CEO) \| Koralo |
| | Talk 2<br>14h30 – 14h40 | **"Powerful actives from the natural marine and aquatic resources of the Azores"**<br>**Miguel Pombo** \| (CEO) \| Ignae |
| | Talk 3<br>14h40 – 14h50 | **"From Research to Market: Developing a Pipeline of Services and Prototypes for the Algae Sector"**<br>**Hugo Pereira** \| (Coordinator) \| GreenCoLab |
| | Talk 4<br>14h50 – 15h00 | **"Aqua Viridi – Microalgae Innovative Solutions from Amazon to Amazon"**<br>**Fabiane Almeida** \| (Co-Founder and CEO) \| Aqua Viridi |
| | Talk 5<br>15h00 – 15h10 | **"Developing Chlamydomonas, a model green algae, into commercial products"**<br>**Xun Wang** \| (President and CEO) \| Triton Algae Innovations |
| | Talk 6<br>15h10 – 15h20 | **"Seaweed to Shelf: Natpa's Journey in Revolutionizing Sustainable Packaging"**<br>**Humphrey Atkinson** \| (Product Manager \| Co-Founder) \| Natpa \| Algapelago |
| **15h20 – 15h50** | **Thematic "Algae" Coffee break \| Poster Session [126–150]** | |
| **15h50 – 17h30** | **SESSION** | **ARE WE TURNING THE TIDE? INDUSTRIES' ROLE IN POPULARIZING ALGAL SOLUTIONS** |
| | Chair<br>15h50 – 15h55 | **Joana Silva** (Head of Biotechnology \| Coordinator)<br>Atlantic CoLAB \| PROALGA |
| | Keynote Speaker<br>15h55 – 16h25 | **"The environmental and social impact and the role of algae: truth or fiction?"**<br>**Stefan Kraan** \| (Managing Director \| President) Ocean Organic Products Ltd \| International Society for Applied Phycology (ISAP) |
| | Guest speaker<br>16h25 – 16h40 | **"From Lab to Market: how co-innovation can drive microalgae-based product launches"**<br>**Anabela Raymundo** \| (Associate Professor with Habilitation \| Coordinator) \|\| ITQB NOVA \| LEAF "Food & Feed" Group |
| | Talk 1<br>16h40 – 16h50 | **"AlgaeHUB: focused to unlock the potential of microalgae"**<br>**Marta Batista de Sá** \| Lgem \| Synalgae |
| | Talk 2<br>16h50 – 17h00 | **"BLUEBIO ALLIANCE network: Linking innovation and growth in the blue bioeconomy with algae"**<br>**Elisabete da Costa** \| (Project Manager and Advisor) \| BLUEBIO ALLIANCE |
| | Talk 3<br>17h00 – 17h10 | **"Rethinking the Ocean: Scaling Seaweed Restoration for Global Impact"**<br>**Jan Verbeek** \| (Scientific Manager) \| SeaForester |
| | Talk 4<br>17h10 – 17h20 | **"Unlocking the power of seaweed for sustainable packaging"**<br>**Camilla Dore** \| (Co-Founder and Chief Innovation Officer) \| BZEOS |
| | Talk 5<br>17h20 – 17h30 | **"Exploring Portugal's Dynamic Algae Ecosystem: An Overview by the Portuguese Association of Applied Phycology (APAA)"**<br>**Celso Alves** \| APAA |
| **17h30 – 18h00** | **CLOSING SESSION** | |
| | Host | **João Navalho** (President)<br>Necton S.A. \| Algae Vertical Promoter Leader |
| | Host | **Eduardo Morgado** (General Secretary)<br>PROALGA |
| | Host | **Hugo Pereira** (Coordinator)<br>GreenCoLab |
| | Guest Speaker | **Miguel Marques** (President of the Executive Board of Inovamar)<br>Inovamar |

1st INTERNATIONAL CONGRESS ON ALGAE BIOTECHNOLOGY

9 - 11 APRIL 2025 • LISBON • PORTUGAL

# AGENDA DAY 1

1

# Engineering, cultivation and application of the fast-growing cyanobacteria Synechococcus sp. PCC 11901, engineered for the synthesis of astaxanthin

Authors
NICO BETTERLE[1]; Edoardo Ceschi[1]; Eliana Gasparotto[1]; Elia Battagini[1]; Nico Olivieri[1]; Francesco Bellamoli[1]; Federico Perozeni[1]; Matteo Ballottari[1];

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## ABSTRACT

The production of high-value molecules in microalgae and cyanobacteria is limited by their growth performances in industrial systems. *Synechococcus* sp. PCC 11901 (Syn11901), recently discovered by the group of prof. Peter Nixon in Singapore, showed exceptional properties suitable for industrial applications. This cyanobacterium, using light and CO2, a) efficiently accumulates biomass, b) has a rapid duplication rate, c) grows in salty soils and d) is genetically manipulable.
This work focused on the engineering of Syn11901 to produce astaxanthin, a valuable non-native ketocarotenoid. In more detail, heterologous β-ketolase from *Chlamydomonas reinhardtii* and β-hydroxylase from *Brevundimonas* sp.SD-212 genes were constitutively expressed. Transformed cells (BC) efficiently accumulated astaxanthin (~85% of total carotenoids) during photoautotrophic growth. Moreover, BC cells grew faster than WT cells in the presence of high light and continuous bubbling with $CO_2$, possibly because of the photoprotective activity exerted by astaxanthin.
At lab-scale, the BC cultures reached ~7g/L dcw upon only 4 days of growth in an air-lift photobioreactor, accumulating ~6 g of astaxanthin per Kg of biomass produced.
Cultivation efforts in a 300 L-PBR, with a large diameter of ~50cm, evidenced a lower biomass accumulation (1 g/L) compared to lab-scale. This drawback is to the low light penetration and limiting $CO_2$ supply, resulting in poor photosynthetic performances. Later, the transformant was tested in a 1000 L-PBR, provided by A4F in the framework of the Asteasier EIC project, with a reduced diameter of ~8 cm, increasing the obtained biomass accumulation to 2.5 g/L.
The algal biomass obtained with the A4F-PBR was then tested by BIOMAR, multinational company for feed production, as a component of the feeding for Atlantic salmon. Salmons fed with the formulation containing Syn11901 biomass evidenced the same pigmentation as the salmons fed with conventional product containing synthetic astaxanthin.
In conclusion, the engineered Syn11901 is a promising platform for the industrial and $CO_2$-consuming synthesis of astaxanthin. Moreover, our research paves the way toward sustainable natural astaxanthin consumption and exploitation by feed producers.

**Nico Betterle**
**Researcher - University of Verona / Co-founder, spin-off company Asteasier**

Nico is a researcher at the University of Verona, collaborating with prof. Matteo Ballottari. Moreover, he co-founded the academic spin-off Asteasier (https://www.asteasier.com/) in July ’24, aimed to produce functional ingredients from microalgae.
His studies focus on producing high added-value molecules in microalgae and plants grown in controlled indoor systems. Nico worked at the University of California Berkeley (> 4 years), having prof. Anastasios Melis as PI. Previously, he was a Post-Doc researcher collaborating with prof. Roberto Bassi (University of Verona, Italy).

# Investigating Calvin Cycle Regulation in Chlamydomonas reinhardtii through Heterologous Expression of Cyanobacterial FBP/SBPase

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## ABSTRACT

Photosynthesis is the metabolic process that enables photosynthetic organisms to convert solar energy into biochemical energy, storing it as carbohydrates from water and $CO_2$. In recent decades, microalgae have gained attention for their potential in food, feed, energy, and raw material production. Moreover, their role as bio-factories for high-value metabolite synthesis is widely recognized. Despite their advantages over plants, the large-scale use of microalgae remains limited by high production costs and low productivity. Therefore, domestication strategies are essential to enhance biomass yield and improve their industrial viability. The Calvin-Benson cycle presents an attractive target for genetic manipulation due to multiple reported bottlenecks in plants and microalgae. One of the most promising findings is that overexpression of the cyanobacterial enzyme fructose-1,6-/sedoheptulose-1,7-bisphosphatase (FBP/SBPase) in tobacco significantly enhances growth rate and biomass accumulation. In this study, we engineered *Chlamydomonas reinhardtii* to overexpress the same enzyme, which catalyzes both the FBPase and SBPase reactions, to assess its impact on photosynthetic efficiency and biomass production. The enzymatic activity and kinetics of the chimeric FBP/SBPase were evaluated and compared to the endogenous FBPase. Additionally, growth performance was assessed under both atmospheric and $CO_2$-enriched conditions, exploring different light regimes in mixotrophic and autotrophic modes. The results revealed alterations in morphology and cell size, along with an increased accumulation of key metabolites such as proteins, lipids, and starch, particularly under $CO_2$-limiting conditions. These findings provide important insights into microalgal carbon metabolism and demonstrate promising potential for enhancing biomass accumulation, supporting future efforts in domestication and industrial applications.

**Martina Bussola**
**Second-Year phd Student; SOLE-Lab University of Verona**

Martina Bussola is a second-year PhD student at the University of Verona, working at SOLE-Lab. Her research focuses on genetic and metabolic engineering in various microalgae species to enhance photosynthesis. The goal is to improve carbon fixation efficiency and drive the production of valuable metabolites for industrial applications. By leveraging synthetic biology and metabolic modeling, her work contributes to developing more efficient and sustainable biotechnological processes using microalgae as a versatile platform for bio-based production.

# Airborne Transport and Characterization of Microalgal Bioaerosols

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## ABSTRACT

The growing demand for natural products has drawn special attention to microalgal biomass. This biomass has a rich nutritional value and is highly valued for producing bioactive compounds with multiple properties, making it useful in various industries (agriculture, food, engineering, cosmetics, etc.). Microalgal biomass is often cultivated in open ponds due to their economic feasibility. However, these systems are highly vulnerable to biological contamination, which reduces both the yield and quality of the biomass. The contamination process, particularly through airborne transport of unwanted microalgal strains or bacteria, remains largely unknown. Therefore, a complete characterization of bioaerosols near open ponds is essential to better understand this phenomenon.

In this study, bioaerosols were collected on quartz filters using a sampler located at the SABANA demonstration plant in Almeria, Spain. The low-volume sampler was located at different locations: approximately 1 m away from the paddlewheels of an 800 $m^2$ open pond, at 10, 20, 30, and 400 m away from the open pond and also inside two greenhouses, one of which housed two 3.5 $m^3$ tubular reactors equipped with 250 L bubble columns each. To assess the number of cells and the content of the filters at different locations, samples were analyzed using metagenomics and electron microscopy.

Results from this study revealed airborne transport of microalgae across different locations, with a progressive decrease in cell numbers as the distance from the source increased. Additionally, different microalgal strains were detected in the filters. These findings highlight how microalgae and other bioaerosols can travel over various distances from the original source, with the potential to contaminate open and closed ponds.

**Dr. César Marina Montes**
**University of Almería**

# Cheese-whey as an alternative growth medium for white Chlorella sorokiniana

Authors
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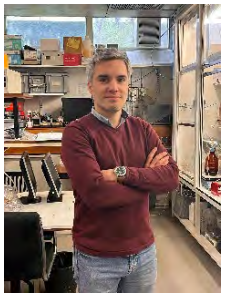
**ABSTRACT**
In recent decades, there has been growing interest in developing new microalgal production strategies capable of increasing biomass production and, consequently, its cost-effectiveness. One of the options widely implemented has been the use of a growth medium rich in organic carbon in the absence of light to promote the heterotrophic growth of microalgae. However, the main challenge for heterotrophs is the high cost and quantity of organic carbon source required (i.e. glucose). The aim of this work was to evaluate cheese-whey (CW) - a by-product of cheese-making industry rich in sugar (lactose) - as a viable alternative to grow heterotrophically the white Chlorella sorokiniana. Microalga was grown on ultrafiltered CH (u.CH), ultrafiltered CW hydrolyzed with β-galactosidase (u.b.CW), and raw CW hydrolyzed sequentially with β-galactosidase and a protease (r.b.p.CW). All experiments carried out solely with CW presented a lower biomass concentration (u.CH: 0.58±0.04 g/L; u.b.CW: 2.75±0.38 g/L; r.b.p.CW: 3.07±0.21 g/L) compared to the commercial medium (8.82±1.67 g/L), $p < 0.05$. u.b.CW was used to evaluate the relevance of different levels of macro (MB) and micronutrients (TM) supplementation, with glucose being replaced by the galactose and glucose present in the u.b.CW. Firstly, different levels of commercial macronutrient (MB) supplementation were evaluated: 100, 75, 50 and 25 % MB. The intermediate levels of MB showed the best performance in terms of growth - u.b.CW.50MB (8.03±0.60 g/L) and u.b.CW.75MB (7.63±0.24 g/L) - compared to 100MB (5.98±0.33 g/L) and 25MB (5.70±0.44 g/L), but remained lower than the commercial control (10.30±1.32 g/L; $p < 0.05$). Using the u.b.CW.75MB, different supplementation levels of TM were assessed: 75, 50, 25 and 0 % TM. u.b.CW.75MB.0TM presented the lowest biomass concentration (5.05±0.31 g/L), while the remaining conditions presented a final concentration between 9.00 and 8.53 g/L. Among them, only u.b.CW.75MB.50TM (9.00±0.60 g/L) presented non-significant differences ($p > 0.05$) against the control (9.97±0.15 g/L). In order to validate this result, this CW-based formulation was scaled-up and compared to the control medium using a 2 L fermenter. The control medium produced higher biomass concentration (11.7±2.33 g/L) than the CW-based medium (8.8±2.05 g/L); however, their differences were not statistically significant ($p > 0.05$). In addition, the nutritional value of C. sorokiniana grown in CW was improved. Protein concentration increased from 38.26±1.76 % (control) to 41.75±1.00 %. This work proved that CW can be a potential organic carbon source for microalgal production. C. sorokiniana showed successful consumption of glucose and galactose from CW, being possible to eliminate the traditional glucose supplementation, and even to reduce 25 % and 50 % of macro and micronutrients supplementation, respectively, without compromising growth performance and its biochemical composition for food applications.



**Filipe Maciel.**
**Centre of Biological Engineering (CEB) - University of Minho**

Filipe Maciel is an invited assistant researcher at the Centre of Biological Engineering (CEB) of the University of Minho (Portugal). He holds a Ph.D. in Chemical and Biological Engineering from the University of Minho, completed in 2023. His doctoral research focused on 'Microalgae production strategies to increase carotenoid and polyunsaturated fatty acid composition for food and feed applications.' He is currently working on the Blue Bioeconomy – Vertical Algas project, exploring cost-effective and sustainable approaches for the heterotrophic production of microalgae, using agro-industrial byproducts and sidestreams as alternative growth media.

# CO2-nanobubble optimization of biomass productivity in micro-algal cultivation: towards large-scale productivity

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## ABSTRACT

Amongst promising biotechnology approaches for algal-sector vertical integrations into technology for, *inter alia*, biofuels, desalination, nutraceuticals and animal/human feedstock, micro-algae cultivation is considered a particularly industrially-scalable approach. This extends into wider carbon-sequestration efforts, in a circular-economy sense, for CO2-fed micro-algae cultures. However, micro-algae cultivation *per se* is fraught with challenges limiting its commercial viability and scalability - due to, amongst other reasons, lower biomass productivity in addition to both high capital and operating costs. With this in mind, the current study demonstrates the application of $CO_2$ nanobubbles for improving microalgae-cultivation efficiency – in tackling some of these fundamental scalability and commercially-limiting "bottlenecks".

Industrial-mimicking trials of a marine micro-algal consortium via saline-water nano-carbonation were performed in miniature raceway ponds. Saline-water carbonation via nanobubble generation was compared to conventional $CO_2$-sparging methods. Several important variables were investigated, such as improvements in seawater-carbonation kinetics an extent, increases in $CO_2$-utilisation efficiency, as well as increases in biomass productivity. Algal growth was monitored over a period of 10 days by measuring $CO_2$ concentration, pH and biomass levels. Clear improvements in the biomass productivity were evident for nano-carbonation. Further, nanobubbles ensured much higher CO2 utilization compared to conventional sparging – reducing CO2-offgassing to the atmosphere. This suggests that nano-carbonation may be an inherently scalable way to increase the level of algae cultivation in a sustainable and "Circular-Economy" sense.

**Niall English**

Niall English is a chartered chemical engineer (FIChemE), inventor, professor and industrialist. He completed a Ph.D. in 2003 on electric-field effects on hydrates and gas in water. During 2004-2005, Niall carried out further hydrate research at the US DOE. During 2005 to 2007, he worked for the Chemical Computing Group in Cambridge (GB) developing molecular-simulation codes, protocols and methods for drug-design applications. Niall took up a lectureship in Chemical & Bioprocess Engineering at UCD in 2007, rising through the ranks to professor in 2017. He has founded various spin-out/ start-up companies, including BioSimulytics for crystal-structure prediction and AquaB for low-energy and membrane-free nanobubble generation (both EIC-Accelerator-supported).

# From Ocean to Innovation: Unlocking the Full Potential of Codium tomentosum

Authors
Inês Oliveira[1]; Andreína Azevedo[1]; Madalena Caria Mendes[2]; Helena Correia[1]; Daniel Pereira[1]; Catarina Coutinho[1]; Rosa Melo[1]; Margarida Martins[1];

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## ABSTRACT

ALGAplus is a Portuguese company located in Ria de Aveiro, dedicated to organic certified Atlantic seaweed and fish farming in a land-based IMTA system since 2011. All phases of seaweed production are carried out in-house: biomass production, processing and packaging. Besides, ALGAplus works with customers on tailoring the seaweed biomass to the desired characteristics and domestication of novel species.

Pioneer in Europe and with a strong focus in R&D, the upscale of high-value species, like *Codium tomentosum* is part of the company's strategy for the next years. With an interesting nutritional profile, *Codium tomentosum* is a valuable source of important phytochemīcals with antioxidant and anti-inflammatory potential, with high potential for the food, cosmetics and nutraceutical markets. Within the scope of the national project Pacto da Bioeconomia Azul (02/C05-i01/2022), the company is currently optimizing its internal cultivation protocols for this species regarding strain selection, in the nursery. The outcome of this work will provide the company with high yielding and stress tolerant strains, resistant to adverse biotic and abiotic factors and increased content of high value compounds. In this presentation data on strain selection, relative growth rates, and yields will be shown. In parallel, new seaweed-based products are being tested in the frame of the European project I3-4-Seaweed (Grant Agreement No 101161142), to develop new cosmetics with this promissory species. ALGAplus expects to be a reference in the EU for this species, providing the European markets with sustainably farmed organic certified *Codium tomentosum* biomass.

## ACKNOWLEDGMENTS

This work was financially supported by I3-4-Seaweed is co-funded by the European Union through the Interregional Innovation Investments Instrument (I3) under call: I3-2023-INV1 and by "Pacto da Bioeconomia azul" (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line "Agendas for Business Innovation" through the funding scheme C5 - Capitalization and Business Innovation.

**Inês Oliveira**

Inês holds a MSc in Marine Sciences – Marine Resources from the University of Porto. Her Master thesis consisted of the cultivation optimization of conchocelis of *Porphyra umbilicalis*. In 2021, she officially joined the ALGAplus team as a maternity technician, focusing on seaweed cultivation, strain improvement and domestication of novel species, with participation in several R&D projects. Currently as innovation technician, Inês carries out work for R&D projects, primarily working for the Vertical Algae, Seamark and I3-4-Seaweed collaborative projects. Currently, she counts on several communications at international conferences and events, and participation in the development of relevant papers on the field.

# Advancing Sustainable Cultivation of Atlantic Nori: Strain Selection for Enhanced Growth and Quality

Authors

Madalena Caria Mendes[1]; Helena Abreu[2]; Andreína Azevedo[3]; Joana Batista[4]; Tiago Conde[4]; Ana Catarina Coutinho[3]; Maria Rosário Domingues[4]; Diana Lopes[4]; Margarida Martins[3]; Rosa Melo[3]; Tânia Melo[4]; Ana Moreira[4]; Inês Oliveira[3]; Daniel Pereira[3]; Marisa Pinho[4]; Ricardo Pinto[5]; Hugo Pereira[1];

Institutions
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## ABSTRACT

Nori species (*Pyropia* and *Porphyra* spp.) are the most valuable and nutritious marine algae crops with applications in the food, nutraceutical, and cosmetic industries, given their associated health benefits. ALGAplus SA. is a pioneer company in the production of organic certified seaweeds within a land-based integrated multitrophic aquaculture (IMTA) system. The company produces year-round Atlantic Nori *(P. umbilicalis* and *P. dioica*), both conchocelis (sporophyte) and blades (gametophyte), by manipulating the life cycle in the nursery. The selection of high-performing strains is imperative to improve Atlantic Nori farming, given the demand for predictable, quality-consistent, high-grade biomass, characterized by variations across different environments and mainly influenced by their genetic make-up. This study aimed to determine the variation in growth and biochemical composition of genetically diverse Atlantic Nori strains, in their gametophyte stage. The strains were initially obtained from induced sporulation of mature female blades, collected from wild populations (in a 50 km radius of the farm) and the resulting conchocelis were deposited in the biobank. Five strains ($n$=3) were selected for screening, having triggered conchospore release from their vegetative propagating conchocelis. The resulting juvenile blades (~8 weeks old) were isolated, homogenized by means of a sieve, and cultivated under standardized conditions, using an organic certified culture media. To evaluate the growth performance, blade length and maximum width were assessed from two-dimensional (2D) imaging (software FIJI) and the wet weight registered to determine the Relative Growth Rate (%. day$^{-1}$) and Yield (g.l.cycle$^{-1}$). Collected data showed significant differences in growth ($p$ <0.05), with three strains standing out as promising candidates for high-yielding production, with RGR as high as 12.7±2.4 %. day$^{-1}$. The lipid content of freeze-dried biomass, extracted with a modified Bligh & Dyer method, was quantified gravimetrically, and the profile of esterified fatty acids was determined by GC-MS analysis. Preliminary results suggest that there are variations in the lipid content between strains. This study highlights the importance of strain selection in optimizing the cultivation of Atlantic Nori within a sustainable, land-based IMTA system. By identifying high-performing strains with superior growth rates and valuable biochemical properties, ALGAplus is paving the way for a more predictable and high-quality production of organic-certified Atlantic Nori, meeting the market demands. Acknowledgements: This work was financially supported by “Pacto da Bioeconomia azul” (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line “Agendas for Business Innovation” through the funding scheme C5 - Capitalization and Business Innovation.

**Madalena Caria Mendes**

Madalena is a phycologist at GreenCoLab, associated to ALGAplus, with a focus on seaweed cultivation, strain selection, domestication of novel species and biobanking. She holds a BSc in Biology, from the University of Lisbon, and a Msc in Aquaculture, from the University of Algarve. Madalena has been working with algae for over a decade, having gained experience in breeding and cultivation techniques, as well as the extraction and characterization of bioactive compounds. Currently, she is pursuing a PhD at the University of Aveiro, within the Lipidomics Lab. Her research is dedicated to the characterization and improvement of farmed Atlantic Nori.

# From sea to land: A way to produce macroalgae in terrestrial areas and the use as biostimulants

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## ABSTRACT

Macroalgae have become increasingly popular over the years due to their ability to produce valuable compounds, their protein-rich composition, and their use as biofilters. The utilisation of land-based systems for algae production has been employed for decades for microalgae production due to the fact that it enables the control of multiple cultivation parameters that facilitate the attainment of a higher quality and more stable biomass throughout the year, thus meeting the standards demanded by the market.

Biostimulants has been used for many decades in the food industry, exhibiting a consistent and gradual increase in adoption, this can be attributed to the economic, social and environmental viability of biostimulants. The utilization of macroalgae as biostimulants in coastal zone culture can be observed throughout history.

The present study focuses on the optimization of various critical parameters for the outdoor cultivation of the cosmopolitan green macroalga Ulva compressa, with the objective of attaining yields comparable to those of microalgae in raceway cultures (30 g DW m2 day-1) without water exchange. Furthermore, the study explores the potential of this biomass as a biostimulant, investigating its application through heat treatment at three temperatures (45, 70 and 100°C).

The data obtained shows that using the optimal parameters of: Harvesting rate, Paddle wheel speed and Culture water height, an increase of 81.1% in Ulva productivity can be achieved when optimal parameters are applied, obtaining a productivity of 29.76 gr DW m2 day-1.

This biomass was then subjected to a freeze-drying and milling process, this powder was utilized for the different treatments, with concentrations of 0.1, 0.5 and 2 g/L, in conjunction with an ultrasound breaking process. Additionally, 100 g/L of powder was subjected to heating for a duration of 1.5 hours at three distinct temperatures: 45, 70 and 100°C to break and dissolve the inner compounds. These extracts, designated as UL45, UL70 and UL100, were diluted to five concentrations (0.1, 0.5, 1, 2, 5%) for the biostimulant tests. It is evident from the results of these bioassays that there is variability in the effects of the different heat treatments, as well as in the dilutions that were tested. Acknowledgments/ Funding: Sustainable and competitive cultivation of native algae associated with desalination brine discharges for the enhancement of the natural environment. Valorisation of the final product in the food industry (ALGASAL+)

**Victor Robles**

Victor Robles is a biologist from the University of Malaga, with a Master's degree in Advanced Biotechnology from the same university. He is currently working on his doctoral thesis on the use and cultivation of macro and microalgae for the agricultural and fish farming industries. He has focused mainly on the cultivation and use of Ulva macroalgae due to its multiple uses and the possibility of year-round production in the Mediterranean area.

# Adaptive Changes in the Fatty Acid Profile of Ulva spp. in Response to Iron and Copper Short-term Exposure

Authors
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## ABSTRACT

*Ulva* spp., a green macroalga, is widely recognized for its versatility in biotechnological applications due to its richness in bioactive compounds, including essential fatty acids. These molecules play crucial roles in human health, aquaculture and various industrial processes, making *Ulva* spp. a promising candidate for sustainable resource exploitation. Moreover, the algae's physiological adaptability to environmental stress factors, such as exposure to an excess of mineral elements, offers a unique opportunity to investigate metabolic shifts that could improve its biochemical and nutritional profile. This study aimed to assess the effects of short-term exposure to two acute concentrations of iron and copper (1,7mM and 3,4mM) on the fatty acid profile of *Ulva* spp., focusing on the potential for induced variations in lipid composition. Samples of *Ulva* spp. were collected from the west coast of Portugal (Peniche), thoroughly cleaned, and maintained in a temperature-controlled room at 20 ± 1°C, with a 14 h light photoperiod. Each assay lasted 24 h and included a control group (artificial seawater) and two exposure concentrations of the element. Samples from each group were collected at 0, 0.5, 1, 2, 5, 12, and 24 h. The fatty acid profile of the treated samples was analysed using gas chromatography coupled with flame ionization detector (GC-FID), enabling the identification of both saturated fatty acids (SFAs) and unsaturated fatty acids, including monosaturated (MUFAs) and polyunsaturated fatty acids (PUFAs). The results showed that exposure to iron and copper induced some changes in the fatty acid profile of *Ulva* spp.. Saturated fatty acids (SFA) showed a definite pattern with exposure to iron, which was not the case with exposure to copper. When exposed to iron, there was a tendency for SFA values to be higher. Polyunsaturated fatty acids (PUFAs), particularly omega-3 and omega-6, tend to decrease in samples exposed to Fe and increase in those exposed to Cu. Both results may be related to oxidative stress responses: on the one hand, the reduction of these molecules suggests they may be oxidized to support cellular protection; on the other hand, their excessive production could serve as an antioxidant response. Monounsaturated fatty acids (MUFAs) show no apparent pattern over time. These results emphasise the sensitivity of the lipid metabolism of *Ulva* spp. to stress induced by mineral elements, revealing their ability to adapt their fatty acid composition in response to abiotic stress. These findings highlight the potential to modulate the lipid composition of *Ulva* spp. through controlled environmental conditions. By targeting specific metabolic pathways, it may be possible to optimize fatty acid production for various biotechnological applications.

**Catarina Duarte Freire**

Catarina D. Freire holds a master's in biotechnology of marine resources and a BSc in Marine Biology and Biotechnology.Her research focuses on marine biology, with an emphasis on applying marine resources to food products. She has developed pasta enriched with algae and marine proteins, conducting sensory analysis and consumer studies. Currently, she is involved in innovative packaging solutions, exploring ecological, sustainable, and functional materials. Catarina is driven by a deep interest in advancing marine biotechnology and its potential to enhance food systems and sustainability.

## SESSION | ADVANCES IN MACROALGAE PRODUCTION & R&D
## MAIN AUDITORIUM

# Advancing Macro- and Microalgae Identification Through Molecular Tools

Authors
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**ABSTRACT**
Accurate species identification is essential for biodiversity research, aquaculture, and biobank management. S2AQUA offers a molecular identification service specializing in macro- and microalgae, using a workflow based on automated DNA extraction, polymerase chain reaction (PCR), sequencing, and phylogenetic analysis. This approach enables precise species determination, addressing the lack of traditional morphological expertise, which can be time-consuming to gain and apply. This efficient method is particularly beneficial for biobanks, research institutions, aquaculture facilities, and algae related industry, where accurate species identification is crucial for numerous applications, including use for food, feed, and pharmaceuticals. Once the sample is received in S2AQUA's labs, the genomic DNA is extracted by an automated system, quantified and using species-specific primers, PCR is performed by amplifying targets key genetic markers, for instance the ITS1 for *Ulva sp.* and *Laminaria ochroleuca* or *cox1* for *Gracilaria gracilis*. These genes are highly conserved between species yet variable enough for precise specie identification. The amplified DNA is then sent for sequencing, and the sequence is compared against reference databases for phylogenetic analysis and accurate taxonomic classification. So far, species from Chlorophyta, Rhodophyta, and Heterokontophyta phyla, including *Ulva ohnoi*, *Ulva mutabilis*, *Codium fragile, Codium tomentosum, Codium decorticatum*, *Chondrus crispus*, *Gracilaria gracilis, Laminaria ochroleuca*, *Saccharina latissima*, *Saccorhiza polyschides*, *Dunaliella salina*, and *Nannochloropsis oceanica*, have been successfully identified. These results demonstrate the effectiveness and reliability of the applied molecular identification methodology. All these analyses can be tailor-made upon request.
A key advantage of this analysis that was established in S2AQUA is the convenience that it offers, where the samples can be stored and sent at room temperature, eliminating the need for specialized preservation methods during transport. This facilitates the collection and submission process, making molecular identification more accessible and cost-effective. The molecular identification workflow used by S2AQUA is a reliable, rapid and efficient method for classifying macro- and microalgae. The successful identification of multiple species demonstrates its effectiveness for use in different sectors and enhances species traceability. Ultimately, it supports resource optimization and strengthens scientific and industrial applications requiring precise species classification.
Acknowledgments: This study was funded by Interface Mission, project (operation code 01/C05-i02/2022.P148) and the WP9- Portuguese Blue Biobank under the Blue Economy Pact (Project Nº. C644915664-00000026), both co-funded by PRR - Plano de Recuperação e Resiliência by the European Union.

**Dr. Iris A.L. Silva**

Iris is a biomedical scientist specialized in genetics with a PhD since 2015. She is currently a senior researcher at S2AQUA leading the Molecular Biology Lab. At S2AQUA, her work focuses on the development of a molecular diagnosis platform to improve diagnosis through innovative techniques, and in the development of a genetic analysis platform to analyse expression of genes related to growth, health, and animal welfare, and optimize genetic selection programs for key traits in aquaculture species. With a career distinguished by 9 national and international awards, she is now driven by her commitment to advance innovation in aquaculture research, promoting sustainability and efficiency in the sector.

## SESSION | TOWARDS ALGAE INDUSTRY AUTOMATION: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS
### MAIN AUDITORIUM

# Machine Learning Models for Estimating Nutrient Demands in Microalgae Cultivation Systems: A Classification Approach


Authors

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**ABSTRACT**

Predicting nutrient requirements in microalgae cultivation systems is essential for enhancing biomass productivity, as it directly influences growth rates, biochemical composition, and overall efficiency of the cultivation process. However, determining the optimal nutrient demands is challenging due to the complex interactions between the microalgae cultivation system and the environmental factors. Data mining (DM) and machine learning (ML) methods provide efficient tools for analyzing large-scale microalgae cultivation data, identifying patterns and relationships that traditional approaches may overlook. In the DM process, models can follow either a regression or classification approach, depending on the nature of the problem. While regression models are useful for estimating continuous variables, classification models categorize data into discrete groups, making them particularly effective for determining optimal nutrient demands. The DM process using microalgae-based data involves several stages, starting with data preprocessing to ensure the quality and reliability of the dataset. Since raw data often contains inconsistencies, such as missing values and outliers, cleaning techniques and outlier removal methods are applied to improve data integrity. Additionally, normalization is performed to standardize feature scales, ensuring that no single feature is more relevant to the model due to differences in scale. After that, data splitting and cross-validation strategies are implemented to ensure that the models are robust and reliable. Proper splitting into training and testing sets prevents overfitting, ensuring that the models can generalize well to unseen data. Cross-validation techniques, such as k-fold and stratified k-fold, allow for rigorous evaluation by testing the model accuracy across multiple iterations, ensuring that the results are not biased by any single data subset. In sequence, ML algorithms, such as random forest (RF), logistic regression (LR), artificial neural network (ANN), and support vector machine (SVM), are employed to build ML classification models that estimate nutrient requirements. The evaluation of these models is crucial, as it determines their accuracy and ability to generalize in real-world cultivation scenarios. The effectiveness of these ML classification models has been demonstrated using a dataset derived from cultivating the microalga *Dunaliella* in a flat-panel photobioreactor (FP-PBR). The results showed that the RF model presented the best evaluation metrics, displaying an accuracy of 90 % and 93 % for the train and test datasets, respectively. In summary, the DM workflow integrated with effective ML classification models can accurately predict the nutrient requirements essential for optimal *Dunaliella* growth during the carotenogenic phase, particularly for β-carotene production in an FP-PBR system.



**Geovani Rocha de Freitas**

Scientific researcher and engineer with a bachelor's degree in chemical engineering at Federal University of Ceará (UFC) and master's degree in chemical engineering at University of Campinas (UNICAMP) in Brazil. During his graduation, he took part in a student exchange program to Germany where he studied process engineering at Anhalt University. Currently pursuing a doctorate at University of Porto in the Doctoral Programme in Refining, Petrochemical and Chemical Engineering, with his doctoral thesis focused on the enhancement of microalgae cultivation systems through data mining and machine learning methods.

# Digital twin-based optimisation of Crocosphaera chwakensis cultivation for efficient Cyanoflan production

Authors
Daniela Wucsits[1]; Vanessa Lopez[2]; Lukas Gsenger[3]; Doris Ribitsch[4]; Georg Gübitz5; Rita Mota[6];
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**ABSTRACT**

As the body's largest organ, the skin demands proper care and treatment. There is a growing preference to avoid synthetic ingredients in skin care products, driven by increased awareness of their potential environmental and health risks. As a result, innovative natural polymers are being used in cosmetics and personal care products as both active and/or non-active ingredients. Cyanobacteria are prolific sources of added value biocompounds, such as extracellular polymeric substances (EPS)[1]. The marine cyanobacterium *Crocosphaera chwakensis* CCY0110 was chosen due to its ability to constantly release a complex and versatile carbohydrate polymer, named Cyanoflan[2]. With the aim of achieving consistent, efficient and cost-effective industrial production of Cyanoflan, efforts have been focused on optimising culture conditions and refining the isolation process. Initially the primary culture parameters selected for evaluation were light intensity, temperature and agitation. Growth was monitored using standard parameters, such as optical density and chlorophyll *a* content, throughout the 1-month culture periods. In addition, the total amount of carbohydrates (intra- and extracellular) and the amount of carbohydrates released into the culture media (RPS) were determined. As expected, preliminary results suggest that all the parameters tested affect the growth of *C. chwakensis* and consequently Cyanoflan production, with light intensity being the most important. The light intensity inside the reactor was modelled mechanistically and coupled to the computational fluid dynamics (CFD) software aiBAT of SimVantage to transiently track the intensity to which the cells are exposed to. The obtained parameter setpoints were integrated in modelling software to develop a digital twin of the bioreactor and associated processes aiming to improve our understanding of cyanobacterial cultivation in terms of efficiency and precision. The result of this study will pave the way for optimising the industrial-scale production of Cyanoflan, with the ultimate goal of commercialising it as a natural ingredient for the cosmetic and personal care industry.

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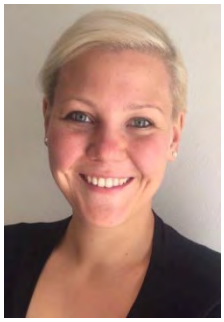
[3] Acknowledgments: This work was financed by the COMET center acib: Next Generation Bioproduction is funded by BMK, BMDW, SFG, Standortagentur Tirol, Government of Lowew Austria und Vienna Business Agency in the framework of COMET – Competence Centers for Excellent Technologies. The COMET-Funding Program is managed by the Austrian Research Promotion Agency FFG.



**Daniela Wucsits**

Daniela Wucsits is PhD student from University of Natural Resources and applied science Vienna (BOKU), employed at Austrian Centre of Industrial Biotechnology (ACIB), working on the topic "Cyanobacterial extracellular polymer and their versatility for personal care industry" together with Dr. Rita Mota. Returned to biotechnology with focus on Cyanobacteria research, after 10 years in Microbiology and Quality Assurance within the cosmetics industry, specializing in sustainability and packaging technology.

## SESSION | TOWARDS ALGAE INDUSTRY AUTOMATION: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS
### MAIN AUDITORIUM

# Evaluating the sustainability of heterotrophic alternative proteins: the Chlorella spp. case study

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**ABSTRACT**
There is a growing demand for new sustainable protein sources, and *Chlorella* spp., with its protein content exceeding 50%, appears as a potential part of the solution. *Chlorella* can be cultivated heterotrophically in fermentation vessels, eliminating the need for arable land, excessive water usage, and ideal environmental conditions. In this context, to evaluate the real environmental benefits of algae biomass production, a Life Cycle Assessment (LCA) was conducted. LCA is a standardized methodology (ISO 14040/44, 2006) used to assess the environmental impacts of a product or a process throughout its entire lifecycle. It follows four key stages: 1) Goal and Scope Definition, 2) Life Cycle Inventory, 3) Life Cycle Impact Assessment, and 4) Interpretation. The LCA was carried out using OpenLCA software with the Ecoinvent database and the EU Environmental Footprint (EF) impact assessment method, which includes metrics such as global warming potential (GWP), resource depletion, eutrophication, and others. A cradle-to-gate approach was used, with the functional unit based on protein mass. Due to the high annual productivity of *Chlorella*, the environmental impacts of the infrastructure are not significant. The LCA also highlighted considerable opportunities for improvement, particularly in the cultivation and drying operations. Sensitivity analysis suggested that utilizing renewable energy and organic carbon sources could enhance the sustainability of algae production. *Chlorella* was also compared to other protein sources. While some impacts, such as GWP, may be higher than those of traditional crops, *Chlorella* has a much lower environmental footprint in areas like land use and water depletion. This highlights the competitiveness of *Chlorella* as a protein source and the importance of considering more than just carbon emissions in sustainability assessments. Although *Chlorella* cultivation is still evolving, the LCA proved to be a valuable tool to support the optimization of the production process. Overall, the established LCA demonstrated that algae biomass is already environmentally competitive compared to other alternative protein sources and stressed its challenges and opportunities to reduce its production impacts.

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**Lais Galileu Speranza**

Lais Galileu Speranza is the Sustainability Group Leader at GreenCoLab. She holds a Ph.D. in Chemical Engineering from the University of Birmingham (UK) and graduated in Environmental and Urban Engineering and Science and Technology's Bachelor at Universidade Federal do ABC (Brazil) with a one-year exchange program at the University of Nebraska – Lincoln (US). She coordinates the team that applies the circular economy approach to promote a positive impact of algae on society and as an ecosystem service and develops the LCA and techno-economic analyses (TEA) models of microalgae and seaweed products and their production and processing facilities.

## SESSION | TOWARDS ALGAE INDUSTRY AUTOMATION: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS
### MAIN AUDITORIUM

# Energising: A Circular Economy Model Integrating Agri-Voltaics, Microalgae Production, and Agro-Industrial Synergies

Authors
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**ABSTRACT**

The global algae market is valued at $3.5 billion, with an annual growth rate of 6% (1) ) global market insight 12/2022. Despite this promising expansion, several challenges impede its full potential. In Italy, where domestic production meets only 13% of the national biomass demand (2) agronotizie 08/2022, various barriers—including complex regulations, lengthy certification processes, limited funding opportunities, and low consumer awareness—continue to hinder industry development (3) EU commission : Towards a Strong and Sustainable EU Algae Sector 11/2022

One of the primary obstacles in algae biotechnology is the underdeveloped supply chain, which limits scalability and commercialization. Ergeva aims to bridge this gap by fostering an integrated framework that connects microalgae production with sustainable value chains. This approach ensures consistent quality, enhances scalability, and facilitates broader market accessibility by strengthening collaboration among stakeholders. To support innovation, Ergeva provides a dedicated space for developing and testing novel technologies, addressing the common hurdles of inadequate infrastructure, technical expertise, and financial resources. Serving as a hub for start-ups, researchers, and industry professionals, Ergeva accelerates technological advancements and provides a robust environment for practical implementation. The involvement of an experienced engineering company further ensures that these innovations progress efficiently from concept to market-ready solutions. Additionally, Ergeva takes a comprehensive approach to overcoming financial challenges. By fostering strong connections among corporations, investment funds, and individual investors, the initiative bridges the funding gap that often limits new ventures. This collaborative model ensures that promising algae-based technologies receive the necessary support to scale effectively, fostering a sustainable and resilient innovation ecosystem. Microalgae production is central to Ergeva's mission. The project includes a pilot facility dedicated to cultivating and processing microalgae for high-value bioactive compounds. This initiative aligns with the growing demand for sustainable bioproducts in sectors such as nutraceuticals, cosmetics, and biofuels. Additionally, the integration of microalgae cultivation within the broader agro-industrial system maximizes resource efficiency, utilizing CO2 from fermentation processes and recycling nutrients from agricultural by products.

Beyond microalgae production, Ergeva encompasses several interconnected projects:

- Development of an agri-voltaic park to achieve energy self-sufficiency while optimizing land use.
- Creation of a supply chain for beer production, leveraging locally cultivated raw materials.
- Implementation of a test field for underground pipeline protection systems, focusing on cathodic protection and advanced coatings.

**Antonio Idà**

Bachelor's Degree in Biotechnology and Master's Degree in Bioinformatics, PhD in Microalgae Biotechnology. Co-founder of Arborea Ltd where he was CTO, Co-founder of Spirufarm srl, Co-founder of Algaria Srl where he has been CEO since 2016. Participates in several national and international research projects. He also serves as a board member in AISAM, the Italian microalgae association, and is a member of EABA. He holds a new position as General Manager at Ergeva. During his career he has explored different potentialities of microalgae from their production, to the creation of new commercial products and their launch on the market, creating several brands currently on the market.

## SESSION | TOWARDS ALGAE INDUSTRY AUTOMATION: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS
### MAIN AUDITORIUM

# Continuous hydrogen production under illumination by Synechocystis sp. PCC6803 using oxygen absorber

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**ABSTRACT**
As we increase our carbon emission and the carbon dioxide concentration continuously elevate, the average temperature of surface increases and leads to global warming, thus it is urgent to find alternative energy sources to resolve this problem. Sunlight is an excellent and abundant energy source, but its long-term storage and general utilization has its limitations. To resolve this issue, biohydrogen can serve as an attractive energy carrier for the future.
The cyanobacterium Synechocystis sp. PCC6803 possesses a bidirectional NiFe-hydrogenase, which is strongly sensitive on the presence of ambient oxygen, thus hydrogen evolution is possible under dark conditions in fermentative way (1). However, at the onset of photosynthesis in dark-adapted cells, hydrogenase catalyses hydrogen production during the brief anaerobic phase of growth (2). Based on these findings, we assumed that if the anaerobiosis under light condition is maintained by using artificial oxygen absorber, the hydrogen production will last longer. To test our assumption Synechocystis was grown on BG11 media supplemented with marine salt at 35 g L-1 concentration. Interrupting the growth, the culture was transferred into an illuminated and sealed, horizontally situated Roux bottle, in which bags of oxygen absorbers were placed and the oxygen and pH level were recorded in the liquid by submerged sensors. Hydrogen accumulation in the headspace was monitored in a daily basis. Besides, status of the culture was followed by photosynthesis measurements, carbohydrate, protein and pigment analysis. As a result, we observed a three-week long continuous hydrogen evolution. The average accumulated hydrogen yield was 14.23 mL g-1 dry matter. With the passage of time, the hydrogen production rate stepwise declined.

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**Gergely Ernő Lakatos**

After completing his PhD at the Biological Research Center Szeged, in Hungary, working on novel algal-bacterial biohydrogen production approaches, Dr. Gergely Ernő Lakatos continued his work at Algatech Centre, in Czech Republic. Here he was involved in projects dealing with diverse bioproducts from microalgae cultivated in pilot scale production systems. After securing a Marie Skłodowska-Curie Fellowship, he investigated the cultivation of psychrophile microalgae in outdoor thin-layer raceway pond to obtain valuable products. Presently, Dr. Lakatos is contributing to EIC Pathfinder Program aims at producing biohydrogen directly by solar energy in large scale bioreactors at National Research Council of Italy.

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# AGENDA DAY 2

2

## SESSION | ALGAE APPLICATIONS (PART I
## MAIN AUDITORIUM

# Lipidomics meets algae: A blueprint for future foods and biotechnological applications of algae lipids

Authors

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**ABSTRACT**

The growing demand for sustainable and nutritious food sources, coupled with poor consumption habits and the rising of global population, underscores the urgent need to diversify lipid sources. Omega-3 lipids, essential for human health, are predominantly derived from fish and fish oil. However, this reliance raises significant sustainability concerns due to overexploitation and environmental challenges. Identifying alternative sources of omega-3-rich lipids is critical to ensuring both ecological and the development of innovative solutions in food and biotechnology.

Algae have emerged as a promising alternative, offering abundant lipid content, minimal environmental footprint, and unique lipid composition. Rich in omega-3 polyunsaturated fatty acids (PUFA) and bioactive lipids, algae represent a sustainable source of lipids for diverse applications. Among algal lipids, polar lipids including phospholipids, glycolipids and betaine lipids, are gaining recognition for their nutritional and bioactive properties. These molecules not only serve as efficient carriers of omega-3 PUFAs but also possess intrinsic bioactive properties, such as anti-inflammatory, antioxidant, and antimicrobial activities, opening up opportunities for innovation across the food, nutraceutical, pharmaceutical, and cosmetic industries.

However, the complexity and diversity of algal lipids remain underexplored, partly because decoding the algal lipidome is a challenging task. Lipid profiles vary significantly between species, requiring advanced lipidomic techniques to unravel their intricate composition. By employing advanced lipidomic techniques, we can delve into the intricate composition of algal lipids, uncovering their diverse array of fatty acids, polar lipids, sterols, and other bioactive compounds. This approach not only underscores the role of algal lipids as nutrients and functional ingredients but also contributes to the development of novel foods and biotechnological innovations.

Moreover, lipidomics enables a deeper understanding of how various cultivation methods and environmental factors influence algal lipid profiles, informing strategies to optimize lipid content and composition to tailor premium products. By emphasizing the importance of lipidomics in unlocking the full potential of algal lipids, this work aims to inspire researchers to explore cutting-edge approaches in utilizing algae as a sustainable resource for both nutritional and biotechnological advancements.

**Prof. Maria Rosário Domingues**

**Associate Professor, Department of Chemistry - University of Aveiro**

Rosário Domingues graduated in Pharmaceutical Sciences, the University of Coimbra (1990), received her Ph.D. degree in Chemistry (1998), and Habilitation in Biochemistry (2014), the University of Aveiro. Since 2016 she held the contract of associated professor with habilitations in the Mass Spectrometry Centre, Department of Chemistry, University of Aveiro (UA). She has over 25 years of research experience in the field of mass spectrometry. She is a well-established researcher in the field of lipidomics, oxidative lipidomics, food and algae lipidomics, and glycomics. She is the leader of the Lipidomic Laboratory of the Mass Spectrometry Centre of the UA.

She has taken part in several juries for academic exams, and scientific committees for congresses, and has supervised post-doctoral, doctoral, and master's students. She is the author of a book and six book chapters and has published more than 220 articles in leading international journals.

Furthermore, Rosário Domingues is Deputy Head of the Chemistry Department and presently is the Director of the UA Doctoral Program.

# 50 shades of yellow: establishing betaxanthin pigment biosynthesis in cyanobacteria

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## ABSTRACT

Natural pigments are of increasing popularity and demand in various industries such as food and textiles. Currently, these pigments are often obtained from natural sources. To meet increasing demand, alternative sources and production systems are urgently needed.

Our research focuses on Betaxanthin pigments. These are water-soluble, yellow to orange nitrogenous pigments derived from the aromatic amino acid tyrosine. Together with reddish to violet betacyanins, they are classified as betalains. This pigment class is naturally produced in certain plants such as beet root and their biosynthesis route is well studied. Thus, various heterotrophic microbial hosts had been used to produce betalains. In *E. coli* heterologous betalains production requires the exogenous addition of amino acids and in yeast the addition of glucose is required[1,2]. However, on an industrial scale, addition of amino acids and glucose is not desirable.

In our work, we explored alternative green routes for microbial production of these pigments. We established betaxanthin biosynthesis by genetic and metabolic engineering in cyanobacteria. First, the core enzymes of the beetroot betalain biosynthesis pathway, a cytochrome P50 and DODA1 were expressed in the model cyanobacterium *Synechocystis* sp. PCC 6803. However, this did not result in any detectable amounts of betaxanthins. Further, we used metabolic engineering to increase the metabolic flux in the shikimate pathway and, thus, the availability of certain aromatic amino acids. This resulted in a betaxanthin titer of 0.1 mg/L. Through optimisation of cultivation conditions, the yield was increased 150 times to a titer of 15 mg/L betaxanthin. This is in the range of reported heterologous production in heterotrophic microbial hosts and very promising for photoautotrophic, sustainable betalain pigment production in microalgal hosts.

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**Sayali Hanamghar**

Looking back, it's amazing to see how my perspective on research has changed. As a school kid, I was always curious about biology but never imagined myself as a researcher. That changed the moment I was introduced to microbiology—I was hooked.
Studying MSc in Microbiology at the University of Pune, along with hands-on research experience, deepened my interest. That's when I knew, I wanted to pursue a PhD.

As a PhD student, I worked on "Strategies for enhancing cytochrome P450-dependent light-driven catalysis and sustainable pigment production in cyanobacteria". It has been a challenging, exciting and rewarding journey.

## SESSION | ALGAE APPLICATIONS (PART I
## MAIN AUDITORIUM

# Exploring microalgae biomass for vegan scrambled egg formulations

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**ABSTRACT**

The production of animal-based foods, including eggs, significantly contributes to environmental issues. Notably, due to increased land and resource requirements, organic and free-range egg production often has a higher environmental impact than caged systems. While eggs are valued for their nutritional benefits, they are also associated with health concerns, including high cholesterol, allergens, and the risk of foodborne illnesses from pathogens. Egg analogues are a sustainable and healthier alternative, and microalgae, with their high protein content and functional properties, offer great potential for egg analogue formulations. This study aimed to evaluate the functional properties of high-pressure-treated microalgae biomasses for developing an algae-based egg analogue replicating scrambled chicken eggs. It assessed the impact of microalgae incorporation on functional properties and colour and compared these formulations to chicken eggs and commercial egg analogues by sensory analysis. High-pressure homogenization (HPH) was applied as a treatment to disrupt microalgae cells of three different strains. Functional properties, such as water holding capacity (WHC), oil holding capacity (OHC), solubility, foaming capacity, emulsion capacity and gelling capacity, were used to assess the quality of raw and treated microalgae biomasses, besides the scrambled vegan egg formulations. The colour of the samples was evaluated using the CIELab system (L*, a*, b*). Untreated biomasses exhibited lower solubility, while the HPH treatment significantly enhanced the emulsion capacity of the two strains tested. Regarding the formulations developed, the results showed that increasing the microalgae incorporation in the formulations led to a decrease in WHC, while OHC was higher in formulations with more microalgae biomass. The emulsion capacity was not influenced by the microalgae incorporation, while solubility increased when the incorporation was more than 20%. The colour attributes of the analogues were significantly affected by the addition of microalgae. The highest scoring sample in the sensory analysis was the formulation with microalgae incorporation, having a more prominent flavour (67%) and smell (48%), while the commercial egg analogue got a higher score on texture. Overall, the results demonstrate that microalgae are a promising ingredient for developing algae-based scrambled egg alternatives that closely replicate the characteristics of chicken eggs, opening new possibilities for innovative algae-based products.

**ACKNOWLEDGMENTS**

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### Kricelle Deamici

Kricelle Deamici is the Food Nutrition Group Leader at GreenCoLab (GCL). She is Food Engineer from Federal University of Pampa (Brazil) and holds a master and PhD in Food Science and Engineer granted by Federal University of Rio Grande (Brazil), being part of her thesis PhD at Ku Leuven University (Campus Kulak Kortrijk). She was a postdoc researcher at Université Clermont Auvergne (UCA – France) and at Federal University of Bahia (Brazil), where she studied microalgae cultivation under different conditions. She has been working for 10 years on microalgal cultures, and she has experience in the bioprocess area, with an emphasis on the cultivation of microalgae, biofixation of carbon dioxide carbon by microalgae and nutritional enrichment of foods with the addition of microalgae. Currently, in GCL, she is responsible for the development of novel algae-based food products and prototypes aimed at enhancing human nutrition, using different algae and their associated compounds.

# Microalgae-Derived Bioactives for Skin Regeneration: A Multifunctional Approach to Inflammation, Microbiome Modulation, and Aging

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**ABSTRACT**

Microalgae are a rich source of bioactive compounds with applications in cosmeceuticals and therapeutics. Their biochemical diversity enables the development of natural solutions for skin regeneration, inflammation control, and microbiome modulation. This study explores the bioactivity of extracts from Tetraselmis chui, Tetraselmis striata, Haematococcus pluvialis, and Spirulina platensis, assessing their potential in dermatology.

The regenerative potential of T. striata extracts was evaluated in in vitro wound healing models using human dermal fibroblasts. Among the tested extracts, Tst_90 exhibited the most promising results, accelerating wound closure by 75% after 32 hours. This extract promoted fibroblast migration without cytotoxic effects, reinforcing its potential for formulations targeting skin repair, tissue remodeling, and post-procedure recovery. Beyond their wound-healing properties, some microalgal extracts demonstrated a combined anti-inflammatory, antioxidant, and antimicrobial effect, making them attractive for skin regeneration. H. pluvialis extracts significantly inhibited pro-inflammatory cytokines, reducing TNF-α, IL-1β, and IL-6 secretion in THP-1 monocytes while lowering ROS levels by 80% in fibroblasts. These dual effects suggest that H. pluvialis extracts could provide protection against oxidative stress and inflammation-induced skin damage. Similarly, S. platensis extracts mitigated inflammation and oxidative damage, further reinforcing their dermatological relevance. S. platensis also exhibited antimicrobial activity against Staphylococcus epidermidis and Cutibacterium acnes, key bacteria involved in skin dysbiosis. The ability to modulate the skin microbiome while reducing inflammation and oxidative stress highlights their potential for next-generation cosmeceuticals. Aging-related processes involve extracellular matrix degradation, oxidative stress, and loss of skin elasticity. Analyses of T. chui, H. pluvialis, and S. platensis extracts revealed strong anti-aging properties, particularly in elastase and tyrosinase inhibition assays. Lipid-based nanocarriers were employed to encapsulate extracts with both lipophilic and hydrophilic properties, enhancing bioavailability and stability. This approach protects active molecules from degradation and ensures controlled release, improving their efficacy in skincare formulations.

The ability of certain microalgal extracts to simultaneously promote wound healing, reduce inflammation, counteract oxidative stress, and modulate the skin microbiome makes them valuable for skin regeneration products. By integrating these bioactives into cosmeceuticals, we aim to provide sustainable, multifunctional dermatological solutions.This research was supported by the Vertical Algae project, Subproject 3, funded by the Blue Bioeconomy Pact through the Recovery and Resilience Plan (PRR).

# Cyanoflan: the innovative polymeric ingredient for the cosmetic industry

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**ABSTRACT**
Synthetic petrochemical-based compounds have become increasingly unwelcomed in cosmetics due to public awareness of their long-term health problems, creating great pressure for industry to shift to natural, safer and environmentally friendly ingredients. In particular, the cosmeceutical and biopharmaceutical industry has been actively seeking for natural ingredients that can contribute to the quality, performance, value, and lifespan of formulations, while promoting a sustainable and eco-friendly economy. In this context, microalgae are prolific sources of added-value biocompounds.
Cyanoflan is a unique extracellular polysaccharidic polymer naturally secreted by a marine unicellular cyanobacterium, requiring minimal isolation steps [1]. Therefore, the biomass surplus can be used to generate value envisaging a biorefinery approach, having the potential to be commercialized as food or feed supplement, for example, due to its high content of proteins, vitamins, and minerals, as well as the blue pigment phycocyanin [2].
Cyanoflan is a complex and versatile macromolecule that can be applied in cosmetic and pharmaceutical formulations as a rheology modifier, showing high apparent viscosity in aqueous solutions and emulsifying activity [3]. Furthermore, *in vitro* and *in vivo* results demonstrated Cyanoflan biocompatibility with human cells and bioactivity, namely antioxidant and anti-inflammatory properties, which can provide protection to the skin and promoting its regeneration [4]. Other functional and bioactive properties of Cyanoflan are being evaluated, mostly envisaging its incorporation into commodities and premium products from the cosmetics and personal care industry. Therefore, basic cosmetic formulations are being develop and their stability studied. In parallel, efforts are being made to efficiently improve the cultivation of this cyanobacterium with the ultimate aim of optimizing the production of Cyanoflan on an industrial scale.

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# Tailored Haptophytes for Aquafeeds and Efficient Industrial Production

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**ABSTRACT**
Microalgae are emerging as sustainable biofactories for high-value compounds in food, feed, and nutraceuticals. In aquaculture, they serve as functional ingredients, supplying essential fatty acids, pigments, and bioactives that enhance fish growth, health, and immunity. Haptophytes like *Pavlova gyrans* and *Tisochrysis lutea* are particularly valuable due to their rich biochemical profiles, including DHA, EPA, fucoxanthin, and immunomodulatory compounds. However, large-scale production is hindered by low productivity and environmental sensitivity. This study aimed to enhance their biochemical yields and stress tolerance through random mutagenesis and targeted screening. Mutant libraries were generated using EMS and screened under metabolic inhibitors, ammonia stress, and high temperatures to identify strains with improved resilience, lipid accumulation, and bioactivities. Selected mutants were evaluated for growth, lipid content, polyphenols, flavonoids, and antioxidant capacity (FRAP, DPPH). Growth trials confirmed that mutant strains maintained similar productivity to wild-type (WT). While total lipid content showed no significant increase, biochemical profiling revealed notable enhancements in functional metabolites. Mutant strain M26 exhibited an 80% increase in flavonoids and a 53% boost in antioxidant capacity ($p < 0.05$), while M38 showed reduced flavonoids. Ex-vivo screening of *P. gyrans* biomass revealed that M26 upregulated key antioxidant response genes, including *NRF2*, aligning with its elevated bioactivity. These findings highlight mutagenesis as a viable tool for enhancing the functional properties of haptophytes in aquafeeds, with improved strains like M26 offering immunomodulatory and antioxidant benefits to support fish health and aquaculture sustainability.

ACKNOWLEDGEMENTS
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**BIO:**

**Daniel Figueiredo**

Daniel Figueiredo is a PhD student at GreenCoLab, focusing on microalgal biomass for aquaculture. He holds an MSc in Biotechnology from the University of Lisbon and a BSc from the University of Minho. He completed his MSc internship at Wageningen University, specialising in microalgae physiology and molecular biology. His interests span microalgae physiology, strain improvement, wastewater treatment, and downstream processing. Currently, he is developing improved *Tisochrysis* and *Pavlova* strains with faster growth, higher PUFA content, and improved abiotic stress resilience for sustainable aquafeed applications.

## SESSION | ALGAE APPLICATIONS (PART I
## MAIN AUDITORIUM

# From Sea to Fork: Merging Algae and Vegetables for Next-Generation Meals

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**ABSTRACT**

The global food industry faces the urgent challenge of feeding a growing population while reducing its environmental footprint through sustainable practices [1]. Adopting the use of algae into food production plays a key role in advancing these practices and promoting a more efficient blue bioeconomy. This work is part of the Sea2Fork project, which aims to develop pre-prepared meals and ready-to-eat foods by combining algae with vegetable raw materials. This initiative focuses on exploring new industrial approaches based on these solutions, representing a significant innovation for SUMOL+COMPAL. It seeks to create nutritionally balanced products with unique sensory qualities, while fostering a transformative shift in consumer culinary preferences. Incorporating macro and microalgae into food products is essential, mainly because of their diverse chemical compositions and health benefits. Achieving this goal requires developing formulations that not only deliver nutritional values but also offer great taste and strong gastronomic appeal [2,3].This study explores the development of algae-enriched food products, from prototype formulation to industrial-scale feasibility. A variety of products, including hummus made from different pulses, tomato pulps, vegetable soups, and risotto with beans, were developed by incorporating dried macroalgae and spray-dried microalgae. The prototypes exhibiting optimal characteristics were evaluated as innovative food solutions, with a focus on attributes such as texture, rheological behavior (viscosity and thixotropy), color, nutritional composition, antioxidant capacity, *in vitro* digestibility and the relation between the volatile organic compounds and sensory appeal. These products were then compared to conventional ones without algae, assessing their functionality, gastronomic potential, and suitability for convenient, on-the-go consumption.

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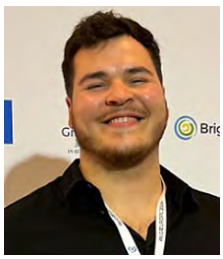

**José Matheus**

With a Master’s in Gastronomic Sciences (2022) from Universidade Nova de Lisboa (Portugal) and a Higher Education Diploma in Gastronomy (2017) from Universidade Potiguar (Brazil), he has a strong background in culinary practice and experience across various food service sectors. Currently, he is a researcher at the LEAF research center, Instituto Superior de Agronomia, University of Lisbon, focusing on developing novel food products incorporating seaweeds, microalgae, and vegetable raw materials. His research interests also include food perception, food rheology, and sustainable alternatives for creating resilient food systems for present and future generations.

## SESSION | BIOREFINERY
## MAIN AUDITORIUM

# Adaptation of the microalga Scenedesmus almeriensis to seawater: Effect on morphological and phsycochemical attributes

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**ABSTRACT**

The search for sustainable alternatives in microalgae production is crucial to reduce dependence on freshwater and improve the economic viability of these systems. This study investigated, for the first time, the adaptability of *Scenedesmus almeriensis*, a freshwater microalga, to saline conditions. The effect of salinity on growth, morphology and biochemical composition was investigated.

Overall, the incorporation of low concentrations of seawater (up to 103 mM NaCl) increased the biomass productivity from 0.15 to 0.22 $g \cdot L^{-1} \cdot day^{-1}$ and the maximum specific growth rate from 0.14 to 0.26 $day^{-1}$, favoured by the availability of micronutrients and adaptive responses to stress. Despite a reduction in productivity when the biomass was produced using only seawater (0.11 $g \cdot L^{-1} \cdot day^{-1}$), the cells managed to maintain a stable growth (0.15 $day^{-1}$). Microscopic observations revealed that the cells showed a 150% increase in cell perimeter and increased roundness (61.5% in freshwater versus 95.8% in seawater). Metagenomic analyses revealed that the use of seawater also limited the growth of other microorganisms in the medium In addition, seawater promoted the synthesis of commercially valuable polyunsaturated fatty acids but significantly reduced the protein content, which continued to be relatively high (~40%). These results demonstrate that seawater is a viable and cost-effective alternative for *Scenedesmus almeriensis* production, optimising the use of water resources without compromising biomass quality. Its large-scale implementation could transform the microalgae industry, providing a sustainable solution for biomass production with applications in food, agriculture and biotechnology.

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### Tomas Lafarga

MSc in Industrial Computer Sciences, MSc in Chemical Engineering, specialisation in Biotechnology and Food Science, by the University of Almeria and PhD in Agriculture and Food Science at University College Dublin. Tomás is a Ramon y Cajal Researcher at the Department of Chemical Engineering of the University of Almeria and the responsible of the *Desalination and Photosynthesis* Functional Unit at the Solar Energy Research Centre (CIESOL). He leads research lines on (i) reutilization and revalorisation of food processing co-products, (ii) the production and characterisation of proteins and biologically active compounds from microalgae, and (iii) the development of microalgae-based processes for different industries. He is a member of the Executive Committee of ISAP and a member of other international networks including PARAQUA, SOLABIAA, RITAL, and RENUWAL. He is also a member of the Editorial Board of International Journal of Food Science and Technology, Phycology, Frontiers in Food Science and Technology, and Revista Latinoamericana de Biotecnología Ambiental y Algal (RELABIAA). He edited 3 books and co-authored over 100 scientific publications on various aspects of food and chemical engineering and more than 80 contributions to national and international conferences. Since 2018 he has been named on the Worlds' Top 2% Scientists List of Stanford University.

# Unlocking the potential of algae with the ALGAEREFINE platform for sustainable biorefinery ingredients

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## ABSTRACT

As the demand for sustainable solutions grows, algae-based biorefineries are emerging as a key strategy for developing high-value ingredients with applications in food, pharmaceuticals, and cosmetics. Algae's versatility, resource efficiency, and potential to replace conventional raw materials make them an attractive feedstock for biotechnological innovation. However, unlocking their full potential requires the development of scalable and sustainable biorefinery processes that maximise biomass valorisation while ensuring economic and environmental feasibility. The ALGAEREFINE platform is dedicated to advancing green biorefinery processes that enhance the sustainability of the algae sector. Through well-defined processing pipelines and standardised methodologies, the platform has successfully developed a portfolio of over 45 ingredients derived from both microalgae and macroalgae. These ingredients, refined using optimised extraction and fractionation strategies, are designed to meet the specific needs of different biotechnological applications. Here we highlighted the most advanced algae-based ingredients developed by the ALGAEREFINE platform (namely, phycoerythrin-, phycocyanin-, exopolyssacharides-, protein-rich extracts, as well as hydrolysates) focusing on their properties, potential applications, and readiness for market integration. Additionally, LCA and TEA are being applied to evaluate the sustainability and cost-effectiveness of these ingredients, ensuring their feasibility for industrial adoption. By bridging the gap between research and industry, ALGAEREFINE is contributing to the broader transition towards more sustainable biorefineries. The continued development of algae-based ingredients represents a significant step towards reducing dependence on fossil-based resources and minimising environmental impact. Collaboration with stakeholders will further drive innovation, enabling the algae sector to expand its role in the bioeconomy. This platform is a significant step forward in the algae industry, expanding the know-how and applicability of algae-based biorefinery ingredients.

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**Mariam Kholany**

Mariam Kholany leads the Biorefinery working group at GreenCoLab, specialising in the development of advanced biorefinery technologies. She holds a PhD in Chemical Engineering from the University of Aveiro (Portugal), where she focused on sustainable, integrated biorefinery processes to enhance resource efficiency and waste valorisation using marine biomass. Mariam also earned her BSc in Biotechnology and MSc in Industrial and Environmental Biotechnology from the same university. At GreenCoLab, she works to optimise sustainable production and valorisation strategies. With a strong foundation in marine biorefinery, she is committed to driving innovation and promoting sustainability within the field.

# Comparative analysis of protein content and antioxidant capacity in microalgae biomasses extracts obtained by acid and alkali enzymatic-assisted extraction

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**ABSTRACT**
Microalgae are a promising industrial source for sustainably producing valuable compounds, including high-quality proteins with applications in food, cosmetics, and pharmaceuticals. However, their rigid cell walls present a major challenge to efficient protein extraction. This work intends to develop a practical methodology for cell disruption of *Spirulina platensis*, *Tisochrysis lutea*, and *Chlorococcum sp*. to enhance the extraction of intracellular water-soluble proteins by using a combination of chemical, thermal, and enzymatic hydrolysis methods. The highest protein extractability was obtained for *Spirulina platensis* (62% on a dry weight basis (dw)) through enzyme-assisted extraction at 50 °C with citric acid (0.1 M) and cellulase (5% w/w; 3 h) followed by alcalase (5% w/w; 2 h) analyzed by Kjeldahl method. In comparison to non-enzymatic extraction (29.3% dw), the combination of these parameters significantly increased the protein content as well as the antioxidant capacity (ABTS) with 175.9 µmol Trolox Equivalents (TE)/g dw. On the other hand, by using alkali (NaOH 0.1 M) extraction combining cellulase (5% w/w; 3 h) followed by alcalase (5% w/w; 2 h) under 50 °C on *Chlorococcum sp*. and *Tisochrysis lutea* resulted in a value of protein extractability of 45.6% and 39.1% dw, respectively. ABTS capacity was 150 µmol TE/g dw and 119 µmol TE/g dw, respectively. These findings further validate microalgae as a viable source of high-quality proteins. Optimizing extraction methods can enhance protein yield and bioactivity, strengthening their potential applications in the food, cosmetics, and pharmaceutical industries.

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## SESSION | BIOREFINERY
## MAIN AUDITORIUM

# Enhancing Bioaccessibility of Chlorella Proteins Through Physical Processing Techniques

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**ABSTRACT**

Microalgae, particularly *Chlorella*, have gained significant attention as a sustainable protein source due to their high nutritional value and potential role in food and feed applications. However, the bioaccessibility of *Chlorella* proteins remains a critical limitation, largely due to the robust cell wall structure that impairs protein release and digestion. This study explores the impact of various physical processing methods—including freeze-thaw cycles, ultrasound treatment, and temperature treatment —on improving protein bioaccessibility in *Chlorella*.

Our experimental approach involved subjecting *Chlorella* biomass to controlled freeze-thaw cycles, ultrasonic disruption, and heat treatments, either individually or in combination. The protein bioaccessibility was assessed using in vitro digestion models, simulating gastrointestinal conditions. The results demonstrated a significant enhancement in protein availability, with certain processing conditions achieving up to a 100% improvement in bioaccessibility compared to untreated biomass. Among the tested methods, synergistic effects were observed when combining freeze-thawing with ultrasound or moderate heat treatment, indicating a potential strategy for optimizing *Chlorella* protein utilization in food applications.

This study highlights the effectiveness of physical processing techniques in overcoming structural barriers to *Chlorella* protein bioavailability. These findings pave the way for innovative approaches in algae-based food formulation, contributing to the broader adoption of microalgae as a functional and sustainable protein source. Further investigations into processing parameters and their influence on protein digestibility will support the development of tailored solutions for food and nutraceutical applications.

**Maria Silva**

Maria Silva holds a degree in Nutritional Sciences from the University of Porto and a MSc in Food Science and Technology from the University of Minho. She is currently pursuing a PhD in Food Science, Technology, and Nutrition through a consortium between the University of Minho, the University of Aveiro, and the Catholic University. Her doctoral research focuses on strategies to harness the potential of microalgae as a protein source. Specifically, she is working with *Chlorella vulgaris*, optimizing its protein fraction and bioaccessibility. Her work aims to contribute to sustainable and innovative protein alternatives in the food industry.

## SESSION | BIOREFINERY
## MAIN AUDITORIUM

# Sustainable Valorization of Residual Spirulina platensis Biomass: Solid-State Fermentation for the obtention of bioactive components and enhanced protein content

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## ABSTRACT
Introduction: Nowadays, blue biotechnology has recognized microalgae biomasses as novel and attractive sources for bioactive compounds recovery (polyphenols, protein, pigments, among others). Despite their significant scientific and industrial potential, the substantial generation of residual biomass remains a challenge. However, these residues still possess considerable nutritional and bioactive value, making them suitable to be used as starting material under sustainable bioprocessing technologies for novel molecules developments. Thus, the objective of the present study was the elucidation of *Spirulina platensis* by-products as a novel substrate to develop a solid-state fermentation bioprocess to recover bioactive fractions using a GRAS microorganism (*Aspergillus oryzae*). Methodology: The study englobed the substrate evaluation (pH, water absorption index, radial growth, critical point of humidity); and the developed of Solid fermentation process (120 h) with protein (Kjeldahl and Bradford assay) and reducing sugar (DNS assay) quantification; antioxidant activity; enzymatic activity (Cellulase and protease); and the FPLC-profile [1]. Results: The results have elucidated the potential of *S. platensis* by-product as a remarkable substrate according to the pH values (pH 5.8); and the radial growth (0.325 ± 0.0 cm/day). These findings could be explained due to biomass nutritional composition (↑Protein and carbohydrates) [2]. The recovered extracts showed a continuous increment in protein and reducing sugar contents (9.6 gEBSA/100g and 0.5 gE Glucose E/100g) and antioxidant activity (FRAP, Folin-Ciocalteu, DPPH and ORAC methods): also, the enzymatic activity showed across the process. The increment in the bioactive fraction could be the result of the fungal metabolism into the microalgae protein and the generation of bioactive peptide fraction with molecular weight between 1 to 3 kDa (FPLC-analysis). Conclusion: The *S. platensis* by-products comprise a potential substrate for SSF technology, that could be used under the new blue bioeconomy trends for the recovery of bioactive fraction with antioxidant activity. However, further studies on optimization processes are required to guarantee a successful implementation of SSF into the food value chain.

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Israel Bautista Hernández is a bright PhD student at UCP. In 2019, he was awarded as young researcher on Biotechnology and Agronomy sciences by UANL-CONAHCYT (México). During his MSc degree at UAdeC on bioprocessing solid-state fermentation process. Also, he obtained the honorable mention for his master's thesis and was awarded with the Juan Antonio de la Fuente Medal 2022. Israel has a h-index of 7 with 289 citations (Google Scholar), 10 publications and 5 book chapters, 6 conferences congress participation with a Best Presentation Award (SUMBio-2022) and actively participating in Mexican projects (CONACYT-CONAFOR: B-S-65769).

# Extraction and stabilization of mycosporine-like amino acids from red macroalgae to create pioneering natural solutions for cosmetic applications

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**ABSTRACT**
The cosmetic industry is undergoing a major transformation, shifting towards natural, eco-friendly ingredients in response to growing consumer demand for safer products and the industry's increasing focus on sustainability. Many synthetic compounds have been linked to health concerns such as skin irritation, allergic reactions, and potential toxicity, prompting greater scrutiny. As a result, natural alternatives are gaining popularity for their functional benefits and ability to promote healthier skin. Marine ecosystems, particularly algae, are emerging as valuable sources of sustainable and renewable cosmetic ingredients. Among these, mycosporine-like amino acids (MAAs) stand out as potent UVA-absorbing molecules, making them an effective natural alternative to synthetic UV filters. Additionally, R-phycoerythrin (R-PE), a vivid red pigment from algae, offers a non-toxic, eco-friendly alternative to synthetic dyes while providing antioxidant and photoprotective properties that enhance skin resilience.
The unique properties of MAAs and R-PE position them as innovative and multifunctional ingredients in cosmetics. However, advancing efficient extraction and stabilization techniques is essential to unlock their full potential and integrate them seamlessly into formulations.
In response to the urgent market demand, an international patent was submitted for a novel, streamlined process leveraging the benefits of alternative solvents—specifically aqueous eutectic mixtures—to extract and stabilize MAAs and R-PE. This innovative approach produced a final extract with improved extraction efficiency compared to conventional solvents reported in the literature. Moreover, the resulting extract demonstrated superior photo- and thermo-stability, alongside an exceptional ability to absorb a broad spectrum of UV-A, UV-B, and high-energy visible (HEV) blue light radiation, surpassing current benchmarks.
Acknowledgments: This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UIDB/50011/2020 (DOI 10.54499/UIDB/50011/2020), UIDP/50011/2020 (DOI 10.54499/UIDP/50011/2020) & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020), financed by national funds through the FCT/MCTES (PIDDAC). This study was funded by the PRR – Plano de Recuperação e Resiliência and by the NextGenerationEU funds at Universidade de Aveiro, through the scope of the Agenda for Business Innovation “Pacto da Bioeconomia Azul” (Project no. 16 with the application no. C644915664-00000026) also supporting the PhD of A. Conde. The authors would like to thank the "Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP" for the fellowship of L.M. de Souza Mesquita (2020/08421-9), and FCT for the doctoral grant of B.M.C Vaz (2022.13816.BD).

## SESSION | EMERGING LANDSCAPES IN ALGAE INDUSTRY: PRECISION FERMENTATION, CELLULAR AGRICULTURE AND UNCONVENTIONAL APPLICATIONS

### MAIN AUDITORIUM

# New Genomic techniques (NGT for sustainable non-transgenic improvement of microalgae of applied interest

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**ABSTRACT**

Genetic engineering can enhance microalgae productivity and their capacity to accumulate high-value compounds[1]. However, the genetic modification of many microalgal strains remains challenging. We have developed a new plasmid (Phyco69) that allows the expression of several genes under the control of the same promoter with high transformation efficiency and ensures high expression and stability of the transgenes; and we have developed a new codon-optimized selective gene (CRTI), that confers resistance to an herbicide, avoiding the undesirable use of antibiotics. The plasmid Phyco69, in combination with the CRTI marker gene, has enabled the successful transformation of species such as *Chlamydomonas*, *Dunaliella*, and *Chlorella,* and can be applied to genetically modify other algae and higher plant species. Although genetic engineering of microalgae has proved to be very effective, the restrictive legislation that regulates the use, release and marketing of genetically modified organisms in Europe has withdrawn its application at industrial scale so far. However, the *appearance of* new gene-editing technologies, such as CRISPR-Cas, has represented an unprecedented breakthrough in generating knock-out and knock-in mutants without the need to introduce exogenous genes. We have optimized in our lab, the use of Cas9 based ribonucleoproteins to knock out target genes in microalgae and, as a proof of concept, we have silenced the first enzyme of the carotenoid biosynthetic pathway, in the chlorophyte Chlamydomonas reinhardtii, obtaining transformants without carotenoids

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## SESSION | EMERGING LANDSCAPES IN ALGAE INDUSTRY: PRECISION FERMENTATION, CELLULAR AGRICULTURE AND UNCONVENTIONAL APPLICATIONS MAIN AUDITORIUM

# Lactobacilli consortium and Corynebacterium glutamicum cultivation in sequential bioreactors to produce Single Cell Proteins (SCP from seaweed residues

Authors

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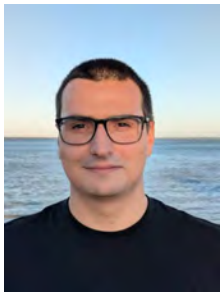
**ABSTRACT**

As global population continues to rise, the demand for sustainable food production, particularly protein sources, has become increasingly urgent. Single-cell proteins (SCP), already produced at an industrial scale, mainly for feed, offer the nutritional amino acid profiles required for human nutrition but still require sustainable media for increasing annual production. Marine residues, rich in nutritional value, remain underexplored as potential medium components. Current worldwide research addresses these challenges with diverse approaches to enhance the cost-effectiveness of these processes. Our research also aims to explore innovative methods of utilizing marine residues and bacterial fermentation towards SCP production. We explore the use of industrial residues of *Gelidium corneum* after agar extraction, as a biomass feed for fermentation due to its favourable carbohydrate and protein contents (27.3 ± 3.0 % DW and 36.0 ± 1.2 % DW, respectively). *G. corneum* biomass was enzymatically hydrolysed in a bench-scale bioreactor to release fermentable sugars. This biomass slurry was supplemented with minerals and corn steep liquor to create a rich medium for lactobacillus growth. A consortium of four lactobacillus (LAB) species was inoculated and a fed-batch fermentation was carried out. The high production of lactic acid (>50 gLA/L) was thereafter converted by *Corynebacterium glutamicum* in a sequential fed-batch bioreactor by supplying the LAB broth as the feed stream. C. *glutamicum* is known to assimilate LA as a carbon source in aerobic conditions, leading to high biomass yields, enriching the final broth with SCP. Total protein content of *C. glutamicum* lyophilized broth increased by 100% in comparison to the seaweed based lyophilized medium supplied to the first bioreactor before inoculation.

This sequential fermentation proved to be an innovative method for increasing protein production from marine derived residues by optimizing the use of metabolites. Further ongoing work is focused on studies regarding bioaccessibility of proteins, amino acid profiles and comparison of these parameters when chemical hydrolysates are used and/or single *C. glutamicum* cultures are processed.

Acknowledgements: Research is supported by the Circular Bio-based Europe Joint Undertaking and its members in the scope of project PROMISEANG (ID 101112378). Further support was provided by the Portuguese Foundation for Science and Technology (FCT) in the scope of the projects UIDB/04565/2020 and UIDP/04565/2020 of iBB and the project LA/P/0140/2020 of the associated laboratory i4HB.



**Diogo Jacinto Marques**

**Researcher, iBB-IST (Institute of Bioengineering and Biosciences – Instituto Superior Técnico) - Portugal**

Researcher with a degree in Biological Engineering at Instituto Superior Técnico, University of Lisbon (IST-Ulisboa). His research focuses on innovative biotechnological approaches for the production of alternative protein sources from marine biomass residues.
Affiliated with the Institute for Bioengineering and Biosciences (iBB), specifically within the 2BRG (Biochemical and Bioengineering Research Group). Future goals include pursuing a PhD to contribute further to the fields of bioprocess optimization and microbial production systems.

# Study of PHB production in a continuous culture of Synechocystis salina in heterotrophy

Authors
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## ABSTRACT

Polyhydroxybutyrate (PHB) is a highly versatile polymer whose properties, similar to plastic's, and biodegradability make it a promising biomaterial to replace conventional plastic. Ensuring its sustainable production is essential, and some cyanobacteria, like *Synechocystis salina,* synthesize PHB under stress conditions, such as nutrient limitation or darkness.

A common path for it is the cultivation in heterotrophy in a two-stages strategy. Firstly, cells grow autotrophically until nitrogen and phosphorus depletion. After that, cells are stressed due to nutrients starvation and they are placed in complete darkness and provided with organic carbon, so they start synthesizing PHB heterotrophically as reserve polymer. This strategy is usually performed as batch cultivation but continuous cultivation could deliver higher productivity and efficiency on resources use.

Objective: The main objective in the present work is demonstrating the feasibility of PHB production by *S. salina* in heterotrophy in continuous culture.

Materials&Methods: In this work, *S. salina* was firstly grown in a 2 L bubble colum following a batch strategy and then transferred to a stirred tank for the accumulation stage; the biomass was harvested after 21 days of accumulation. On the other hand a continuous culture strategy was followed; biomass was harvested after a steady state was reached in the stirred tank where the accumulation takes place(hydraulic residence time of 21 days). Sodium acetate 4 $g \cdot L^{-1}$ and glucose 4 $g \cdot L^{-1}$ were used as organic carbon source for accumulation stage.

Results: After 21 days of batch culture, *S. salina* reached a biomass concentration of 0.95 $g \cdot L^{-1}$ and a PHB content averaging 18.75 %(w/w), involving a PHB productivity of 7.66 $mg \cdot L^{-1} \cdot day^{-1}$. On the other hand, during steady state in continuous culture, a biomass concentration of 0.96 $g \cdot L^{-1}$ and PHB content of 24.7 % were achieved, encompassing a PHB productivity of 9.52 $mg \cdot L^{-1} \cdot day^{-1}$.

Conclusion: This work demonstrates that PHB production in a continuous culture of *S. salina* is not only more productive, but also achieves a higher PHB content in cells, reducing harvesting costs. Besides, it opens the door to continuous large-scale PHB production with cyanobacteria and involves two main advantages: 1) $CO_2$ is captured and biomass is valorized, raising the process sustainability, and 2) their requirements for growing make the use of wastewater or industrial effluents for PHB production possible, promoting thus the circular bioeconomy and the concept of "zero-waste".


**Javier Garrido Romero**

I studied the Biotechnology Bachelor's degree in Pablo de Olavide University (Sevilla). Afterwards, I started working with microalgae during an Erasmus Traineeship at the University of Hamburg. Recently, I graduated from the Industrial and Agri-food Biotechnology Master's at the University of Almería. where I recentlv started mv PhD.

## SESSION | EMERGING LANDSCAPES IN ALGAE INDUSTRY: PRECISION FERMENTATION, CELLULAR AGRICULTURE AND UNCONVENTIONAL APPLICATIONS

### MAIN AUDITORIUM

# A novel Chlorella vulgaris mutant strain allows for the efficient production of lutein and zeaxanthin, pigments required for human health


Authors

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## ABSTRACT

Lutein and zeaxanthin are two carotenoids characterized by strong antioxidant properties. They are used in various applications, such as cosmetics and animal feed. However, their primary use is in the nutraceutical and pharmaceutical sectors: lutein and zeaxanthin play an important role in eye health, reducing the incidence of conditions such as age-related macular degeneration and cataracts. Although both lutein and zeaxanthin are present in fruits and vegetables, it has been estimated that EU citizens take an average of 1-2 mg/day of lutein and 0,2-0,9 mg/day of zeaxanthin from their diet, against a recommended dose of at least 10 mg/day of lutein and 2 mg/day of zeaxanthin, thus highlighting the need for increasing their daily intake using dietary supplements. The fast-growing green alga *Chlorella vulgaris* is considered a possible alternative source of lutein: in this study, we isolated by UV mutagenesis and characterized a mutant strain of *C. vulgaris*, named *fm53*, constitutively accumulating zeaxanthin, lacking other β-β xanthophylls. Whole genome sequencing revealed a single point mutation in the 5' UTR of the zeaxanthin epoxidase gene, impairing mRNA translation. Besides an altered carotenoid composition, *fm53* mutant showed a rearranged photosynthetic complex organization and reduced Photosystem II maximum efficiency. NPQ and its fast component qE were strongly reduced in the mutant because of the constitutive quenching due to zeaxanthin. Despite these differences, biomass and carotenoid yields were comparable between the WT and *fm53* under various growth conditions. Notably, the zeaxanthin yield in *fm53* reached double the maximum value observed in the WT strain even without strong light stress. *fm53* mutant can thus be considered a promising source for lutein and zeaxanthin, representing 80% of total carotenoids produced. Moreover, this study provides new insights into the role of different xanthophylls in light harvesting and photoprotection in non-model microalgae.


**Matteo Ballottari**

Prof. Matteo Ballottari graduated in Biotechnology at the University of Verona in 2004. He is a member of several national and international scientific societies, among which the International Society of Photosynthesis Research. Moreover, he is a member of the scientific committee of AISAM, the Italian Association for the Study and Application of Microalgae, and a member of the steering committee of the Italian Society of Plant Biology (SIBV). Matteo Ballottari is involved in national and European projects financed by public and private funds to exploit photosynthetic organisms to produce biofuels and high-value products. Prof. Ballottari group (SOLE-LAB) studies plant metabolism in microalgae and higher plants, focusing on how it might be improved to produce biomass and high value products through an interdisciplinary approach ranging from omics to biophysics, biochemistry, and genetic engineering. Matteo Ballottari is the founder and CEO of the start-up ASTEASIER SRL, a company based in Italy launched in 2024 and devoted to the production of additives and ingredients for food, feed, and cosmetic applications.

# Potential antioxidant, anti-inflammatory and wound healing properties of marine microalgae extracts isolated from Moroccan coastlines

Authors

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## ABSTRACT

Marine microalgae have attracted extensive attention for their biotechnological potential, particularly in the cosmeceutical and medical fields for skin regeneration properties. They can synthesize various biologically active substances such as peptides, polysaccharides, polyunsaturated fatty acids, phycobiliproteins, and pigments, which exhibit antioxidant, antibacterial, antiviral, antitumor, neuroprotective, and immuno-stimulating effects. Chronic non-healing wounds represent an increasingly significant public health concern and a serious financial burden on healthcare systems worldwide. This study aims to investigate the potential of marine microalgae isolated from Moroccan coastlines as a source of bioactive compounds with wound healing-promoting, skin regeneration, and anti-inflammatory properties. Ethanolic extracts were obtained from four different strains: Chlorella sp., Phaeodactylum sp., and Tetraselmis sp., Isochrysis sp. using Accelerated Solvent Extraction (ASE) equipment. The in vitro biological activities of microalgae ethanolic extracts were evaluated. Antioxidant activity was determined using the DPPH radical scavenging assay. Results showed that all extracts exhibited significant antioxidant activity. The 5-lipoxygenase Inhibition activity, evaluated by colorimetric method, showed that Phaeodactylum sp. and Chlorella sp. extracts exhibited the highest inhibition of lipoxygenase, with 50 % and 48,04%, respectively, at the concentration of 25 ug/mL. Further investigations were conducted to evaluate the effect of extracts on the proliferation of human keratinocytes (HaCaT) and their potential effect on wound closure using the scratch assay. The Cell viability was determined using MTT assay. Results showed that the extract were non-cytotoxic in concentrations up to 200 µg/mL. After 48h of treatment, the extracts significantly induce wound closure, with a percentage of 76,96 ± 3,01% and 76,25 ± 3,84 % at a concentration of 10 µg/ml for Tetraselmis sp. and Isochrysis sp., respectively, compared to the untreated control cells. Chemical analysis of the extracts performed using GC-MS, revealed a diverse lipid profile rich in polyunsaturated. These findings highlighted the anti-inflammatory and wound-healing properties of marine microalgae extracts, suggesting them as potential candidates for promoting accelerated skin repair and regeneration. Keywords: Marine microalgae, 5-lipoxygenase inhibitory, HaCat cells, Scratch assay, antioxidant.

**Ghita Loubane**

Ghita Loubane is a doctoral researcher at Mohammed VI Polytechnic University (UM6P), affiliated with the Faculty of Medical Sciences (FMS) and the Moroccan Foundation for Advanced Science, Innovation and Research (MASCIR). She holds a Master's degree in Microbial Biotechnology. Her current research explores the therapeutic potential of marine microalgae, with a focus on bioactive compounds involved in skin regeneration and wound healing. Her academic interests include marine biotechnology, natural products, and biomedical applications of microalgal metabolites

## SESSION | ALGAE VERTICAL PROJECT: PART I
## MAIN AUDITORIUM

# Unveiling the diversity and algal growth promoting features of the microbiome of cultivated Atlantic Nori (Porphyra spp.) at early developmental stages

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**ABSTRACT**
Algal-microbiome interactions are considered pivotal for host health and development. Current understanding of the diversity and function of algal-associated microorganisms, particularly in aquaculture settings, remains limited, preventing the development of microbiome-based solutions for sustainable algal growth. We employed cultivation-dependent and -independent approaches to determine the structure of bacterial communities associated with aquacultured Atlantic Nori (*Porphyra dioica* and *P. umbilicalis*) at early developmental stages. Cultivation of algal bacterial symbionts on diluted (1:2) Marine Agar medium and next-generation sequencing of 16S rRNA gene fragments amplified from total-community DNA were performed for algal samples harvested from indoor photobioreactors at stages S1 (conchocelis cultures growing vegetatively), S2 (induction of conchosporangia), and S3 (vegetatively growing young blades) and their corresponding culturing water. Analysis of > 200,000 16S rRNA gene amplicons from a total of 36 algae and culture water samples revealed that the phyla *Pseudomonadota* (*Alpha-* and *Gammaproteobacteria* classes) and *Bacteroidota* were dominant in algal tissue, followed by *Planctomycetota*, *Actinobacteriota,* and *Verrucomicrobiota*. We found that these communities were highly structured throughout the host's life cycle. Several bacterial taxa such as uncultivated lineages Sva0996 (*Actinomycetota*), OM190 (*Planctomycetota*), Pir4 (*Planctomycetota*) and the genera *Blastopirellula*, *Algoriphagus*, *Hyphomonas*, and *Marinobacter*, among others, were enriched in algal samples and presented significantly different abundances across developmental stages. In some cases (e.g., genera *Aquimarina*, *Sulfitobacter*, *Maribacter,* and *Nonlabens*), those changes were influenced by the bacterial community of the culturing water. Particularly, the genera *Ensifer*, *Paraglaciecola*, and the uncultivated lineages DEV007 (*Verrucomicrobiota*) and pir4 (*Planctomycetota*) were consistently present in *P. dioica* and *P. umbilicalis* samples at multiple developmental stages. Laboratory cultivation of 134 symbionts of *P. dioica* and *P. umbilicalis* resulted in the identification of multiple bacterial genera and putative novel species, mostly belonging to the families *Roseobacteraceae*, *Flavobacteriaceae,* and *Alteromonadaceae*. This culturable consortium was found as well to shift in taxonomic composition across algal developmental stages, and to present numerous producers of the algal growth-promoting hormone auxin, most notably from the genera *Alteromonas*, *Aliivibrio,* and *Yoonia-Loktanella*. This study unveils complex, phylogenetically distinct, and temporally structured microbiomes possessing algal morphogenesis-inducing capacities during the early developmental stages of *Porphyra* species. It highlights the potential of microbiome-based interventions for sustainable growth of marine algae in aquaculture.

**Rodrigo Costa**

Rodrigo Costa holds a PhD degree in Life Sciences from the Technical University of Braunschweig (Germany) and is Associate Professor at the Department of Bioengineering of Instituto Superior Técnico, University of Lisbon. His research features > 100 publications in international scientific journals, and addresses the diversity and function of microorganisms in natural and fabricated biomes - with emphasis on Eukaryote-Prokaryote symbioses -, their implications to host/ecosystem health and climate regulation, and potential use as sources of innovative biotechnologies. Prof. Costa is the Ambassador of the International Society for Microbial Ecology (ISME) in Portugal and Senior Editor of ISME Communications.

# Development of algae-based fish analogues: traditional and non-traditional approaches

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## ABSTRACT

Algae-based foods have attracted considerable attention as a natural source of micro- and macronutrients and trace elements, thereby enhancing their nutritional value. They can grow on non-arable land and their unique sensory profile, characterized by umami flavor richness, marine-like aroma and natural salinity, renders them well-suited for emulating the taste and texture of seafood products. The Blue Bioeconomy Pact embraced the challenge of reindustrializing Portuguese food industries, by leveraging marine bioresources, such as algae, to create higher value-added products. Aligning with the growing trends of vegetarianism and health-conscious lifestyles, this work focuses on developing algae-based fish analogues, one based on a “traditional Portuguese codfish pastry” and the other on a sliced smoked salmon (CoralSea). The nutritional and functional properties of micro- and macroalgae were analyzed, leading to the selection of white *Chlorella vulgaris* and *Alaria esculenta* for use in pastry. For CoralSea, orange lentils were chosen as the base ingredient for their color and protein content, while *Palmaria palmata* powder, *Fucus vesiculosus* powder, and white *Chlorella vulgaris* powder were selected as key components. To assess consumer acceptance, a sensory analysis was conducted with a panel of 60 consumers familiar with vegetarian/vegan products. The environmental performance was performed using a comparative cradle-to-gate Life Cycle Assessment (LCA) methodology against fish products.

The analogue inspired by the “traditional Portuguese codfish pastry” received high overall acceptability. It had an appealing appearance and a natural, pleasant flavor, with enough of a sea-like taste to evoke the sensation of eating fish. Texture was the least favored aspect, as the internal consistency was described as very soft and slightly lumpy. Notably, 72% of the panelists indicated they would likely or definitely purchase the product. CoralSea had low overall acceptance, primarily due to shortcomings in flavor, odor, and visual appeal. While texture showed potential, improvements in flavor balance, aroma intensity, and visual presentation are necessary to increase consumer acceptance. The LCA showed that algae-based food analogues have a significantly lower environmental footprint, particularly in terms of greenhouse gas emissions, when compared to their animal-origin counterparts.

**Dalila da Assunção Maia Vieira**
**Sr. Researcher, Colab4Food - Collaborative Laboratory for Innovation in the Agri-Food sector - Portugal**

Dalila M. Vieira obtained a bachelor’s and a master’s degree in biomedical engineering and technology from Polytechnic Institute of Bragança, and a Ph.D. in Science and Engineering of Polymers and Composites, from the University of Minho.
Throughout their academic career, worked on numerous research topics related to microencapsulation of various polymers. She has focused her research on characterization of flow and wettability using confocal microscopy applied to biological fluids and sustainable food packaging development. Currently, she is working in Innovation & Value2Market Department at Colab4Food Association, with a role in the R&D&I and customer services.

# Decoding the Microbiome of Porphyra spp.: A Path to Enhanced Aquaculture Production

Authors
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**ABSTRACT**

*Porphyra* species are of great economic importance worldwide, with a multitude of applications, from human and animal food products to nutraceuticals and cosmetics. In aquaculture systems, the asexual reproduction of mature blades is the preferred method, still, sexual reproduction has been gaining relevance, when the conchocelis biomass is intended for nutraceuticals and cosmetic applications. In Portugal, *P. dioica* and *P. umbilicalis* are produced in a complete organic integrated multi-trophic aquaculture (IMTA) system by ALGAplus through sexual reproduction. In this study, we aim for the full microbiome characterization of both species throughout their entire life cycle, since microorganisms can greatly impact the physiology of their host. The first three production stages are cultivated indoors under control conditions: S1 - conchocelis, S2 - conchospororangia, and S3 - juvenile blades; while the remaining two stages are mature blades produced outdoors under environmental conditions in increasingly larger tanks (S4 and S5). Our goal was accomplished by performing shotgun metagenomic sequencing and assessing both unassembled metagenomic reads and metagenome-assembled genomes (MAGs). In the unassembled reads approach, our results show a decrease in bacterial diversity through the indoor stages of *P. dioica* and an increase in outdoor stages, while recording bacterial diversity stability in *P. umbilicalis* throughout its life cycle. *Pseudomonadota* are dominant through the life cycle independently of the *Porphyra* species, with indoor stages being dominated by *Pseudomonadota* (63%) and *Actinomycetota* (11%). These phyla decrease in abundance (40% and 4%, respectively) in outdoor stages, along with an increase in *Cyanobacteriota* (7% vs 25%), *Bacteroidota* (8% vs 13%), and *Bacillota* (4% vs 10%). Clearer differences arise at family level. *Roseobacteraceae* is abundant throughout the life cycle of both *Porphyra* species, mostly in S1 of *P. dioica* (15%) and in S3 (19%) and S4 (15%) of *P. umblicalis*. *Rhizobiaceae* is dominant in S2 (22%) and *Oceanospirillaceae* in S3 (69%) of *P. dioica*, while *Alteromonadaceae* is dominant in S2 (14%) and *Flavobacteriaceae* in S4 (21%) of *P. umbilicalis*. Some members of these families have been reported to possess antifouling and antimicrobial activities, to be algae growth and morphogenesis promoters, vitamin B12 producers, and to be able to degrade diverse algal polysaccharides. Reconstruction of 117 medium and high-quality MAGs showed the prevalence of *Alteromonadaceae* (22%), *Flavobacteriaceae* (20%), and *Roseobacteraceae* (19%), with 30% of unclassified MAGs at the family level, possibly representing new, undescribed bacteria. Functional analysis of the recovered MAGs is ongoing and will help to elucidate the ecological role of these families in the microbiome of *Porphyra* spp., paving the way for the development of microbiome engineering strategies to improve production in IMTA.

**André C. Pereira**

André C. Pereira holds a PhD in Microbiology by the Faculty of Sciences of University of Lisbon. He is currently working on the Blue Bioeconomic Pact project, particularly on the Algae Vertical and Blue Biobank. His work has been focusing on the microbiome of *Porphyra dioica* and *Porphyra umbilicalis*, by trying to uncover the taxonomic and functional composition of such microbiome, untangling the microbiome-*Porphyra* interactions in integrated multi-trophic aquaculture systems. Ultimately, his work will provide solutions in macroalgae production optimization by promoting algae growth and morphogenesis and by dealing with algae disease in an organic and eco-friendly manner, with a role in the R&D&I and customer services.

# InAlgae® AOX: A Sustainable high performance seaweed-based ingredient for Cosmetics

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**ABSTRACT**
InAlgae® AOX is a seaweed-based multifunctional, and sustainable ingredient developed to be a natural replacement for synthetic ingredients that are widely used in the cosmetic industry, which often have a high carbon footprint and potential health risks. Developed by the Portuguese marine biotechnology company Ínclita Seaweed Solutions, this ingredient is formulated from Fucus vesiculosus, a seaweed sustainably harvested from the North Atlantic coast. In vitro assays have demonstrated that InAlgae® AOX has outstanding antioxidant performance compared to cosmetics industry benchmarks. It has 31% higher efficacy than green tea extract and 30% better performance than ascorbic acid, both considered standards. Additionally, it provides a UVA protection factor, deep hydration, and anti-pigmentation effects similar to kojic acid. In terms of InAlgae® AOX environmental sustainability, when compared to benchmark antioxidant ingredients by a Life Cycle Assessment (LCA) analysis, the F. vesiculosus extract has proven to have 97% less environmental impact than green tea extract, and 55% less than ascorbic acid. Moreover, the production of this seaweed-based ingredient is integrated into a biorefinery system, at which the remaining biomass of its production is repurposed to obtain other co-products such as biostimulant, functional feed, or even serve as a raw material for other cross-industrial processes aligning with the principles of the circular economy. Additionally, InAlgae® AOX has international COSMOS and NATRUE certifications, validating its compliance with environmental and social standards. The innovation behind InAlgae® AOX lies in its multifunctionality, integrating antioxidant, moisturizing, anti-pigmentation, and UVA protection properties into a single ingredient. This comprehensive approach replaces multiple synthetic compounds traditionally required to achieve the same benefits, making it a high-performance and sustainable alternative. In conclusion, InAlgae® AOX stands as proof of the seaweed potential as a mark of sustainability and Innovation supporting the leverage of the Algae Industry.

**Helena Melo Amaro**

Helena Melo Amaro is a microbiologist with a PhD in Biomedical Sciences, and for the past 20 years, she has been a committed researcher in the field of blue biotechnology. Throughout her career, Helena has developed innovative methodologies in algal biotechnology, with a particular focus on algae production, extraction of bioactive compounds, and the valorization of algal compounds. Her work has spanned several renowned Portuguese research centers, covering key areas such as health, food and feed, and the environment, all with sustainability as a guiding principle.
Currently, Helena is the Research and Development Manager at Inclita Seaweeds Solutions, a company dedicated to the development and commercialization of seaweed-based ingredients.

## SESSION | ALGAE VERTICAL PROJECT: PART I
### MAIN AUDITORIUM

# Exploring sequential protein extraction from Porphyra dioica: structural and functional implications for food applications

Authors
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## ABSTRACT
Seaweeds are promising protein sources. They can help to meet the demand for protein that is arising with the rapid increase of world population, following the grow of vegetarianism and providing similar amounts of protein when compared to vegetables matrices. The use of alternative proteins will decrease the negative environmental impact that is created through the production of the traditional animal protein sources. However, the way these proteins are extracted has a major impact on how they will work if applied to food products. Moreover, the degree of denaturation and its structural characteristics will determine the existence or lack of functional properties (e.g., emulsifying and foaming).
In this work, the Osborne fractionation method was used to study the type of proteins that were present in the red seaweed *Porphyra dioica*. The seaweed was kindly provided by ALGAplus. Through sequential extraction in different solvents (i.e., dH2O, NaCl, EtOH, and NaOH), the best extraction methodology was established aiming the recovery of the maximum amount of protein from this seaweed. In this case, *Porphyra dioica* proteins demonstrated to have higher affinity to water and alkaline environments, being saline and alcoholic solutions the solvents that provided less protein content. Thus, H2O and NaOH were selected as extraction solvents and protein-rich extracts were produced using sequential extraction. Different techniques (e.g., ultrafiltration and ammonium sulfate precipitation) were used to concentrate and purify the protein rich extracts. Extracts were nutritionally characterized, and protein structure was extensively studied using several techniques (e.g., gel permeation chromatography, circular dichroism, and Mastersizer). Moreover, the presence of gelling, emulsifying, and foaming capacities were also assessed and the viscoelastic behavior of each extract determined. Results showed that the produced concentrates were made of around 15 % and 21 % (gprotein/100g extract) of protein, for H2O and NaOH extraction, respectively. Despite ultrafiltration itself did not promote a significant increase in protein content, a first step of ammonium sulfate precipitation prior to ultrafiltration lead to the presence of extracts containing around 81 % (gprotein/100g extract) and 78 % (gprotein/100g extract) of protein for H2O and NaOH extracts, respectively. Moreover, the use of purification techniques also promoted protein aggregation and denaturation that influenced functional properties. No gelation was observed in either extract but good emulsifying capacity, and emulsion stability were found, being the maximum value of 100 % achieved for purified H2O extracts that maintained the capacity in values above 70 % seven days after emulsion production. Thus, using different approaches, protein can successfully be extracted from red seaweed *Porphyra dioica* with the intention to be used in the formulation of new food products with good functional properties.

**Cristina Rocha**

Cristina Rocha is an Assistant Researcher at the Centre of Biological Engineering of the University of Minho. She got her M.Sc. (1997) in Biological Engineering and her PhD in Chemical and Biological Engineering – sub-area of Food Technology (2008) in the University of Minho. She has experience in algae-based biorefineries, green extraction technologies and chemical, physical and structural characterization of different extracts, food matrices and packaging materials. She is presently responsible for CEB's Laboratory of Clean Technologies. She was involved in several research projects (national and international) and has published 7 book chapters and 65 peer-reviewed articles in international journals.in Ínclita continues to shape sustainable innovations in this growing field.

# Exploring Cyanobacteria and Microalgae Metabolites for Biotechnological Advances in Diabetes

Authors
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## ABSTRACT

Diabetes is a metabolic disease affecting nearly 422 million people worldwide and growing. It is characterized by a state of hyperglycemia that leads to severe harm to organs and nerves causing 1.5 million deaths each year. Insulin injections are used to control diabetes though alternative solutions are still needed for the treatment and prevention of this disease. More than two thirds of our planet is covered with water and the aquatic environment remains an understudied resource with great potential for discovering new compounds with medicinal properties. Cyanobacteria and microalgae are well known for their ability to produce metabolites for biotechnological and biomedical applications. This work explored the potential of 15 cyanobacteria and microalgae species to produce compounds with applications for diabetes. Dichloromethane/methanol (DCM/MeOH) and acetone extracts were prepared from dried microalgae biomass. Transgenic zebrafish model [Tg(ins:YFP-T2A-NTR3, cryaa:mcherry)] were exposed to microalgae extracts for 24 hours at 25 ug/ml to test the recovery of insulin-producing β-cells after chemical ablation with MTZ and expression of nitroreductase in the β-cells. Results identified DCM/MeOH extracts of Scenedesmus oblíquos, Arthospira platensis, Nanochloropsis oceânica, Nanofrustulum shiloi, Phaeodactylum sp., Chlorococcum sp., which increased significant the pancreatic β-cells number compared to the MTZ ablation group. The metabolic profile of extracts was evaluated by liquid chromatography with tandem mass spectrometry (LC-MS/MS), and in silico analysis by Global Natural Product Social Molecular Networking (GNPS) to highlight putative compound families with bioactivities. The mRNA expression of glucose regulating genes was studied to get further insights into the mechanism of action of bioactive extracts. In the future, the responsible compounds from the bioactive extracts could be developed as new nutraceuticals with human health applications.

**Diogo Ferreira-Martins**

I am Diogo Ferreira-Martins, a molecular physiologist specializing in endocrinology. I hold a B.Sc. in General and Aquatic Biology and a Ph.D. in Animal Sciences from the University of Porto. During my Ph.D., I received a Fulbright Research Grant to study migratory fish physiology at USGS Conte Anadromous Fish Research Center, USA. I later conducted postdoctoral research at the University of Massachusetts, USA. Currently, I am a postdoc Interdisciplinary Centre of Marine and Environmental Research of the University of Porto, in the Biodiscovery for Health group, exploring algae and cyanobacteria applications in biotechnology and biomedical research.

## SESSION | ALGAE VERTICAL PROJECT: PART II
## MAIN AUDITORIUM

# Exploring the Bacteriome Associated with Industrially Produced Microalgae

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**ABSTRACT**
Microalgae-associated bacteria influence algal growth, metabolism, and culture stability, making them essential for optimizing large-scale cultivation. This study investigates the bacterial communities associated with the industrial production of three microalgae species: *Chlorella vulgaris*, T*isochrysis lutea*, and *Nannochloropsis oceanica*. Metagenomic amplicon sequencing (Illumina) targeting the V4 region of the 16S rRNA gene was performed using primers 515F and 806R, and a comprehensive bioinformatic pipeline was applied to characterize bacterial diversity and distribution. For this, we characterized the community from the inoculum to the harvesting, with a particular focus on the microbiome of three fractions: the supernatant (free-living bacteria), the phycosphere (closely associated bacteria), and the whole microbiome (unfractionated community) throughout the cultivation in different production systems. Comparative analysis revealed distinct microbial profiles for each species, with *C. vulgaris* enriched in Pseudomonadota and Campylobacterota, *T. lutea* exhibiting higher Bacteroidia abundance, and *N. oceanica* being associated with Cyanobacteria and Patescibacteria. *C. vulgaris*, as the only freshwater microalga analyzed, displayed the most distinct microbial community structure across all taxonomic levels. Alpha and beta diversity analyses further confirmed a strong differentiation between *Chlorella* and the other species, with microbial richness increasing over time, particularly in the supernatant fraction. Key bacterial taxa were strongly associated with the different microalgae. Additionally, bacterial isolates were obtained from these microalgal samples and characterized to assess their biotechnological potential, including growth-promoting effects and metabolite production (carotenoids, vitamin $B_{12}$, and amino acids). These findings contribute to a deeper understanding of species-specific microalgae-bacteria interactions and provide insights into optimizing microalgal cultivation through microbial consortia engineering.

**Tamára Santos**

Tamára Santos graduated in Marine Biology from the University of Algarve, where she also earned her MSc in Aquaculture. Since 2019, she has been a researcher at CCMAR/University of Algarve's Marine Biotechnology (MarBiotech) Research Group, focusing on the bioprospecting of novel microalgal strains and the bacteriome associated with microalgae production. Tamára is currently exploring innovative strategies to enhance industrial microalgal biomass production using metagenomics. She has co-authored 25 papers in international peer-reviewed journals and has presented her work in ten posters and four oral communications at international conferences.

## SESSION | ALGAE VERTICAL PROJECT: PART II
## MAIN AUDITORIUM

# Enhancing Sustainability and Efficiency in Industrial Microalgae Production: Innovations in Cooling and Harvesting at Necton

Authors
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## ABSTRACT
The industrial production of microalgae is continuously evolving to achieve greater efficiency and sustainability. However, high production costs and resource-intensive processes continue to hinder the sector's growth. As part of the Algae Vertical project, Necton has implemented two large-scale innovations focused on optimizing water and energy use.
One advancement addresses the cooling requirement of tubular photobioreactors. Traditionally, cooling at large scale relies on freshwater utilization. When temperatures exceed the critical threshold, water is sprayed or dripped on the tubes. However, where freshwater availability is frequently constrained by drought, this method is not always viable. Hence, this challenge extends beyond Necton, affecting many of the world's sunniest and most productive microalgae-growing regions. To mitigate this issue, Necton developed an innovative cooling system that integrates an industrial chiller powered by photovoltaic energy with specially designed heat exchangers. This system capitalizes on the natural correlation between high temperatures and solar availability, eliminating freshwater use and reducing dependence on grid energy. Initial results confirm that culture growth remains unaffected, ensuring the system's compatibility. However, while the system has low operational costs (OPEX), its capital expenditure (CAPEX) is relatively high, therefore its use may be limited to the production of high-value biomass. The second major innovation focuses on optimizing the biomass harvesting process. Necton integrated an 80-m² membrane filtration system into the harvesting pipeline, enabling culture pre-concentration before centrifugation. This upgrade decreased centrifugation time, leading to a 45% increase in volumetric harvesting capacity and a 31% reduction in energy consumption per harvested batch. Compared to a centrifuge with a similar CAPEX, the membrane system proved to be a more efficient and sustainable solution. However, initial trials revealed biomass losses ranging from 10% to 30%, emphasizing the need for further process optimization. Additionally, the reduced lifespan of the membranes presents an economic factor that must be carefully evaluated. Overall, these innovations reinforce Necton's commitment to pioneering sustainable microalgae production, setting new benchmarks for efficiency, resource conservation, and industrial best practices worldwide.

### Alexandre Rodrigues

Alexandre Rodrigues holds a licentiate degree in Microbiology and Genetics from the Faculty of Sciences of Lisbon University, Portugal, and a PhD degree awarded by the Faculty of Medicine of Lisbon University. His PhD studies about the *in vivo* regeneration of zebrafish and *Xenopus* tissues were developed at the Centre of Regenerative Medicine in Barcelona (CMRB), Spain. After his PhD, Alexandre worked as a research technician in histology and genetics laboratories in Barcelona, after which he moved back to Portugal to work as a post-doc at the University of Algarve.
In 2017, Alexandre started collaborating with Necton S.A. as a sales consultant. Given his scientific background, in 2019 he moved to the Innovation Department as a Project Manager, becoming responsible for the ongoing R&D projects' management, applications to new projects, and student coordination. In 2022 he was nominated Coordinator of the growing Innovation Department and in the beginning of 2023, he also became the Coordinator of Allmicroalgae's Innovation Department, after the acquisition of this company by Necton. Alexandre now leads two teams of 6 PhDs, 4 PhD students, and 2 technicians (MsCs) involved in the development of the technology, sustainability and innovative products.

# Modulation of appetite, reduction of lipids and uptake of glucose by extracts from micro- and macroalgae

Authors
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## ABSTRACT

Novel molecules to fight obesity are urgently needed, and algae are important resources for valuable compounds with human health benefits (e.g. polyunsaturated fatty acids, pigments, vitamins). The aim of this research was to screen extracts from microalgae and macroalgae in zebrafish larvae using phenotypic assays relevant for metabolic diseases (obesity and diabetes). Two different appetite assays reducing assays were performed based on fluorescent labelled liposomes and paramecia. Furthermore, the capacity of the extracts to reduce neutral lipid reservoirs was analyzed, as well as the potential to stimulate the uptake of the fluorescent glucose analogue 2-NBDG. The results revealed that 5 extracts reduced the appetite > 40% from *Chlorella vulgaris* (grown either autotrophic or heterotrophic) and from *Chlorococcum* sp. Interestingly, different extracts were found to be active in both assays. Promising extracts were submitted to metabolite profiling with LC-MS/MS to receive insights into responsible compounds, and cluster of known and unknown compounds belonging to benzenoids, lipid and lipid-like molecules (in particular glycerolipids), phenylpropanoids and polyketides were identified. Some unsaturated fatty acids (oleic acid, linoleic acid, palmitoleic acid) and nucleosides (adenosine, methylthioadenosine) were selected from those clusters, and confirmed their appetite reducing activity as pure compounds in concentrations at 5 – 20 µM. The analysis of mRNA expression of appetite regulating genes demonstrated that the extract from autotrophic *Chlorella* increased pomc and cartp mRNA, both involved in the anorexigenic, neuroendocrine signaling of appetite. Aqueous extracts from *Tetraselmis chuii* stimulated glucose uptake at 40%, and lipidic extracts of both *Pavlova gyrans* and of *Phaeodactylum triocornutum* reduced lipid level at 50%. Furthermore, the macroalgae *Porphyra dioica* reduced neutral lipids in zebrafish at 40%, while *Codium tomentosum* increased the glucose uptake at 50%. In summary, promising activity was observed for microalgae and macroalgae extracts, which could lay the ground for the future development of nutraceuticals for the treatment of obesity and diabetes.

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**Ralph Urbatzka**

Ralph Urbatzka is a principal researcher at CIIMAR, and team leader of "Biodiscovery for Health". He graduated in Biology in 2002 in Cologne, Germany and received his PhD in 2007 in Molecular Biology from the Humboldt-University Berlin, Germany. His current research interests focus on the bioactivity screening and elucidation of molecular mechanism of natural products from aquatic ecosystems, in particular for metabolic diseases.

## SESSION | ALGAE VERTICAL PROJECT: PART II
## MAIN AUDITORIUM

# Public Perception of Algae in Portugal: Insights from a National Survey

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**ABSTRACT**

The production of microalgae biomass and derived products is a hot topic, with an increasing number of production facilities being built and several products being launched into the market every year. However, little is known about the perception that consumers have about these products. Understanding public perception of algae is essential to identifying knowledge gaps, improving consumer awareness, and guiding strategies for market development and sustainability initiatives. In this context, a total of 3018 interviews were carried out from 29 November 2024 to 6 January 2025, with Portuguese citizens aged 18 to 65. A mixed-method quantitative approach was applied, using both online surveys (CAWI – Computer-Assisted Web Interviewing) and in-person surveys (CAPI – Computer-Assisted Personal Interviewing). The results showed that the most frequently mentioned sources of information on “algae” were the Internet and social media, primarily in the contexts of human nutrition and supplementation, as well as in relation to beaches and in the areas of cosmetics, pharmaceuticals or health. Many participants reported having consumed algae-based food and being familiar with certain algae species. Among them, Spirulina (genus *Limnospira*) and sea lettuce (genus *Ulva*) were the most recognized ones. When considering the purchase of algae-based products, participants highlighted product characteristics, price, and origin as the most influential factors. The most well-known purchasing locations were supermarkets and specialized dietetic, herbalist, bio, or vegan stores. Regarding the perceived functional benefits of algae consumption, immune system support and digestive health were the most acknowledged, followed by weight control, though with less expression. Notably, more than 36% of participants did not associate algae with any specific nutritional benefits. Sustainability awareness was high, with 75% of surveyed individuals agreeing that algae cultivation is an environmentally sustainable solution. Furthermore, nearly 90% acknowledged the importance of algae for maintaining aquatic ecosystem balance.

Despite this awareness, most participants were unfamiliar with specific brands of algae-based products or with algae producers and harvesters. Given Portugal's inclusion in Europe's algae roadmap, it is crucial to enhance consumer literacy regarding algae-related products, companies, and scientific advancements in the country.

ACKNOWLEDGMENTS: This work was financially supported by “Pacto da Bioeconomia azul” (Project No. C644915664-00000026) within the WP7 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line “Agendas for Business Innovation” through the funding scheme C5 - Capitalization and Business Innovation.

Margarida **Eustáquio**

Margarida Eustáquio holds a degree in Nutritional Sciences, a Master’s in Clinical Nutrition, and a postgraduate degree in Project Management. Throughout her career, she has worked as a Nutritionist, Business Developer, and Purchasing Director, gaining significant experience in the production and processing of algae. Currently, as the Project Manager of PROALGA, she is responsible for planning and executing the association’s activity plan and managing the initiatives related to Algae Vertical project within the BLUE BIOECONOMY PACT. This project is part of the mobilizing agendas for business innovation under the PRR framework.

Margarida has accumulated extensive experience in managing funded projects, including team coordination, budget management, activity planning, and event organization, such as international congresses. She also oversees communication and promotional activities within the algae sector.

## SESSION | ALGAE VERTICAL PROJECT: PART II
## MAIN AUDITORIUM

# Bioactive profile, bioaccessibility and antioxidant activity of Diatoms: a comparative study

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**ABSTRACT**
Diatoms are microalgae with significant biotechnological potential due to their richness in bioactive compounds, including carotenoids and phenolics, contributing to their antioxidant properties. This study aims to compare the bioactive profile and antioxidant activity of three diatom species: *Chaetoceros calcitrans*, *Nannofrustulum shiloi*, and *Cylindrotheca fusiformis* cultivated in closed Flat Panel photobioreactors by Necton S.A. The biomass was harvested via centrifugation, freeze-dried, milled, and vacuum-packed for subsequent analysis.
Carotenoids were extracted using ethanolic extraction assisted by ultrasound and analyzed through HPLC-DAD. The Total phenolic content (TPC) was determined using the Folin-Ciocalteu method, considering both free and bound phenolics to provide a comprehensive understanding of their distribution. Antioxidant activity was evaluated using ABTS, ORAC, and DPPH assays, offering complementary insights into the radical-scavenging potential of the diatom species. Additionally, a bioaccessibility assessment was performed using the standardized INFOGEST *in vitro* model to evaluate the stability of these bioactive compounds.
Carotenoid analysis revealed distinct profiles among the species. *N. shiloi* exhibited the highest levels of β-carotene and zeaxanthin, highlighting its strong potential as a source of antioxidant pigments, whereas *C. fusiformis* showed a balanced composition of β-carotene, zeaxanthin, and other carotenoids, suggesting a varied antioxidant capacity. In contrast, *C. calcitrans* contained comparatively lower levels of these carotenoids. In addition to carotenoids, phenolic compounds play a significant role in the antioxidant potential of these diatoms. The TPC varied significantly, with *C. fusiformis* presenting the highest levels, followed by *N. shiloi* and *C. calcitrans*. Besides the differences in the results of the antioxidant activity among species, all exhibited considerable antioxidant capacity, suggesting the presence of multiple bioactive compounds contributing to distinct yet effective mechanisms of action. These findings highlight the potential of diatoms as sources of natural bioactives, particularly for nutraceutical and pharmaceutical applications. The study underscores the importance of species selection in maximizing bioactive compound yield and antioxidant properties, paving the way for further exploration in functional food and cosmetic industries.

**Helena Rocha**

Helena Rocha is a PhD student in Biotechnology with specialisation in Food Science and Engineering at Universidade Católica Portuguesa. She is conducting her research under the project “Blue Bioeconomy Pact – Algae Vertical”, where she is involved in the complete characterisation of the biochemical composition of algae under different culture conditions. Her work focuses on microalgae, carotenoids, their bioaccessibility, and their role in gut microbiota modulation and health. Through her research, she aims to enhance the understanding of carotenoids and their potential applications in improving human health and promoting sustainable biotechnological solutions.

# AlgaeHUB®: focused to unlock the potential of microalgae

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**ABSTRACT**
At the AlgaeHUB® we develop tailor-made algae production facilities for you. Our team offer lab, pilot, de-risking, and consultancy services. The services offered allow you to evaluate our production units. De-risking allows you to validate your business case on a commercially relevant scale. R&D services offer groundbreaking possibilities, solutions, and improvements to your envisioned process. This includes any guidance, training, or consultancy you might need.
Our 7000 m² AlgaeHUB® facility near Amsterdam Schiphol Airport (20 FTE with >18 production units available) is formed by a dedicated team, that include skilled bioprocess engineers, biologists, and specialised operators. Additionally, we offer mechanical, electrical, and software engineers to design your bespoke production facility.
At the AlgaeHUB®, we collaborate closely with customers to understand their needs and design a fitting microalgae-based solution. At Lgem, we use our own technology for all validations, a patented two-phase operational concept, that results in the optimal culture mixing. Our product portfolio ranges from 5 L to more than 1.000.000 L of tubular photobioreactors, equipped with our proprietary “Bubblebrush” and “Wavywind” technology. Our validation process includes the evaluation of process conditions, its effect on product content and productivity, and evaluation of the suitable downstream processing process. We test and validate the commercial value of algae, understand their applications and create new value chains. Throughout the validation process, Lgem generates extrapolatable data on algae for each market demand, providing an updated business case.
Our focus is to unlock the potential of microalgae. Find out how we make algae cultivation easy for you.

**Marta Batista de Sá**

Marta Batista de Sá has an M.Sc. in Food Engineering and a Ph.D. in Chemical and Biochemical Engineering. She has worked at several food research institutes specializing in aquaculture, viticulture, and coffee production. During her Ph.D., she developed an online sensor for microalgae production using fluorescence spectroscopy. Later, as a Domain Expert at OnePlanet Research Center, she served to bridge the gap between sensor technology and the Food and Biotech industries. Marta is the AlgaeHUB team manager at Lgem| Synalgae, where we aim to provide the microalgae industry with tailored solutions.

## SESSION | ARE WE TURNING THE TIDE? INDUSTRIES' ROLE IN POPULARIZING ALGAL SOLUTIONS
### MAIN AUDITORIUM

# Exploring Portugal's Dynamic Algae Ecosystem: An Overview by the Portuguese Association of Applied Algology (APAA)


Authors

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**ABSTRACT**

The Portuguese Association of Applied Algology (APAA), a non-profit organization, aims to foster the growth of Portugal's algae sector through scientific, educational, technological, and industrial initiatives within a social, economic, and environmental framework contributing to create collaborative networks among stakeholders in this sector. Here, it is provided a comprehensive overview of Portugal's Algae Ecosystem, showcasing its dynamic growth and positioning Portugal as a relevant player in the global algae sector. Historically, seaweeds have been a vital source of fertilizer in Portugal since at least the 14th century, particularly through the collection of beach-cast seaweeds in coastal fields. The emergence of the Portuguese seaweed industry can be traced back to World War II, driven by the scarcity of agar from Asia. The first agar factory was established in 1947, and by 1971, Portugal had six such factories, positioning the country as a global leader in agar production. However, the industry began to decline due to factors such as overexploitation of stocks, settling and deposit issues, inadequate population recovery, and decreasing interest from divers. Since the 1980s, microalgae have gained prominence as a serious business focus, transforming the landscape. Today, nearly all higher education institutions in Portugal host research groups dedicated to algae studies, covering macro- and microalgae. These efforts encompass ecological and environmental assessments, algae production, and innovative applications, paving the way for sustainable practices and value-added products and services development.
The ecosystem includes 47 organizations actively contributing to algae research and applications: 13 Universities, 6 Polytechnics Universities, 8 Collaborative Laboratories (COLABS), 11 additional organizations, and 10 culture collections. Over the last two decades, the knowledge generated in academia has catalyzed the emergence of innovative companies, redefining the sector's trajectory. The close collaboration between academia, collaborative laboratories, and the private sector has created a unique environment in Portugal that fosters innovation not only in biomass production but also in the development of novel, high-value products. The industrial sector is currently divided into two major groups: seaweed (21 companies) and microalgae (20 companies), reflecting the vibrant and evolving nature of Portugal's algae ecosystem. This presentation aims to provide a comprehensive overview of this dynamic sector, highlighting its remarkable growth, collaborative efforts, and high potential for future developments in both research and industrial domains.


Acknowledgments: The Portuguese Association of Applied Algology (APAA) extends its gratitude to all individuals and organizations that contributed to the collection, organization, and presentation of the data showcased here.


**Celso Alves**

Celso Alves holds a PhD in Marine Science, Technology, and Management from the University of Aveiro. He is currently Senior Researcher at MARE – Center for Marine and Environmental Sciences/ESTM at the Polytechnic University of Leiria and President of the Portuguese Association of Applied Algology. His research focuses on marine organisms, with a particular emphasis on macroalgae and associated microorganisms, as sources of novel natural compounds with therapeutic and biotechnological potential for various applications. He is a co-author of several scientific articles, patents, and presentations at international conferences.

# "Productivity and carbon dioxide loss monitoring in large-scale microalgal photobioreactors"

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## ABSTRACT

Large-scale microalgal cultivation in photobioreactors remains under development, primarily focusing on reducing production and processing costs. Cost reduction is tackled by the mass cultivation of fast-growing species and efficient use of resources. However, accurate and real-time quantification of resource utilization efficiency and biomass productivity are sometimes overlooked on a large scale. Furthermore, optimal process conditions tailored to the microalgal strain must be ensured to achieve the desired biomass productivity. To tackle these challenges, we developed a monitoring and control strategy for a 275L-scale photobioreactor. With a gas analyzer, we measured oxygen and carbon dioxide concentration in the off-gas of the system to perform a gas-phase-based balance, obtaining oxygen and carbon dioxide transfer rates. Accurate estimation of the transfer rates was ensured by implementing control systems for temperature, pH, and inlet gas flow. From the transfer rates, we could estimate biological rates and biomass productivity. We could observe the effect of nitrogen limitation on growth, which led to lower transfer rates and productivity. Additionally, carbon dioxide losses and utilization efficiency could be assessed. These parameters were insightful in designing a new control system for efficient carbon dioxide supply. With this work, we showed that online process monitoring can be used to optimize microalgal growth on a large scale.

### Luca Buscaglia

Luca Buscaglia was born in Vercelli (Italy) on the 13th of December 1998. He earned his BSc in Chemical and Food Engineering from Politecnico di Torino in 2020 and pursued an MSc in Chemical and Sustainable Processes Engineering at the same University. During his MSc, he developed an interest in the intersection between engineering and biotechnology, concluding with an MSc Thesis on a model-driven control study for scaling-up mixotrophic cultivation of Galdieria sulphuraria. In 2023, Luca joined the Bioprocess Engineering group of Wageningen University to begin a PhD. His work is focused on monitoring and control of large-scale photobioreactors.

# Innovative and Sustainable Approaches for the gentle disruption of Microalgae Cells to extract valuable Compounds using Pulsed Electric Fields

Authors
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**ABSTRACT**
Pulsed Electric Field (PEF) technology is an innovative and sustainable solution for processing microalgae, offering a gentle, low temperature and energy-efficient method for cell disruption and extraction. By applying short electrical high-voltage pulses, PEF causes electroporation of the cells. This enables the controlled release of valuable intracellular compounds such as proteins, pigments, lipids and antioxidants through the PEF-induced pores in the cell membranes. Unlike conventional mechanical or chemical methods, PEF minimizes damage to sensitive bioactive molecules, preserving their functional integrity and quality. This makes it a highly attractive technology for industries focused on nutraceuticals, functional foods, biofuels, and biopharmaceuticals. Its flexibility in terms of the chosen PEF settings such as electric field strength and specific energy, but also the electrode design, allows it to be applied to a wide range of microalgae species, from Spirulina and Chlorella to extremophilic species such as Galdieria, each with unique processing requirements. This research explores the potential of PEF as a scalable and eco-friendly approach for the algae biotechnology sector. It highlights opportunities for optimizing treatment parameters to suit diverse microalgal species and discusses how PEF can address industrial-scale challenges. With its ability to combine efficiency, sustainability and high product quality, PEF technology represents an innovative tool for unlocking the full potential of microalgae as a renewable resource.

# Modification of the biochemical composition of Pavlova gyrans through in situ electric field application throughout growth

Authors
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## ABSTRACT

Microalgae, renowned for their remarkable metabolic adaptability and complex and versatile biomass composition, provide a sustainable platform for bioactive compound production and hold significant commercial value across various industrial sectors. Examples of such are its use in biofuel production, nutritional supplements and functional foods, cosmetics and pharmaceuticals, bioremediation and $CO_2$ mitigation, and in aquaculture feed. Microalgae *Pavlova gyrans* has the particularity of synthesizing omega-3 polyunsaturated fatty acids (PUFAs), such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), essential for human and animal health. Additionally, it synthesizes carotenoids, useful as natural colorants in food and feed industries, given its antioxidant properties. Thus, considering its high protein content and balanced fatty acid profile, *P. gyrans* serves as an excellent feed for aquaculture species.

Conventional stress-inducing growth strategies rely on the modulation of nutritional and environmental factors, leveraging microalgae's inherent metabolic plasticity towards value-added biomass and improved recovery yield. Herein, the effects of *in-situ* electric field (INEF) on the growth and biochemical composition of microalgae *P. gyrans* were addressed. INEF was applied at different growth stages, with varying treatment durations, and in combination with the dark phase of the cellular photoperiod. The consequent effect on cell viability was also evaluated. While not stimulating growth, INEF notably influenced the biochemical profile of *P. gyrans*. The most pronounced changes included increases of 74.9% and 66.2% in chlorophyll a and carotenoid content, respectively, as well as enhancements of 4.72%, 18.7%, and 5.41% in lipid, carbohydrate, and protein content in independent experiments. These findings demonstrate the potential of INEF as a novel approach to modulate microalgal biochemical composition, offering promising applications for industrial biotechnology.

**Mariana Barreiros**

Mariana Barreiros, a PhD student in Chemical and Biological Engineering at the Centre of Biological Engineering (CEB), holds a BSc in Biochemistry and MSc in Plant Biology, Biotechnology, and Bioentrepreneurship from University of Minho, Portugal. Her previous research spanned from the effects of calcium on grape berries' (*Vitis vinifera*) biochemical profile, to the production of functional textiles from marine residues and textile waste recycling. Her current PhD work focuses on electrical stimulation to enhance microalgae biomass production (*Pavlova gyrans*), with the aid of bioinformatics and artificial intelligence, building on her master's thesis and emphasizing her commitment to innovative biotechnology solutions.University to begin a PhD. His work is focused on monitoring and control of large-scale photobioreactors.

# A novel, fast and reliable alternative for microalgal growth assessment in scalable cultivation systems

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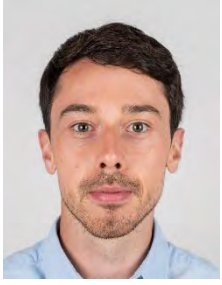
**ABSTRACT**
Microalgae, a diverse group of photosynthetic microorganisms, hold immense potential for sustainable applications in food security, renewable energy, and climate change mitigation. However, traditional methods for monitoring microalgal growth, including optical density (OD) measurements, cell count, and dry weight (DW) assessment, are labour-intensive, resource-intensive, and challenging to keep up to date in realtime for industrial applications. This study evaluates two novel devices, the Optura® Palm® and Optura® Spy®, which employ near-infrared (NIR) bio-reflectance technology to provide quick, automated, reliable and contactless cell culture/growth measurements. The aim of this study was to test the two devices across five microalgae species growth—*Microchloropsis gaditana*, *Chlorella vulgaris*, *Arthrospira platensis*, *Synechococcus elongatus*, and *Phaeodactylum tricornutum* - encompassing range cell sizes, shapes, and taxonomic families of species for marine, brackish and freshwater environments. Measurements were benchmarked against traditional methods such as turbidity measurements (OD750), flow cytometry cell count, and dry weight analysis. Results demonstrated a strong correlation ($R^2 > 0.9$) for most of the species and high accuracy even for the growth of species with different cell morphologies. The Optura® Palm® is excellent for portability and ease of use, while the Optura® Spy® offers rapid adaptability for real-time monitoring in photobioreactors and large-scale cultivation systems. Key advantages of these small devices include rapid assessment and minimum labour requirements, automatization, prevention of human error, and low reliance on single-use consumables, aligning with the principles of sustainability and circular economy. By simplifying and automating microalgal growth assessment, these technologies provide an efficient, scalable, reliable and eco-friendly alternative to conventional methods, paving the way for more sustainable microalgal production and management.



**Jose Ignacio Gayo-Peláez**
**PhD. Student, Swansea University United Kingdom**

With 10 years' experience in academia and industry, I specialize in biotechnology, bioremediation, and algae-based solutions for sustainability. I hold a Biology degree, an International Master's in Biotechnology of Environment and Health and am pursuing a Ph.D. in Chemical Engineering at Swansea University. I've worked on microalgae projects like ALG-AD, RICE, and AlgaeBrew, which focus on converting waste into valuable products using microalgae. My current research, in collaboration with industrial partners, explores carbon sequestration and sustainable manufacturing via novel photobioreactors and automatization to tackle environmental challenges through microalgal biotechnology.

# LOCALITY: an algae-based circular initiative in the North and Baltic Seas

Authors
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## ABSTRACT

LOCALITY, a HORIZON Innovation action with the title *Nature-positive algae-based products made from the North and Baltic Sea ecosystems*, is a project targeting the development of sustainable and circular value chains for the production of algae-based technology and products. The project aims to bridge the gap between industrial stakeholders and the market by leveraging algae's potential to create innovative products for food, aquafeed, agriculture, and textiles while supporting Europe's marine ecosystems' protection and restoration.

An intensive and thorough characterization of waste streams from the three targeted industries was performed: greenhouse plant production, fish production and processing, and textiles industries. The focus on these industries is strategically determined by their location and market role in the region. A diverse range of microalgae strains, sourced from NORCCA culture collection, were tested. The potential for cultivation was demonstrated for all tested waste streams, and the set-ups are now being upscaled. Industrial synergies have been fundamental in establishing the proposed ecosystems based on resource circulation. Seaweed producers are providing an ecosystem service in the Baltic and North Seas while producing seaweed. 123 kg of seaweed was harvested and sent to the R&D and academic partners for product development.

Biorefinery pipelines are under development for the microalgae and seaweed biomasses produced, and raw and treated ingredients are currently being tested for their nutritional, functional, and structural activities to integrate formulations aimed at the food, aquafeed, agriculture, and textile markets. An integrative methodology ensures synergies among R&D partners, industry, and SMEs, collectively working in each market sector to develop innovative and sustainable algae-based products. With a steady market-oriented approach, LOCALITY aims to overcome the challenges of consumer perception, regulatory compliance, and technological barriers. The consortium is equipped with the tools to overcome those barriers, and recommendations are being drafted and documented. This effort is expected to facilitate the successful introduction of algae-based products into the European market, contributing to the broader goals of environmental sustainability and economic viability.

**Margarida Costa**

Margarida Costa is the Microalgae Section leader at the Norwegian Institute for Water Research (NIVA). Her group leads several algae biotechnology-related transnational and interdisciplinary projects developing scientific and industrial algae-based solutions. Margarida has a strong background in added-value marine compounds, having worked with cyanobacteria at CIIMAR, Portugal, and sponges in an ITN Marie Skłodowska-Curie PhD grant, at the University of Iceland. In 2019, she enrolled in an industrial postdoc at Allmicroalgae´s production facility, optimizing microalgae cultivation and producing added-value compounds. Margarida has over thirty peer-reviewed scientific papers, three book chapters, and a patent.

# Microalgal Booms: a sustainable approach for marine aquaculture wastewater treatment

Authors
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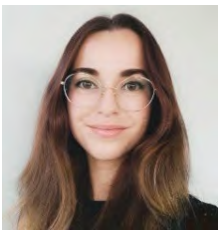
## ABSTRACT

Microalgae have gained popularity due to their applications in areas such as cosmetics, pharmaceuticals, nutrition and biomaterials, as well as environmental applications, including heavy metal bioremediation, $CO_2$ fixation, and wastewater treatment. Amid growing concerns about water scarcity and pollution, this study focuses on sustainable solutions through the potential of microalgae technology for marine aquaculture wastewater treatment using natural microalgal blooms. Batch-mode screening tests in 100 mL Erlenmeyer flasks were initially carried out under controlled conditions to identify the minimal requirements of macronutrients, trace metals and vitamins for optimal growth of the microalgae bloom in this wastewater. The six best-performing conditions were scaled up to 8 L photobioreactors to evaluate kinetic parameters of growth and nutrient removal efficiency. Lastly, the three most promising conditions based on the requirements studied in the 8 L reactors were tested in outdoor 70 L High-Rate Algal Ponds, operated in semi-continuous mode under ambient temperature and irradiance conditions, to assess the effectiveness of natural algal blooms in producing a depurated effluent that meets regulatory standards.

Batch experiments revealed that in this nitrogen-rich wastewater, adding phosphorus following the Redfield Ratio (N:P=16:1) enhanced microalgal growth, achieving nitrogen (N) and phosphorus (P) removal efficiencies exceeding 98%. In the outdoor experiment, three conditions were tested: (i) addition of phosphorus, trace metals and vitamins; (ii) addition of phosphorus and trace metals; and (iii) addition of phosphorus. The three conditions yielded similar biomass productivities and achieved consecutive cycles where the effluent met the most restrictive limits for N and P established in the Directive (EU) 2024/3019 concerning urban wastewater treatment for discharge (<0,5 mg/L P and <8 mg/L N). Notably, the condition with the P addition alone demonstrated that an algal bloom can be produced without the need for trace metals or vitamins, while effectively removing N and P from this wastewater.

Acknowledgements/Funding: Grant PID2022-140125OB-I00 funded by MICIU/AEI/10.13039/501100011033 and by ERDF/EU. PhD funded by PLAN PROPIO - UCA (2025-2027).



**Bethany Louise Short**

Bethany Louise Short is a PhD student at the University of Cádiz, where she studied a double degree in Marine and Environmental Sciences, followed by a Master's in Biotechnology. Her current research focuses on sustainable industrial wastewater treatment using microalgae, reflecting her commitment to advancing environmentally friendly technologies through marine sciences.

# Sustainable production and valorization of microalgal biomass from ultrafiltrated livestock digestate

Authors
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## ABSTRACT

Healthcare is one of the highest concerns these days. New viral diseases have emerged in different geographical areas, such as Ebola virus, West Nile virus or coronaviruses (CoV), caused or probably caused by zoonoses (Dhama et al., 2020). In this context, searching for new molecules able to inactivate viral damages can be an excellent approach to deal with these healthcare issues, whether current or in preparedness for future potential new threats. Natural products obtained by organisms are more than one-third of the FDA-approved new molecular products. Some of them have shown high anti-inflammatory, antiviral or cytotoxic capacity, which demonstrates the potential of these molecules obtained from natural sources. Among these organisms, microalgae are photosynthetic microorganisms that have raised the interest of researchers and biotechnological industries due to their ability to capture $CO_2$ and their capacity to produce different bioactive compounds, that can be used as a source of medical and pharmaceutical products, such as carotenoids, polyphenols or terpenoids

In this work, ten species of freshwater and seawater microalgae have been screened for their antiviral activity using three different bacteriophages, including the enveloped Phi6 and the nonenveloped MS2, and Phix174. The first screening was performed in plates, for 16 h, using the double agar technique, and quantified by PFU (plaque-forming unit), as described by Torres-Franco et al., (2024). Microalgal concentration in the extracts was $OD_{600}$=5.0. The results showed an inactivation from 20 to 55% of Phix174, and from 10 to 50% of MS2 and Phi6 in that period, depending on the microalgae tested. While species as *Chlorella vulgaris* or *Nannochloropsis gaditana* showed higher inactivation rates for the DNA virus Phix174 (49% and 62% of control PFUs, respectively), other species, such as *Isochrysis galbana* demonstrated to be more efficient in the inactivation of the RNA virus MS2 (48% of control PFUs). Additionally, the best performed microalgae were selected to be cultivated in liquid medium and the decay of the three viruses was studied along the time through PFU and qPCR. The results obtained in this work pointed out microalgae as a potential source of antiviral molecules, being the next steps the extraction and isolation of the selected microalgal extracts to identify the molecules with antiviral activity.

**Tea Miotti**

Dr. Miotti Tea is a second-year PhD candidate in Biotechnology at the University of Verona. Her research focuses on waste valorisation and the production of high-value products using microalgae. She explores innovative approaches to harness microalgae for environmental and industrial applications, with a particular emphasis on developing sustainable solutions for waste treatment and bio-based product generation, such as biostimulants.

# Engineering of a microalgal-bacterial consortium for the removal of organic pollutants from petrochemical industry

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## ABSTRACT

The key role of diesel, petroleum, and their derivatives in society during the last century, has positioned petrochemical industry as one of the most relevant industries. Unfortunately, petrochemical effluents have significantly contributed to the pollution of aquatic environments with high concentrations of aliphatic hydrocarbons, phenolic compounds and polycyclic aromatic hydrocarbons. The degradation of these compounds using microorganisms has emerged as a promising solution to prevent the deterioration of aquatic environments. Although there are many studies using bacteria for biodegradation of these compounds, recent studies have highlighted the potential of different microalgae- bacteria consortia, which reduce the need for mechanical aeration and the risk of pollutant stripping (Parsy et al., 2024).

The purpose of this work is to develop an effective consortium using the microalga *Chlorella vulgaris* and the bacterium *Rhodococcus opacus* for the removal of different pollutants of petrochemical industry, such as phenol, benzene, toluene, ethylbenzene and *o*-xylene. The results showed that the presence of *R. opacus* improves the tolerance of *C. vulgaris* to BTEX compounds, being able to grow at concentrations of 15 mg $L^{-1}$ of benzene and toluene, 8 mg $L^{-1}$ of ethylbenzene; and 3 mg $L^{-1}$ of *o*-xylene. Additionally, the presence of the bacterium also improves the biodegradation rate of the system with the single pollutants until 65, 70, 78 and 87% of initial benzene, toluene, ethylbenzene and *o*-xylene, respectively, at the mentioned concentrations. Moreover, under optimized nitrogen and headspace conditions, the consortium metabolized 100% of a mixture of phenol, benzene, toluene, ethylbenzene and *o*-xylene at 25, 3, 3, 3 and 1 mg $L^{-1}$, respectively, within 6 days of cultivation. These results highlight the potential of algal-bacterial consortia to biodegrade organic pollutants from petrochemical industries. Thus, the co-culture of the microalga *C. vulgaris* and the bacterium *R. opacus* represents a promising platform for the biodegradation of different organic pollutants from petrochemical industry, such as phenol, BTEXs or a mixture of thereof.

Parsy, A., Ficara, E., Mezzanotte, V., Mantovani, M., Guyoneaud, R., Monlau, F., Sambusiti, C., 2024. Culture of photosynthetic microalgae consortium in artificial produced water supplemented with liquid digestate in closed column photobioreactors and open-pond raceway. Biomass and Bioenergy 184. https://doi.org/10.1016/j.biombioe.2024.107165

### Antonio León-Vaz

Dr. Antonio León Vaz studied Chemistry at University of Huelva (Spain), where he also completed a PhD in Biochemistry and Molecular Biology. After that, Antonio obtained a 'Margarita Salas' postdoctoral fellowship at Umeå University (Sweden) for a year. Currently, Antonio joined the VOC and Microalgae Research Group and the Institute of Sustainable Processes (ISP) as a 'Juan de la Cierva' postdoctoral researcher. His research is focused on the inactivation of viruses using microalgae-based systems and exploring the mechanisms related with that inactivation.

# Tertiary wastewater treatment by native microalgae consortia

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## ABSTRACT

The recently revised Urban Wastewater Treatment Directive (UWWTD) significantly challenges the wastewater sector by setting ambitious targets for tertiary and quaternary treatment and requiring energy neutrality. Strategic investments in sustainable solutions, such as algae-based systems, will only achieve these objectives.

Though the potential of microalgae for urban and industrial wastewater treatment has been demonstrated, tertiary treatment processes for advanced N and P removal by microalgae have only recently been addressed. Due to the ability to recover N and P, while consuming CO2 in a low energy demand process, microalgae-based solutions are suitable candidates for sustainable wastewater treatment. Because urban wastewater composition shows high variability over time, highly robust microalgae are needed for adequate nutrient removal efficiencies. That is more likely to be achieved with indigenous consortia of microalgae and bacteria than with pure cultures, since these will naturally adapt to the changes in the medium composition.

In this work, two pilot-scale raceway systems (RW) of 5 $m^2$ each were installed at a mixed urban-industrial WWT plant in Lisbon region (Portugal), for polishing secondary effluent in a semi-continuous process, and operated for 86 days in the autumn of 2023. Instead of inoculating a specific microalga, an indigenous consortium was allowed to develop naturally. For the first 36 days, the consortium of each RW was monitored and, although being operated identically at a hydraulic retention time (HRT) of 6.2±1.5 days, significant differences were observed. RW A had *Scenedesmus* spp. as dominant species, while RW B presented a mixed culture of *Scenedesmus* spp. and *Micractinium* sp.. RW A and B presented 3.2±1.2 and 2.7±0.7 $g.m^{-2}.day^{-1}$ biomass dry weight productivities, respectively. The final $NO3^-$ and $NH4^+$ levels attained for both were almost always below the quantification limit of the methods (0.35 and 0.78 $mgN.L^{-1}$, respectively) and the $PO4^{3-}$ contents were 0.23±0.07 and 0.49±0.33 $mgP.L^{-1}$ for RW A and B, respectively. Thus, both consortia were able to remove N and P to levels below those set by the UWWTD.

The variability in performance of these systems was assessed from the $36^{th}$ day onward, by inoculating RW B with culture from RW A and operating the systems as replicates (HRT of 6.9±0.2 days). In this period, the consortium suffered little changes, maintaining *Scenedesmus* spp. as the dominant microalga and other microalgae and cyanobacteria with low abundances. RW A and B presented very similar biomass productivities (2.7±0.6 and 3.0±0.7 $g.m^{-2}.day^{-1}$, respectively), and N and P removal efficiencies (final P concentration 0.30±0.18 and 0.37±0.20 $mgP.L^{-1}$, respectively). The similarity of results attained for both RWs indicate the robustness of the systems. Overall, the results confirm the ability of native microalgae-based systems as a tertiary treatment step of urban wastewater.

**Sofia Vaz**

Sofia holds a MSc in Biological Engineering from Instituto Superior Técnico, University of Lisbon, and is currently a PhD student at A4F - Algae for Future and CERES - Chemical Engineering and Renewable Resources for Sustainability research centre, University of Coimbra. Sofia's PhD research focuses on domestic wastewater treatment using microalgae, particularly on phosphorus, nitrogen and carbon recovery.

# Integrating Microalgae Cultivation with Wastewater Treatment: The FRONTSHIP Project's Technological Innovations

Authors

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**ABSTRACT**

Microalgae cultivation in wastewater is recognized as a promising biotechnological approach for nutrient recovery from wastewater and biomass production with applications in sustainable agriculture. The FRONTSHIP project investigates the feasibility of using microalgae for wastewater treatment from industrial and domestic sources in Poland. The study aimed to assess the potential of different effluents to support algal growth, their impact on biomass yield, and the development of an on-site cultivation system. Industrial and domestic wastewaters from a multinational company specialized in the production of plastics, rubbers, coatings and domestic wastewater from the Parzęczew municipality, were evaluated for its suitability for Chlorella vulgaris cultivation. Additionally, gaseous streams from industrial processes were quantified in terms of CO2 to assess them as a supplementary carbon source for the cultures. Preliminary toxicity trials indicated that the industrial wastewater severely inhibited algal growth. In contrast, domestic wastewater from Parzeczew demonstrated an optimal carbon/nitrogen/phosphorus (C/N/P) balance, which significantly promoted the growth of C. vulgaris. The microalga effectively assimilated the nutrients, leading to biomass accumulation. Further experimental work will focus on optimizing operational parameters, such as $CO_2$ and nutrient supplementation, to increase biomass yield. Beyond biomass productivity, the project will investigate the agronomic efficacy of the produced biomass as a biofertilizer or biostimulant through various bioassays. The integration of waste valorization and resource recovery principles within the FRONTSHIP's project aligns with broader sustainability goals and contributes to the development of circular bioeconomy models.

To facilitate microalgae cultivation from wastewater in situ, a mobile tubular photobioreactor prototype with an integrated LED lighting system was designed and constructed. This system enables to control algal growth, optimizing environmental conditions to enhance biomass productivity. Mobile photobioreactors provide significant advantages by allowing flexibility in deployment and reducing the need for extensive infrastructure investments. The ability to maintain stable growth conditions irrespective of external climatic variations makes them a valuable tool in the advancement of wastewater bioremediation strategies.

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**Alice Ferreira**

Alice Ferreira holds an MSc in Biological Engineering from Instituto Superior Técnico, University of Lisbon. She is currently awaiting her PhD defense in Environmental Engineering from the School of Agronomy, University of Lisbon. Her PhD research consisted on microalgae biotechnology for piggery wastewater treatment and the development of sustainable agriculture products. Previously, she has worked as a Research Fellow at LNEG, in several projects focusing on wastewater treatment and bio-based applications. She has co-authored 28 papers in scientific journals and three book chapters. Her expertise includes wastewater valorization, bioenergy, green extractions, and sustainable agriculture solutions.

# Life cycle assessment of a photoautotrophic production of Limnospira platensis (Spirulina) in an industrial facility

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## ABSTRACT

Rapid population growth comes with challenges in health, social and economic stability, resource depletion and others. A higher demand for food, water and energy intensifies the industries' demand, driving the emission of greenhouse gases, deforestation and intensive land use. These factors are leading to biodiversity loss, and extreme weather events, among others. *Limnospira platensis* (Spirulina) grows autotrophically and can be part of the solution for a sustainable human population expansion. This is because Spirulina can have up to 70% of its dry weight in protein, is rich in vitamins (beta-carotene and vitamin K), in fatty acids and has a complete amino acid profile. Unlike traditional crops it can be cultured on non-arable land. Its cultivation reduces pressure on freshwater resources, avoids agricultural land competition, and actively sequesters carbon dioxide, mitigating climate change. Environmental sustainability is a topic of increasing interest worldwide, and consumers are becoming more concerned with their products' environmental impact. From this perspective, Life Cycle Assessment (LCA) is a recognised methodology to evaluate a product's or process's environmental impact throughout its life cycle. A study on the LCA of Spirulina production at an industrial scale was made, providing important data on the environmental impacts of the process. A cradle-to-gate LCA was performed using the Environmental Footprint (EF) method v3.1, incorporating key factors such as facility construction, operational use and equipment cleaning. The functional unit was defined as 1 kg of dried and packaged Spirulina. The analysis reveals that spray-drying is the main hotspot of the process due to its manufacturing and, mostly, operational energy consumption. Sensitivity analysis were also performed to suggest modifications to improve the system's performance, such as a different downstream alternative. Therefore, LCA is a valuable decision-making tool to support the optimised development of the spirulina production system.
Funding: This work was financially supported by FCT via the 2022.13209.BDANA PhD grant and by funding through "Pacto da Bioeconomia Azul" (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line "Agendas for Business Innovation" through the funding scheme C5 - Capitalization and Business Innovation.

**Sofia Navalho**

Sofia Navalho is pursuing a PhD focusing on Spirulina production's life cycle assessment (LCA). Her research examines the environmental impacts of the production process and aims to develop strategies for its improvement. Previously, she gained five years of experience improving microalgae strains using non-GMO techniques such as adaptive laboratory evolution and random mutagenesis, enhancing these organisms for industrial applications. With a background in Biological Engineering from Instituto Superior Técnico, her expertise connects strain optimisation with sustainability analysis, contributing to fostering an environmentally responsible microalgae biotechnology.

# Microalgae as a Main Ingredient in Mayonnaise - Steps to achieve a Clean Label prototype

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## ABSTRACT

Consumers awareness towards animal welfare and natural origin of ingredients in food production is a growing concern during the current millennium, added to the fact of a raising trend to adopt plant based diets. Not only food industry needs to readapt and reshape traditional and staple foods to answer consumers demands, as environmental concerns also reclaim sustainable sources. Commercially available mayonnaise is traditionally prepared with egg powder, colorant agent and synthetic antioxidant, among remaining ingredients.

This research intends to study the balance between heterotrophic microalgae *Chlorella vulgaris* (*C. vulgaris* Smooth) and *Saccharomyces cerevisiae* yeast protein extract (*Sc* YPE) – as a sustainable emulsifier mixed system to act as egg replacer. Both colorant agent and the synthetic antioxidant become unnecessary upon microalgae addition, responsible for the supply of natural pigments and bioactive compounds composition. *Sc* YPE offers interesting kinetic stability provided by the yeast polymers composition. Since there is a strong droplets electrostatic repulsion, YPE based emulsions have an increased resistance against physical degradation and microbial spoilage. Microalgae is considered in the past two centuries as a potential supplement to implement in human diets, regarding its functional properties and nutritional composition. Microalgae biomass is rich in fatty acids, and proteins that play an interesting synergy with the YPE polymers, generating a stable emulsifying agent. Response Surface Methodology (RSM) was used to compare different concentrations of two independent variables (*C. vulgaris* Smooth ranged from 1 to 4% wt and *Sc* YPE ranged from 0.5-2% wt) - 12 formulations were produced. Texture, viscosity, mechanical behaviour (G' and G'') and droplet size distribution, were considered as dependent variables. Mechanical spectra G'1Hz ranged from $2x10^{1}$-$9.6x10^{2}$ Pa, while the plateau model ($G^{0}N$) ranged from $3.9x10^{2}$-$1.5x10^{3}$ Pa; Limit of zero shear viscosity (η0) ranged from $1.6x10^{4}$–$4.9x10^{4}$ Pa.s and flow rate (*k*) ranged from $1.29x10^{2}$-$1.97x10^{2}$ s; Sauter diameter ($d_{3,2}$) ranged from 5.4-10.3 µm; Firmness from 0.05-0.101 N and Adhesiveness ranged from 0.284-0.755 N.s; ph depicted slight deviations from 3.933-4.393; color was analyzed based on the CIELAB color space coordinates for perceptual lightness (L*) that ranged from 55.13-71.15; a* depicted greener tones from -7.88 to -6.39; b* depicted yellow tones from 30.83-37.09.

Based on the RSM results, 4 prototypes were considered mainly due to the rheology measurements, since it was possible to statistically predict the formulation that would better fit the mimics of the Control mayonnaise. Also, to avoid triggering symptoms of food neophobia among the consumers due to the greener color, a lower concentration of microalgae was picked. Finally, a suitable vegan analogue prototype was elected to begin scale-up phase and studied for shelf-life purposes.

### Pedro Coelho

Pedro Coelho is a PhD candidate from LEAF-ISA Food&Feed group with a multidisciplinary background. Academic journey started with a B.A. in Cultural and Communication Studies, further defied by a M.Sc in Food Engineering. Currently working under a fellowship from the VIIAFOOD agenda, main focus is to assess alternative proteins in order to formulate food products feasible to the industry. Circular economy, cultural interchange and sustainable production are the main pillars for the motivation in new products development. Food and letters represent the willingness to contribute for a prosper future. Research outputs may be found in ongoing peer-reviewed-articles and congresses presentations.

# Edible coatings: From seaweeds to food products

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**ABSTRACT**
Seaweeds are sustainable and highly available, presenting high grow rates, high photosynthetic productivity and high amounts of polysaccharides (generally, 50 % of dry weight). Nonetheless, only a few species, mostly from red and brown phylum, are explored sources of these polymers. Green seaweeds are rich in biodegradable polysaccharides with the ability to form films and coatings, which is of utmost importance to study. Polysaccharide-based films present good oxygen barrier properties and are impermeable to oils and fats. However, they show low tensile strength and are water soluble. Considering that, seaweed-based polysaccharides can be used to produce edible coatings for fried food, aiming at reducing the oil uptake. Moreover, seaweeds are good sources of bioactive compounds, which can be added to the films, enhancing their functionality. In this study, two green seaweeds (*Codium tomentosum* Stackhouse and *Ulva* sp.) and one brown seaweed (*Sargassum vulgaris* Grunow) were studied as source of polysaccharides and bioactive compounds. To obtain these compounds, hydrothermal and ultrasound-assisted extraction processes were applied, following a central composite rotatable design. *Ulva* appears to be the most promising for polysaccharides extraction, with hydrothermal treatment, which showed to be the most efficient extraction method. Conversely, *Sargassum* extracts presented higher phenolic content and greater antioxidant activity, which did not depend on the extraction treatment. As such, for the recovery of these compounds, ultrasounds is preferred since it allows lower extraction times and lower energy consumption. Therefore, the results suggest using *Ulva* polysaccharides together with bioactive compounds from *Sargassum* to produce functional edible coatings that minimize oil uptake in fried food products.

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**Gabriela Sousa**

Gabriela Sousa is a PhD student in Food Engineering at the Instituto Superior de Agronomia (ULisboa). Her project is on the design of functional edible coatings for frying fish products within the concept of ocean bioeconomy.
She is studying the extraction of polysaccharides and bioactive compounds from less explored seaweeds to produce edible coatings, as a strategy to decrease the oil uptake during frying. Her focus and goals are in the sustainable use of marine resources by the food industry, under a circular economy context.

# Algae biomass as a potential ingredient for seafood analogues

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## ABSTRACT

Estimates indicate that the global population may reach approximately 9 billion by 2050. This demographic expansion is anticipated to coincide with a substantial increase in food demand, projected at 70%. Such projections underscore the urgent necessity to investigate food sources and alternative food systems that can meet this escalating requirement. Among the potential solutions, microalgae have emerged as crucial ecological and economic contributors, renowned for their rich nutrient profile and associated health benefits.

Microalgae exhibit a remarkable capacity to replicate seafood flavors, presenting a promising aroma for the development of seafood analogs. Our research specifically investigates the potential of two microalgae: *Nannochloropsis oceanica (N. oceanica),* and Tetraselmis chui (T. chui). A comparative analysis was conducted on various cell disruption technologies to evaluate their efficacy in maximizing protein recovery while preserving the integrity of the proteins' native structures. The methodologies explored in our study included high-pressure homogenization (HPH), ultrasound-assisted extraction, pH shifts, freeze-thaw cycles, and enzymatic extraction. After a thorough evaluation of the protein extraction methods, we chose to purify the HPH extract using ammonium sulphate precipitation, followed by ultrafiltration. We analysed several critical metrics, including protein recovery yields, the secondary and tertiary structures of the proteins, molecular weights, and morphological characteristics. Additionally, the rheological properties of the extracts were explored, along with their emulsifying capacities, to assess their viability as functional ingredients within food applications. Recognizing the potential of microalgae to serve as marine odorants, we further investigate the key odorants present in both *N. oceanica* and *T. chui.* Utilizing Headspace Solid-Phase Microextraction, we compared these odorants to those found in traditional seafood sources, especially examining both raw and boiled shrimp. The culmination of our extensive research efforts led to the successful development of a formulation, which was subsequently employed in a 3D printer to create the seafood analogs. This innovative approach not only brings our vision of microalgae-based shrimp alternatives to fruition but also opens up new avenues for sustainable food production, addressing both environmental and nutritional challenges associated with traditional seafood harvesting.

Our research underscores the significant potential of microalgae as a sustainable food source, highlighting their ecological and economic benefits while reinforcing the importance of innovation in food systems to meet future global demands. Through continued exploration of microalgae applications, we aim to contribute to the development of alternative proteins and sustainable food technologies.

### Catarina Moreira

Catarina Moreira is currently finishing her Ph.D. in Food Science and Technology and Nutrition at Minho University in Portugal. Her doctoral research focuses on developing seafood analogs from algae biomass, addressing challenges related to protein rearrangement and flavor retention.
Previously, Catarina was awarded the esteemed EIT RIS Fellowship and gained valuable experience in research and development within an industrial context at Puratos (Brussels, Belgium). With six years of expertise in biotechnology, she has dedicated the last four years to the study of protein extraction and its applications from microalgae. Since 2021, Catarina has authored and collaborated on seven articles.

# Spirulina as the main ingredient of a plant-based animal product alternative

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## ABSTRACT

The global population is projected to increase by 2 billion by 2050, driving the demand for agricultural products to rise by at least 50%. This highlights the urgent need to find alternative sources to meet human dietary requirements sustainably. Arthrospira platensis (commonly known as Spirulina), is a protein-rich cyanobacterium (50-70%) that contains all the essential amino acids, making it a promising protein alternative. However, consumer acceptance of Spirulina is hindered by its distinctive organoleptic properties, limiting its incorporation into food products. A biorefinery approach presents a solution to these challenges, fractioning Spirulina biomass into various food-grade ingredients with milder sensory characteristics. Additionally, incorporating these ingredients into new food products, namely a meat analogue, can offer a sensory experience more aligned with consumer preferences. The most widely used process to achieve this product is high-moisture extrusion (HME). This method combines pressure, temperature and shear stress to modify the proteins' structure, creating a fibrous texture in the final product, mimicking the texture of animal-derived products.

This study aimed to develop a Spirulina-based alternative to animal products, using HME. A central composite design was used to investigate the influence of key extrusion parameters, namely water content (47.5-52.5%), flow rate (0.6-1.0kg.h-1) and cooking temperature (140-150ºC) using a powder composed of 60% Spirulina and 40% pea protein isolate. The obtained extrudates were evaluated based on textural parameters such as anisotropic index (AI), springiness, and cohesiveness and were compared against cooked chicken breast and cuttlefish. Results demonstrate that the AI, which correlates with the fibrousness of the meat, reached values comparable to both controls, while springiness and cohesiveness were similar only to those of the cuttlefish. The model was then used to determine the optimal combination of process variables to obtain a texture that best mimics cuttlefish, and the selected conditions were validated. The same conditions were then applied to evaluate the viability of a Spirulina extract (a residual fraction of phycocyanin extraction). The final products were analyzed in terms of texture, nutritional profile and sensory attributes and compared to a 100% pea protein extrudate. The findings gathered in this work provide valuable insights into the potential of Spirulina-based products as sustainable and nutritionally viable alternatives to conventional animal products, particularly in the unexplored cephalopod analogues market.
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### Inês Guerra

Inês Guerra is on the 4th year of a PhD entitled "Production and formulation of an Arthrospira platensis protein-based meat analogue". She worked in Allmicroalgae where she gained experience in microalgae cultivation and growth optimization, either in lab, pilot and industrial scales. In GreenCoLab she developed a pilot scale multi-product biorefinery with focus on extraction of phycocyanin from Spirulina's biomass. She also worked in IRTA with high and low moisture extrusion to the formulation of alternatives to animal products. Inês has 5 publications, 2 book chapters and 3 oral presentations performed in international

# Antiviral activity in different species of microalgae: a promising approach to discover new high-value molecules

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## ABSTRACT

Healthcare is one of the highest concerns these days. New viral diseases have emerged in different geographical areas, such as Ebola virus, West Nile virus or coronaviruses (CoV), caused or probably caused by zoonoses (Dhama et al., 2020). In this context, searching for new molecules able to inactivate viral damages can be an excellent approach to deal with these healthcare issues, whether current or in preparedness for future potential new threats. Natural products obtained by organisms are more than one-third of the FDA-approved new molecular products. Some of them have shown high anti-inflammatory, antiviral or cytotoxic capacity, which demonstrates the potential of these molecules obtained from natural sources. Among these organisms, microalgae are photosynthetic microorganisms that have raised the interest of researchers and biotechnological industries due to their ability to capture $CO_2$ and their capacity to produce different bioactive compounds, that can be used as a source of medical and pharmaceutical products, such as carotenoids, polyphenols or terpenoids In this work, ten species of freshwater and seawater microalgae have been screened for their antiviral activity using three different bacteriophages, including the enveloped Phi6 and the nonenveloped MS2, and Phix174. The first screening was performed in plates, for 16 h, using the double agar technique, and quantified by PFU (plaque-forming unit), as described by Torres-Franco et al., (2024). Microalgal concentration in the extracts was $OD_{600}$=5.0. The results showed an inactivation from 20 to 55% of Phix174, and from 10 to 50% of MS2 and Phi6 in that period, depending on the microalgae tested. While species as *Chlorella vulgaris* or *Nannochloropsis gaditana* showed higher inactivation rates for the DNA virus Phix174 (49% and 62% of control PFUs, respectively), other species, such as *Isochrysis galbana* demonstrated to be more efficient in the inactivation of the RNA virus MS2 (48% of control PFUs). Additionally, the best performed microalgae were selected to be cultivated in liquid medium and the decay of the three viruses was studied along the time through PFU and qPCR. The results obtained in this work pointed out microalgae as a potential source of antiviral molecules, being the next steps the extraction and isolation of the selected microalgal extracts to identify the molecules with antiviral activity.

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### Antonio León-Vaz

Dr. Antonio León Vaz studied Chemistry at University of Huelva (Spain), where he also completed a PhD in Biochemistry and Molecular Biology. After that, Antonio obtained a 'Margarita Salas' postdoctoral fellowship at Umeå University (Sweden) for a year. Currently, Antonio joined the VOC and Microalgae Research Group and the Institute of Sustainable Processes (ISP) as a 'Juan de la Cierva' postdoctoral researcher. His research is focused on the inactivation of viruses using microalgae-based systems and exploring the mechanisms related with that inactivation.

# Implementation of a transversal scalable multi-product aqueous-based biorefinery pipeline for red algae biomass

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## ABSTRACT
For some years now, algae, particularly red algae, have been in the spotlight of biotechnology as one of the most promising alternative biomasses for extracting high-value compounds, including exopolysaccharides (EPS) and phycoerythrin, which have immunomodulatory and antioxidant properties. Several approaches have been employed in exploring these organisms, from single-compound extractions to multi-product biorefineries. However, most of these have explored either expensive or unscalable methodologies, which were ultimately economically and environmentally unsustainable. This has prevented these biomasses from gaining recognition and showcasing their full potential to industry and end consumers. With this work, the goal is the implementation of an aqueous-based multi-product biorefinery for two red algae species, the macroalga Palmaria palmata and the microalga Porphyridium purpureum. Considering the latter (P. purpureum), the first step of our pipeline included the valorization of the culture media rich in exopolysaccharides (EPS) – with great potential in cosmetic applications due to its rheology and properties, including antioxidant activity. The EPS concentration process was optimized using membrane technology and precipitation/purification techniques, resulting in a highly concentrated product free of salts and high viscosity, which was biochemically characterized. Afterwards, an assessment of the best cell disruption methodologies was performed for both biomasses, including high-pressure homogenization, freeze-thaw cycles, ball milling and enzymatic hydrolysis, with special focus on our target products: soluble proteins, carbohydrates, and phycoerythrin. The soluble compounds were fractioned and purified, resorting to simple and innovative techniques such as salt precipitation, adsorption with activated charcoal, and flocculation using chitosan. The resulting purified products were fully characterized, exhibiting high purity as well as antioxidant activity, highlighting their potential for applications in several sectors, including food, textile, and cosmetic industries. The resulting residual biomasses were explored for their content in high-value lipids, using simple extraction techniques with organic solvents. These results, though preliminary, are promising to prove the enviro-economic viability, scalability, and transversality of this pipeline for red algae biomass valorization. Ultimately, more than implementing a biorefinery pipeline, it is about creating a blue circular economy that will help us maximize the value we extract from our oceans.

## KEYWORDS
Microalgae, Macroalgae, Biorefinery, Supplements and cosmetics, Environmental solutions/ Circular Economy, Algae Market

### Pedro Letras

Pedro Letras has a BSc in Biology (Universidade de Lisboa) and a MSc in Marine Biology (Universidade do Algarve). His thesis “3D printed gluten-free snacks with the incorporation of Chlorella vulgaris and/or Arthrospira platensis (Spirulina)” at Instituto Superior de Agronomia, was published in the scientific journal Algal Research in 2021. Several science related experiences followed including algae downstream processing and product development at Arborea. In April 2023 he joined GreenCoLab, as biorefinery technician. In December of the same year, he embarked on a PhD (GreenCoLab, CCMAR, CICECO) focusing on the development of an aqueous-based multi-product biorefinery pipeline for red algae.

# Cell disruption of microalga Nannochloropsis oceanica using bead milling: effect on recovery, composition, and bioaccessibility of partially disintegrated biomass

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## ABSTRACT

The microalga *Nannochloropsis oceanica* is a promising future source of nutritionally valuable compounds such as protein, omega-3 fatty acid, and vitamin $K_2$ and $D_3$[1]. Unfortunately, these compounds are effectively protected by a cell wall consisting of a thick cellulose layer coated by chemically recalcitrant algaenan[2]. If left unprocessed, this cellular defense severely hampers the bioaccessibility of nutrients in whole-cell biomass. Therefore, the present study aimed to evaluate the use of bead milling as a cell disruption method for processing of *N. oceanica* biomass. Suspensions of freeze-dried biomass were subjected to varying degrees of cell disruption, ranging from approximately 20% to 80% disrupted cells. The influence on bioaccessibility of vitamin K in the harvested biomass was evaluated as the main response. Additional side effects on biomass recovery and the content of amino acids (AA) and fatty acids (FA) were assessed in parallel. The experiment revealed that bead milling had no significant impact on the total content of amino acids and fatty acids in the retrieved biomass. The two fractions remained relatively stable at approximately 310 mg AA·$g^{-1}$ DM and 120 mg FA·$g^{-1}$ DM, irrespective of the cell disruption level. However, lower recovery of dry matter during centrifugation reduced the recovery of amino acids by up to 32% compared to a non-disrupted control. Fatty acid recovery also dropped in response to increasing cell disruption, by up to 23% compared to the control. Yet, the effect of bead milling was overall less severe on fatty acids, including the omega-3 fatty acid EPA. The influence on vitamin K bioaccessibility will also be presented at the conference. The generated knowledge will enable finetuning of the bead milling process to enhance the bioaccessibility of *N. oceanica* biomass with minimal losses in the recovery and content of valuable nutrients.

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**Emil Gundersen**

Emil Gundersen is currently employed as a PhD candidate at DTU National Food Institute. In his current position, Emil works with developing microalgae as a future, sustainable source of food ingredients. More specifically, his research focuses on improving the productivity and bioaccessibility of protein, omega-3 fatty acids, and vitamins K and D in the microalga *Nannochloropsis oceanica*. Emil has previously been involved in several microalgal research projects, developing technologies based on both cyanobacteria and diatoms. Through his research, he seeks to supply vital knowledge for a growing microalgal industry in Denmark.

# Inducible Microalgal Autolysis: A Key Step Towards Sustainable Multi-Product Biorefineries

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## ABSTRACT

Microalgae biorefineries are shifting from single-product to multi-product systems. The development of new technologies is however required in order to ensure their economic feasibility. Enzyme-assisted extractions have been touted as a promising method to hydrolyze microalgal cell walls in a targeted manner, improving product extraction. However, the high cost and single-use limitations of commercially available enzymes hinder their commercial application. To overcome these challenges we propose an innovative strategy involving genetic engineering to introduce an inducible autolytic system in microalgae. This approach involves a preliminary screening for strain-specific lytic enzyme(s) based on the unique composition of their cell walls followed by optimizing the treatment conditions to maximize the cell wall hydrolysis. For the case of *Nannochloropsis*, enzymes such as cellulases and endoglucanases could be tested. Subsequently, the algae are genetically modified to produce the selected enzymes once the desired cell concentration is reached. The enzyme expression is activated by certain external triggers, such as a nutrient change in the growth medium [1], [2]. Culture conditions will then be fine-tuned to facilitate optimal cell wall hydrolysis. The development of microalgal strains with inducible autolysis mechanisms wherein the cell walls are selectively degraded without disrupting intracellular biomolecules represents a promising solution for mild multiproduct downstream processing. These approaches already demonstrated in cyanobacteria [3], could thus advance the sustainability and economic feasibility of microalgae-based production processes.

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**Sylviah Khamila**

Sylviah Khamila is a PhD candidate in Bioprocess Engineering, focusing on microalgal autolysis for sustainable product recovery. Her research explores enzyme-assisted microalgal cell wall disruption as a cost-effective alternative to traditional high-energy and solvent-intensive methods. By leveraging microalgal genetic engineering, her work aims to develop an efficient inducible autolysis system that enhances multiproduct extraction in microalgae biorefineries, contributing to more sustainable and scalable bioprocessing.

# Strategies of Stabilization of R-Phycoerythrin for Plant-Based Seafood

Authors

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## ABSTRACT

Phycobiliproteins are key photosynthetic pigments found in cyanobacteria, red algae, and cyanelles, which have been the focus of much attention in recent years. Among them, R-phycoerythrin, the predominant pigment in Rhodophyta, has garnered attention for its antioxidant properties with high potential for both food and health applications. Additionally, its distinct pink hue provides a natural alternative to synthetic pigments, enhancing both the health benefits and aesthetic appeal of food products. Incorporating R-phycoerythrin into plant-based seafood enhances its visual appeal and authenticity while promoting sustainability by reducing reliance on animal products. However, its application faces two key challenges: cost-effective extraction and the stability of phycobiliproteins. This study aims to overcome these challenges by developing an environmentally friendly and cost-effective approach for the extraction technologies and the inherent stability limitations of phycobiliproteins. Following extraction with only water, an encapsulation technique was used to protect the bioactive compounds from environmental factors such as light and temperature. The study employed polysaccharides from renewable sources as encapsulating agents to optimize pigment retention and stability. Pigment solutions underwent centrifugation and freeze-drying to remove the excess solvent. Stability tests were conducted on the powdered extracts by varying light and temperature conditions, with color changes monitored through UV-Vis analysis and color gamut calculations. The goal of this research is to incorporate the stabilized pigment into food formulations, enabling the production of plant-based fish analogs with enhanced color and texture, further contributing to the advancement of sustainable and appealing seafood alternatives.

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### Alexandra Conde

Currently, Alexandra Conde is pursuing a Ph.D. in Chemical Engineering, with a central focus on the development of environmentally friendly downstream processes. Her research aims to develop efficient methods to stabilize pigments extracted from algae while simultaneously exploring ways to enhance the development of related products. These products are intended for applications within the cosmetics and pharmaceutical industries, aligning with her strong interests in green chemistry, sustainable processes, and harnessing renewable resources.

# Pairing Chlorella with Cost-Effective Byproducts to Develop Protein-Rich Food Innovations: Gelation Properties and Application in Cookies

Authors
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## ABSTRACT

The current work builds on previous findings that highlighted the emulsifying and gelling properties of two distinct microalgal biomasses—autotrophic *Chlorella vulgaris* (Auto-*Chlorella*) and heterotrophic Para*chlorella* kessleri (Hetero-*Chlorella*)—in protein-rich products such as food emulsions and plant-based ham. Based on these findings, a plant-based gelled dessert was formulated using *Chlorella*, κ-carrageenan, and starch. Rheological analysis and texture profiling confirmed successful gel formation at a protein concentration of 2.5 g/100 ml. The type of *Chlorella* used significantly influenced the gel's structural properties, with Hetero-*Chlorella* contributing to a more complex gel network, as evidenced by higher viscoelastic functions (G′, G″). Particle size analysis suggested that the larger particle sizes observed in the Hetero-*Chlorella* biomass played a key role in these rheological and structural differences. The increased particle size likely enhanced particle-particle interactions, providing a greater surface area for reactions and contributing to a stronger gel network with enhanced mechanical properties. In collaboration with Sumol-Compal, a leading beverage company, apple pomace was incorporated into the gel formulation to enhance sustainability. κ-Carrageenan was replaced with gellan gum (GG), and added sucrose was eliminated in favor of natural sweetness from apple pomace, optimizing the gel's nutritional value. To study the effect of GG concentration on rheological and texture properties, samples were formulated with 70% pomace, 30% water, and varying GG concentrations (0.25%, 0.5%, and 1.0%). The resulting gelled snacks displayed various textures: soft, spoonable gels, structured gels for fillings, and firm gels suitable for standalone products. Hetero-*Chlorella* was incorporated into a selected gel (0.5% GG) to enhance protein content, meeting food claim standards (12% of energy from protein). This protein-enriched gel was then used as a filling in an optimized cookie recipe, adding both sensory and nutritional benefits. The gels, as well as the filled cookie, were subjected to public sensory evaluations at a national event and a project meeting, receiving high acceptance, which demonstrated their strong market potential. These results emphasize the potential of pairing microalgae with cost-effective byproducts to create innovative, protein-rich, and consumer-friendly food formulations. By leveraging *Chlorella*'s functional properties and aligning with market trends, this approach not only enhances product acceptance but also promotes sustainability in the food industry.

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Sheyma Khemiri is a Biochemical Food Engineer with an MSc in Food Science and Technology and a PhD in Biological Engineering. As a postdoctoral researcher in the LEAF-Food and Feed Group, she works on the "VIIAFOOD" project, focusing on developing new food products with alternative proteins. Her research explores the functional properties of macromolecules, rheological behavior of food matrices, and the use of microalgae biomass and food industry by-products in sustainable food products. With over six years of experience, she has published 15 peer-reviewed articles and co-supervised master's theses, presenting at various national and international congresses.

1st INTERNATIONAL CONGRESS ON ALGAE BIOTECHNOLOGY

## POSTER SESSION

# ALGAE APPLICATION

# 10868 | GOING SUPER WITH SUPERNATANTS: ISOLATION, CHARACTERIZATION AND VALORIZATION OF EXTRACELLULAR VESICLES FROM INDUSTRIALLY RELEVANT SPECIES IN THE MICROALGAE SECTOR

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## ABSTRACT
Microalgae and cyanobacteria are increasingly recognized as promising and sustainable sources of relevant products [1]. While the focus is frequently centered on the intracellular potential of their metabolism, their supernatants also hold significant value but are frequently overlooked. Found in the supernatant, extracellular vesicles (EVs) are non-replicative biogenic nanoparticles secreted from the parent cell envelope to the extracellular medium and are considered key mediators of cell paracrine activity. EV composition and ability to protect and carry biomolecules to otherwise inaccessible targets, makes them a cutting-edge biotechnological tool for various applications [2]. Despite their potential, EVs in the microalgae sector remain unexplored, particularly when considering supernatants from industrially relevant species.
In this study, EVs from supernatants of the industrially relevant Chlorella vulgaris (industrial-scale culture, cultivated in heterotrophy) and Arthrospira platensis (lab-scale culture, cultivated in autotrophy) were investigated. After separating the cells by centrifugation, EVs were isolated through tangential microfiltration of the supernatants, followed by ultrafiltration, in which membranes with different cut-offs were evaluated. The resulting retentates were ultracentrifuged for further purification. The obtained EVs were then characterized through various methods, including protein analysis (BCA quantification and SDS-polyacrylamide gel electrophoresis), nanoparticle tracking analysis (particle concentration and size distribution) and transmission electron microscopy (morphology). The effects of freeze-drying on vesicle stability were also assessed. Considering their potential application in the aquaculture feed sector, freeze-dried EVs from these two species were further investigated for their bioactivity in an ex vivo screening platform based on fish intestinal explants, demonstrating interesting immunostimulatory properties.
This work sheds light on a largely unexplored area in the microalgae sector, highlighting the biotechnological potential of supernatants and their derived EVs, which are often overlooked and discarded. EVs from industrially obtained supernatants of other relevant species are now being isolated and characterized to evaluate their potential in aquaculture and beyond. (Arial 10 cor preto)

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## KEYWORDS
Microalgae, Biorefinery, Feed

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# 10905 | STANDARDIZATION AND OPTIMIZATION OF ENGINEERING WORKFLOWS IN A FILAMENTOUS CYANOBACTERIUM

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## ABSTRACT
Multicellular cyanobacteria produce a plethora of natural products with more than 1,100 metabolites identified1. Nevertheless, their potential remains largely untapped for biotechnological applications. In recent years, significant advances in engineering microalgae have been achieved. However, the existing toolkit in cyanobacteria is mainly restricted to unicellular strains.
In this study, we standardized and optimized engineering workflows for filamentous cyanobacterial hosts. We used Nostoc sp. PCC 7120 (herein, Anabaena 7120), a model filamentous freshwater strain, as a chassis. First, we improved transformation protocols by optimizing triparental mating conjugation protocols. This enabled faster and more robust strain generation: individual colonies can be obtained on plates in only five days compared to standard reports in the literature of 2–3 weeks2. Next, we adapted and expanded the GoldenGate-based CyanoGate MoClo syntax for Anabaena 7120. A new Level T plasmid, designed for genome integration and transferable via conjugation, was developed. We tested a diverse range of existing and new genetic regulatory elements using a fluorescent reporter protein assay. Finally, we characterized and compared several new integration sites on the genome and native plasmids. Expanding the modular genetic toolkit paves the way to unlocking Anabaena 7120 and other filamentous strains for the production of natural products and future biotechnological applications. (Arial 10 cor preto)

## REFERENCES
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2 Videau & Cozy, 2018, Curr Protoc Microbiol.

## ACKNOWLEDGEMENT/FUNDING
Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), SFB 1127 ChemBioSys, project number 239748522.

BIOGRAPHY SECTION
I hold a Bachelor’s in Biotechnology and a Master’s in Industrial and Molecular Biotechnology from the University of Bologna. During my Master’s, I spent a year at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig, conducting my thesis in collaboration with Bayer Crop Science. I later returned to UFZ as a research assistant in the Biophotovoltaic team, where I developed an interest in microalgae. Now in Jena, I am a PhD student in Julie A. Z. Zedler’s group, focusing on synthetic biology and optimizing phototrophic production using unicellular and filamentous cyanobacteria in axenic and community contexts.

## KEYWORDS
Microalgae, Environmental solutions/ Circular Economy

# 10910 | THE ANTIVIRAL AND ANTI-ANGIOGENIC POTENTIAL OF POLYSACCHARIDES EXTRACTED FROM THE RED ALGA PLOCAMIUM CARTILAGINEUM: CHEMICAL AND STRUCTURAL CHARACTERIZATION

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**ABSTRACT**
Marine algae are abundant in the marine environment and hold great potential as a source of bioactive compounds. This study focused on evaluating the properties of a sulfated polysaccharide (PSPC) extracted from Plocamium cartilagineum, a Moroccan red macroalga collected in the El Jadida region.

The PSPC was analyzed for its chemical composition using techniques such as UV–visible spectroscopy, Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (X-RD), scanning electron microscopy (SEM), and high-performance liquid chromatography coupled to mass spectrometry (HPLC-MS), and for its antiviral activity, cytotoxic and anti-angiogenic effects were evaluated.

The PSPC showed strong antiviral activity against herpes simplex virus (HSV-1), with an $EC_{50}$ of 3.84 ± 2.8 µg/mL and no cytotoxic effect was observed on the Vero cells. It also demonstrated anti-angiogenic potential in chorioallantoic membrane assays, reducing vascular branching by 35.82% ± 2.28% and 46.26% ± 2.22% at concentrations of 50 and 100 µg/egg, respectively.

This study highlights the potential of Plocamium cartilagineum sulfated polysaccharides as antiviral, and anti-angiogenic agents, making them promising for therapeutic use.

**KEYWORDS**
Plocamium cartilagineum, Polysaccharides, antiviral activity, anti-angiogenic activity.

# 10912 | ANTI-DERMATOPHYTICL POTENTIAL OF POLYSACCHARIDES EXTRACTED FROM THE BROWN ALGA FUCUS SPIRALIS: CHEMICAL AND STRUCTURAL CHARACTERIZATION

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**ABSTRACT**
Dermatophytosis, a prevalent fungal infection that affects the skin, nails, and hair, represents a substantial public health concern. It is primarily caused by zoophilic fungi from the Trichophyton and Microsporum genera, with Trichophyton rubrum and Microsporum canis being the most common pathogens in humans. Although antifungal treatments are available, the increasing prevalence of drug resistance and the limited effectiveness of conventional therapies often result in recurring infections. Moreover, prolonged use of antifungal medications can lead to systemic side effects, such as hepatotoxicity and leukopenia.
Natural products have long been regarded as promising antifungal agents with minimal side effects. Marine macroalgae, in particular, are a rich natural source of bioactive compounds.
The present study had two objectives: firstly, to extract and characterize the polysaccharides of the brown alga Fucus spi ralis, collected from Sidi Bouzid, El Jadida (Morocco), using techniques such as UV–visible spectroscopy, Fourier Transform Infrared (FT-IR) spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), and high-performance liquid chromatography coupled with mass spectrometry (HPLC-MS). The second objective was to evaluate their anti-dermatophyticl activity against two fungal strains, Trichophyton rubrum and Microsporum canis, using a microdilution methodology.
This study highlights the potential of Fucus spiralis polysaccharides, which demonstrated significant antifungal activity against the fungal agents responsible for human skin infections, making them promising for therapeutic use against dermatophytosis.

**KEYWORDS**
Fucus spiralis Polysaccharides, Anti-dermatophyticl activity, FTIR, HPLC-MS, Macroalgae

# 10913 | FORMULATION AND EVALUATION OF PTEROSIPHONIA COMPLANATA EXTRACT GEL FOR THE TREATMENT OF VULVOVAGINAL CANDIDIASIS IN A MURINE MODEL

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**ABSTRACT**

Vulvovaginal candidiasis (VVC) is a frequent fungal infection caused principally by Candida albicans and Candida glabrata, which can result in considerable physical and psychological discomfort. The emergence of antifungal resistance underscores the necessity for alternative treatment strategies.

Marine macroalgae, in particular, represent a rich source of bioactive compounds with broad-spectrum antimicrobial properties, and are considered to be diverse in their applications, creating potential for their use in this field.

This study developed a gel (Pter-compla 1%) from Pterosiphonia complanata for treatment of vulvovaginal candidiasis caused by Candida albicans and Candida glabrata. The antifungal activity of the extract was evaluated in vitro using the microdilution method, which revealed significant efficacy, with minimum inhibitory concentrations of 31.25 µg/mL against Candida albicans and 125 µg/mL against C. glabrata. Toxicity tests on Vero cells and Artemia salina confirmed the non-toxic nature of the extract.

An in vivo mouse model demonstrated that the gel reduced fungal load and inflammation in vaginal tissues while normalising elevated white blood cell counts associated with infection.

The findings of this study indicate that Pterosiphonia complanata gel is a promising therapeutic option for treating vaginal Candida infections.

**KEYWORDS**

Vulvovaginal candidiasis, Candida albicans, Candida glabrata, antifungal, Pterosiphonia complanata, Pter-compla 1% gel, murine model, Macroalgae

# 10915 | WAVES OF CHANGE: ULTRASOUND AND MICROWAVES OPTIMIZING SUSTAINABLE HYDROCOLLOID-ASSISTED EXTRACTION FROM SEAWEEDS

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## ABSTRACT
With the growing demand for sustainable clean-label ingredients, optimizing extraction methods is crucial for improving efficiency and reducing environmental impact. Hydrocolloids from red algae, valued for their functional properties and health benefits, are widely used across industries. However, conventional techniques, such as enzymatic hydrolysis and acid-base treatments, require high energy input and long processing times, limiting scalability and sustainability. In response, ultrasound-assisted (UAE) and microwave-assisted extraction (MAE) offer efficient alternatives while preserving hydrocolloid functionality. UAE uses acoustic cavitation to generate localized heat and pressure, disrupting cell walls and releasing polysaccharides. Similarly, MAE employs electromagnetic waves to induce dipole rotation and ionic conduction, enhancing mass transfer through rapid internal heating.
The aim of this study is to compare the effectiveness of MAE and UAE for extracting hydrocolloids from red macroalgae, focusing on yield, gel strength, and rheological properties. An environmentally friendly extraction approach is being applied, avoiding the use of harsh chemicals, reducing the environmental impact of the process, and increasing the bioactive properties of the extracts. The dried macroalgae (Chondrus crispus, Gracilaria gracilis, Gelidium corneum) were hydrated in distilled water at a solid-to-liquid ratio of 1:15 under constant stirring at room temperature for 30 minutes to ensure uniform hydration. UAE was conducted at 60°C for 1 hour, while MAE was conducted at 60°C for 10, 15, and 20 minutes to assess the influence of time on hydrocolloid extraction efficiency.
Extraction efficiency was evaluated through rheological analysis (temperature, time, and frequency sweeps), texture assessment post-gelation, and dry weight determination after lyophilization. Compared to UAE, MAE significantly reduced extraction time while preserving hydrocolloid integrity, particularly yield, gel strength, and rheological properties. These findings support prior research on MAE's efficiency in polysaccharide extraction while maintaining functional properties. Further analyses will explore the impact of extraction parameters on bioactivity, aiding in the optimization of sustainable methodologies for industrial applications.

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## KEYWORDS
Environmental solutions/ Circular Economy, Algae Market, Macroalgae, Food

# 10919 | CYANOBACTERIAL DIVERSITY IN NORTHERN PORTUGAL: NEW TAXA DESCRIBED FROM THE CIIMAR BUILDING AREA

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## ABSTRACT
The CIIMAR building area, located at the Porto de Leixões Cruise Terminal in Matosinhos, northern Portugal, is an important spot for different types of cyanobacteria due to continuous maritime traffic. Terrestrial cyanobacteria are underexplored in northern Portugal, and are considered a rich source of secondary metabolites with significant biotechnological potential, but they also produce potent cyanotoxins that pose risks to human health. Here, we employed a polyphasic methods, comprising 16S rRNA gene Maximum Likelihood and Bayesian Inference phylogenies, 16S rRNA identity (p-distance), 16S-23S ITS secondary structures, morphological and habitat analyses. The presence of microcystin, cylindrospermopsin, anatoxin, and saxitoxin also be assessed for all strains. Our work result in thirteen isolates distributed by Desertifilales (1), Leptolyngbyales (1), Oculatellales (1), Oscillatoriales (2), Chroococcidiopsidales (3), Geitlerinematales (1), Nostocales (4) orders. Also, we described two new genus (into Desertifilales and Chroococcidiopsidales orders) and one new species (into Chroococcidiopsidales order). Additionally, a new genus (into Chroococcidiopsidales order) has some unique features never seen before in cyanobacteria. These findings contribute to the expanding knowledge of terrestrial cyanobacterial diversity and highlight the need for integrative taxonomic approaches in future studies.

## ACKNOWLEDGMENTS
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## KEYWORDS
cyanobacteria, LEGE-CC, polyphasic approach, taxonomy, terrestrial environment, Microalgae

# 10935 | MICROALGAE-DERIVED BIOACTIVES: A NATURAL APPROACH TO COMBAT INFLAMMATION

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## ABSTRACT
Microalgae produce valuable bioactive compounds, including carotenoids, polyunsaturated fatty acids, phenolics, terpenes, and sulphated polysaccharides, known for their antimicrobial, anti-inflammatory, antioxidant, and anti-tumoral properties. Beyond these known compounds, microalgae biomass remains an untapped resource with the potential to yield novel bioactives with unique structures, making them promising candidates for therapeutic and nutritional applications.
As chronic inflammation is one of the cornerstones of most modern-day human ailments (diabetes, cancer, hypertension, neurological diseases, dyslipidemia, cardiovascular diseases, obesity, among others) it is imperative to provide anti-inflammatory compounds which not only are of natural origin but also display less side effects than the anti-inflammatory drugs currently available on the market.
Microalgae's ability to produce secondary metabolites with diverse bioactivities, including anti-inflammatory properties, makes them potentially beneficial for human health, thereby positioning microalgae in the biotechnological spotlight for applications in a variety of fields, such as human nutrition, nutraceutical, and medicinal goods.
The purpose of this study was to assess bioactive properties of different industrially produced microalgal and to find potential sources of biologically active substances that might assist in the treatment of different human ailments.
In this study, ethanol, ethyl acetate and hexane extracts from four commercially available microalgae species (ALGAE4IBD_46, ALGAE4IBD_47, ALGAE4IBD_230, ALGAE4IBD_237)* were evaluated for their cytotoxicity in human macrophage differentiated THP-1 cells (Mac THP-1 cells) through MTS assays, and anti-inflammatory properties in liposaccharide (LPS) stimulated Mac THP-1 by quantification of Tumor Necrosis Factor alpha (TNF-α) and Interleukin-1 beta (IL-1β) accumulation.
Fractionation of crude extracts resulted in several bioactive fractions with a powerful anti-inflammatory effect, in some cases, stronger than the reference compound dexamethasone – a commercially available prescription anti-inflammatory drug.
The tentative identification of compounds in most promising fractions through untargeted metabolomics is ongoing.
Overall, these findings indicate that fractions derived from industrially cultivated microalgae species have the potential to serve as new sources of bioactive compounds, which could be valuable for the development of functional foods or nutraceutical products, thereby addressing health challenges in society.

* - This work is part of a H2020 project, Algae4IBD (GA: 101000501). As the results presented here are under a patenting process, the identity of the used strains cannot currently be disclosed.

## KEYWORDS
Microalgae, Food, Supplements and cosmetics, Algae Market

# 10936 | DEVELOPMENT OF AQUAFEED BASED ON MICROALGAE

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**ABSTRACT**
The increase and rapid population growth, higher demand of fish is driving the aquaculture industry to rapid expansion. One of the main challenges in aquaculture industry is to ensure sustainable feeds. Historically, fishmeal and fish oil were considered the two most essential ingredients, with essential benefits, but the decrease in the availability, the increase in the prices of fishmeal and fish oil have prompted the search for sustainable alternatives for aquaculture feeds. This has resulted to utilization of some plant based aquafeed, to substitute fish meal and fish oil, one of the most utilized plant based aquafeed and the alternative protein source to fish meal is soybean meal. However, the use of aquafeed high in plant protein affect the growth performance, and the production of soybean meal requires important arable land, that could be used for crops for human consumption. The aquaculture industry's growth is currently being driven by increased human consumption, as a result, researchers must look for sustainable and suitable feed ingredients to substitute fish meal, fish oil and soybean meal.
Microalgae are expanding continuously in different domains such as bioenergy and production of biofuel, agriculture, wastewater treatment, pharmaceutical, food, and feed industries. Major components of microalgal biomass are proteins with essential amino acids, lipids with polyunsaturated fatty acids (PUFA), carbohydrates, pigments, and other bioactive compounds.
Focusing on microalgae as alternative aquafeed is gained interest because microalgae are a primary producer in aquatic food chains, have an appropriate and well-balanced biochemical composition, naturally, omega 3 fatty acid rich microalgae were found to be a suitable substitute for lipids in feed, as well as fish oil, and microalgae contain proteins that can be used as alternative to fish meal proteins.
The fish feed alternative must be high nutritional value, rich in omega 3 fatty acids, protein content, essential amino acids, digestibility, and taste. Microalgal biomass is rich in essential nutrients, and present advantages to be utilized as source of aquafeed.
Our study will investigate the potential application of microalgae in aquaculture feed, nutritional value, and possible replacement of conventional feed ingredients.

**KEYWORDS**
microalgae, aquaculture, aquafeed, biochemical composition, sustainability, circular economy, Microalgae, Feed, Environmental solutions/ Circular Economy

# 10938 | EXPLORING SUGAR AND ORGANIC ACID DYNAMICS IN SOURDOUGH FERMENTATION SUPPLEMENTED WITH CHLORELLA VULGARIS AND SPIRULINA: IMPACT ON THE NUTRITIONAL QUALITY AND DIGESTIBILITY OF WHEAT BREAD

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## ABSTRACT
The incorporation of microalgae into sourdough can influence fermentation by interacting with the sourdough microbiota, altering microbial activity and metabolite production. These interactions enhance flavor development and contribute to greater aromatic complexity.
This work aims to study the impact of microalgae on sourdough fermentation and bread quality. Dried biomass of Chlorella vulgaris and Limnospira platensis (Spirulina) was incorporated at 4% (w/w) into the sourdough starter. The fermentation process was monitored until the pH stabilized. High-performance liquid chromatography (HPLC) was used to analyze the chemical composition of the sourdough, quantifying key fermentation metabolites, including organic acids (acetic acid, lactic acid, and glutamic acid), sugars (glucose and maltose), and ethanol. Additionally, 3% (w/w) microalgae were incorporated into the bread dough formulation, which consisted of 72% wheat flour and 25% sourdough, resulting in a final algae content of 4% (w/w) in the bread. The resulting bread was evaluated for its nutritional composition, bioactivity, and digestibility.
HPLC analysis revealed that microalgae supplementation significantly influenced sugar metabolism and organic acid production during sourdough fermentation compared to the control (sourdough without algae). C. vulgaris and Spirulina notably enhanced lactic acid production (2.0% in sourdough with microalgae vs 1.5% in the control), while sourdough with Spirulina exhibited lower concentrations of acetic acid and ethanol. In the nutritional assessment of sourdough bread, enriched formulations showed increased protein content and an improved mineral profile, meeting the requirements of Regulation (EC) No. 1924/2006 for health claims. The control bread derived 18% of its total energy from protein, qualifying as a "source of protein" (≥ 12%). Bread enriched with C. vulgaris (21%) and Spirulina (21%) met the "high in protein" claim (≥ 20%). The bioactivity and total phenolic content (TPC) of bread extracts was assessed using FRAP and DPPH, and the Folin-Ciocalteu method. Results showed a significant increase in TPC and antioxidant capacity in enriched bread. Regarding digestibility, protein hydrolysis assays revealed a higher degree of protein digestion in microalgae-enriched samples, suggesting enhanced protein bioavailability.

## ACKNOWLEDGEMENTS
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## BIOGRAPHY
Nancy Mahmoud is a PhD candidate in Food Engineering at the Instituto Superior de Agronomia (ISA), University of Lisbon. Since 2023, she has been conducting research at LEAF, ISA, exploring innovative strategies to enhance the sensory attributes of algae-based bread. To date, she has published a scientific paper and a book chapter and has presented her work at several international and national conferences.

## KEYWORDS
Microalgae, Food

# 10952 | SYNTHESIS OF METAL NANOPARTICLES FROM ALGAE EXTRACTS FOR ANTIMICROBIAL APPLICATIONS

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## ABSTRACT
Metal nanoparticles are widely used in science to enhance chemical, biological, and physical processes. Silver nanoparticles (AgNPs) are particularly valued for their antimicrobial and antifungal properties, as well as their thermal and optical properties, high electrical conductivity, ease of synthesis, and strong surface absorption capacity. In addition to utilizing nanoparticles, science must embrace sustainable approaches to make large-scale processes more environmentally friendly. Algae biomass plays a key role in green processes due to its antimicrobial and anticancer properties, as well as its stabilizing and thickening abilities, making it highly valuable across industries [1].
The main aim of this project is to develop a sustainable alternative to conventional antifouling coatings, which often contain toxic biocides that harm ecosystems and human health [2]. To achieve this, we explore the green synthesis of bioactive silver nanoparticles (AgNPs) using natural algae extracts (e.g. Ulvophyceae, Florideophyceae, and Phaeophyceae) provided by AlgaPlus, Lda, optimizing their production methods [3]. AgNP formation is confirmed via UV/Vis spectroscopy, ensuring suitability for commercial coating formulations. Their properties are analysed using FTIR, TEM, and DLS, while HPLC-DAD detects bioactive compounds from biomass on the NPs. The ultimate goal is to immobilise AgNPs into a silicone-based (PDMS) coating and assess their effectiveness against a model bacterial biofilm [4], demonstrating their potential for eco-friendly antifouling applications.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Environmental solutions/ Circular Economy, Algae Market, Macroalgae, Production, Microalga

# 10953 | EVALUATION OF MICROALGAL BIOMASS AS BIOFERTILISER: CONVERSION OF MARINE AQUACULTURE WASTEWATER INTO AGRICULTURAL INPUTS

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**ABSTRACT**
The rapid growth of the world's population has increased pressure on natural resources, agriculture, and the environment, particularly as a result of the rising demand for food. Conventional agriculture plays a critical role in meeting this demand but has also led to increasing dependence on chemical fertilisers and pesticides. However, their intensive use has led to several environmental problems including the degradation of soil quality, pollution of water, and threats to biodiversity. In addition to environmental concerns, chemical fertilisers have significant limitations regarding the sustainability of their sources. Chemical fertilisers such as phosphate-based fertilisers rely on finite resources such as phosphate rock, while nitrogen-based fertilisers require large amounts of energy from fossil fuels to be produced.

In contrast, phycoremediation offers a sustainable alternative by using wastewater as a low-cost nutrient source. Microalgae efficiently encapsulate and convert essential nutrients and organic matter into forms readily available to plants, such as amino acids, phytohormones and other beneficial compounds. This study aims to determine the optimal dose of microalgal biomass to produce positive effects on seed germination. Seed germination affects crop production, quality optimum plant growth and yield.

The microalgal biomass was a bloom produced outdoors in semi-continuous systems using aquaculture wastewater under different nutrient conditions. The biomass was then harvested and dehydrated by centrifugation to form a paste.
The crop species tested in the seed germination experiments include four fast-growing fresh crops (Brassica rapa pekinensis -Chinese cabbage; Lepidium sativum -watercress; Lactuca sativa -lettuce; and Capsicum annuum L. -pepper) and two slower-growing industrial crops (Hordeum vulgare -barley and Triticum spp. -Don Ricardo durum wheat). The results show the differences among doses and the effect on the species of seeds, indicating the potential use as biofertilizer.

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**KEYWORDS**
Microalgae, Agriculture, Environmental solutions/ Circular Economy

# 10966 | EXPLORING THE WOUND HEALING AND ANTI-INFLAMMATORY POTENTIAL OF TETRASELMIS STRIATA EXTRACTS FOR SKIN REPAIR APPLICATIONS

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## ABSTRACT
The skin is a crucial protective barrier against external threats, making rapid healing essential upon injury. The cosmetic industry has increasingly focused on developing products that enhance skin repair and tissue regeneration. Bioactive compounds found in algae extracts offer promising applications for healing injured skin, making them valuable ingredients for innovative skincare products. This study investigated the biological properties of Tetraselmis striata extracts on human dermal fibroblasts and monocytes, aiming to evaluate their potential for treating skin injuries by improving healing outcomes and reducing inflammation.
Fibroblast cells were treated with various concentrations of four T. striata extracts and cell viability was measured using the MTT assay. Among these, Tst_90 showed no cytotoxicity across the tested concentration range; therefore, we proceeded with this extract for further analysis. We evaluated the wound healing capability of Tst_90 through a scratch assay, measuring cell migration in fibroblasts. Additionally, we assessed the extract's antioxidant activity through the ABTS assay and by examining its ability to reduce menadione-induced oxidative stress in fibroblasts. To investigate anti-inflammatory properties, we analyzed the effect of Tst_90 on pro-inflammatory cytokine secretion in THP-1 human monocytes.
Results indicated that treatment with Tst_90 accelerated wound closure by 61% and 75% after 24 and 32 hours, respectively. The extract showed an antioxidant activity of around 70% in the ABTS assay, although this was not reflected in the percentage of ROS-positive cells. In addition, the extract demonstrated anti-inflammatory properties by reducing TNF-α secretion by 95% and IL-6 secretion by 66% in LPS-stimulated monocytes.
Taken together, our findings suggest that T. striata has potential for promoting skin repair and regeneration. The Tst_90 extract demonstrated effective wound healing properties in fibroblasts and anti-inflammatory effects in monocytes. These findings highlight the value of algae extracts as innovative ingredients for skincare products such as creams, serums and masks that promote skin repair and reduce inflammation.

## KEYWORDS
Microalgae, Supplements and cosmetics, Algae Market

# 10892 | ALGAE VALORISATION INTO NEW SUSTAINABLE ADDITIVES FOR THE TEXTILE INDUSTRY

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## ABSTRACT

The ecological and health concerns related to synthetic dyes and chemicals in the textile industry highlight the need for eco-friendly and sustainable alternatives, bringing natural materials back to the forefront as a viable solution. The colouring potential of algae pigments, together with their reported functionalities and environmental benefits, make the exploration of these natural materials an appealing path to follow in this industry, creating a synergy between the 2 sectors. This project aims to study different extraction processes with more sustainable techniques and materials to obtain pigments and functional compounds from algae and scale up the process. Additionally, algae-based materials are being incorporated into fibres and woven and knitted fabrics.

Concerning the extraction processes, various techniques were tested, including ultrasound-assisted extraction, enzyme-assisted extraction, pressurized liquid extraction and microwave-assisted extraction. These methods were used to obtain aqueous and hydroethanolic freeze-dried extracts from various microalgae. Generally, the resulting pigments exhibited colors such as green, yellow, pink and blue, with antioxidant activities ranging from 3% to 90%, very interesting for textile applications.

In terms of material incorporation, algae-based compounds are being incorporated into fibres and textile structures through a more sustainable technology. Fibre production begins with the incorporation of microalgae or their extracts into a biopolymer through compounding extrusion. The resulting compound is then processed by melt-spinning, where algae biomass works as a natural dye and others additional functionalities, such as antioxidant properties. Furthermore, algae-based materials are being applied on textile structures through spray coating technology and the treated fabrics exhibit the presence of antioxidant and anti-UV properties, in addition to natural dyeing.

These developments pave the way for a new generation of environmentally, socially, and economically responsible textile products. They offer high-value textiles with enhanced functional properties, representing a significant step toward sustainability in the industry.

## ACKNOWLEDGEMENT

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## KEYWORDS

Microalgae, Environmental solutions/ Circular Economy

# 10970 | LIPIDOMIC INSIGHTS INTO THE IMPACT OF IN VITRO INTESTINAL LIPID DIGESTION OF FOUR DIFFERENT STRAINS OF CHLORELLA VULGARIS

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## ABSTRACT
Microalgae have emerged as a promising source of organic and sustainable ingredients, offering a wide range of nutrients and bioactive compounds, including lipids.
Chlorella vulgaris is a widely used microalga in the food industry, with its market size and value steadily increasing. Several edible strains of C. vulgaris, such as C-Auto, C-Hetero, C-White, and C-Honey, are commercially available, each offering different organoleptic properties tailored to consumer preferences in flavor and aroma.
Despite the potential health benefits of consuming C. vulgaris lipids, since they are rich in essential omega-3 and omega-6 polyunsaturated fatty acids (PUFA), which vary depending on the algae strain, little is known about their digestibility and absorption capacity by the human body, to access the circulation system, and thus to reach the appropriate target location.
Therefore, the aim of this work was to evaluate the digestibility of lipids from 4 strains of C. vulgaris using an in vitro model of intestinal digestion using an in vitro digestion protocol with pancreatin to digest lipids (INFOGEST). The lipid profile before and after enzymatic digestion was analyzed by liquid and gas chromatography coupled to mass spectrometry (LC-MS and GC-MS).
A clear decrease in the polar diacyl species (from phospholipid, glycolipid and betaine lipid classes) and an increase in the lyso species was observed after enzymatic digestion for lipids belonging to the four C. vulgaris strains. Regarding C-Honey, a strain rich in neutral lipids (mainly triglycerides), low digestion efficiency was observed, which may be explained by the greater difficulty in forming micelles due to the lower content in polar lipids.
Overall, these results highlight the importance of the study of the digestion of lipids from algae, as variations in lipid profiles, among different algae, can influence their digestion and, consequently, the nutritional and bioactive potential of their lipids.
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## KEYWORDS
Microalgae, Food, Supplements and cosmetics, Environmental solutions/ Circular Economy

# 10982 | UNVEILING THE HIDDEN TREASURES OF LEGE CULTURE COLLETION

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**ABSTRACT**
Natural products (NPs) (often referred as specialized or secondary metabolites) are an unparalleled source of bioactive compounds, many of which are applied in different fields such medicine or agriculture. Traditionally, these compounds were isolated by bioactivity-guided approaches; however, advances in genomics and bioinformatics, have paved the way for modern genomics-based discovery approaches. In microbial genomes, genes for the synthesis of NPs are physically grouped together in biosynthetic gene clusters (BGCs). Advances in sequencing technologies and bioinformatics tools have played a pivotal role in the discovery of BGCs through genome mining revealing that bacteria are a massive untapped trove of new metabolites that is reflected in a much greater biosynthetic diversity than the compounds characterized so far. In the last years, Cyanobacteria have been pointed out as one of the most promising groups of bacteria as producers of NPs due to their potent bioactivity and structural uniqueness. However, there are few reports exploring the biosynthetic potential of these organisms. This study focuses on describing the natural product genetic potential in cyanobacterial strains from an important Culture Collection from Portugal, the Blue Biotechnology and Ecotoxicology Culture Collection (acronym LEGE), which harbor more than 700 cyanobacterial strains covering a wide range of geographical habitats. Regardless of such biodiversity, only a small fraction of the diversity present at LEGE CC was studied and chemodiversity potential of many unique strains remains unknown. In this work, we report 100 newly-generated LEGE strains genomes in Cyanobacteria, which expand the genomic representation of the Phylum from undersampled habitats, mainly from Portugal. Using phylogenomics and sequence similarity BGC networking analysis, we characterize the biosynthetic potential of cyanobacterial strains from LEGE Culture Collection. Our results highlight a number of highly interesting BGCs for genome mining among these cyanobacterial strains that could open new avenues for drug discovery.

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**KEYWORDS**
Microalgae

# 10992 | SUSTAINABLE PRODUCTION AND VALORIZATION OF MICROALGAL BIOMASS FROM ULTRAFILTRATED LIVESTOCK DIGESTATE

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## ABSTRACT
The management of anaerobic digestate effluent is essential to avoid negative impacts like land and water contamination and eutrophication of water bodies. Microalgae offers a promising solution since they can recover nutrients from these effluents while capturing atmospheric CO2, converting them in new biomass and high bioproducts.
The integration of digestate into microalgae cultivation reduces the need for external inputs, creating a synergistic loop between microalgae cultivation and anaerobic digestion. This recycling process not only lowers production costs but also enhances the sustainability of the overall system by reducing carbon and water footprint.
The high turbidity of the digestate, the presence of the microbial component and solid suspension presents several challenges. This work describes an innovative ultrafiltration system to separate and concentrate nutrients from digestate effluents, facilitating the successful cultivation of different algal species, with the best results obtained in the case of Chlorella sorokiniana and Nannochloropsis oceanica. Testing different ultrafiltrate concentration and light regimes it was possible obtain up to 133% increase in growth rate and biomass accumulation compared to optimal synthetic medium, recovering nearly all nitrogen and phosphate.
To close the rim of the circular economy, biomass obtained from algal growth was successfully used as a biostimulant on crops of interest. This sustainable approach can reduce upstream and downstream costs of algal production and valorize industrial waste into new bioproducts, reducing the need for synthetic fertilizers.

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## KEYWORDS
Microalgae, Production, Agriculture, Environmental solutions/ Circular Economy

# 11002 | ENCAPSULATION OF ALGAE LIPID EXTRACT IN NANOEMULSIONS FOR FOOD APPLICATIONS

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## ABSTRACT
Algae lipids, particularly those rich in polyunsaturated fatty acids, have attracted growing interest as functional ingredients due to their health-promoting properties. However, their incorporation into food systems remains challenging due to poor stability, low bioavailability, and susceptibility to oxidative degradation. To address these limitations, lipid-based nanosystems, such as nanoemulsions (NEs), have emerged as promising delivery platforms.
This study aimed to encapsulate an algal lipid extract (LE), produced using food-grade solvents, in stable NEs for potential food applications. The LE was obtained via ultrasound-assisted extraction with ethyl acetate from an algae blend (Algaessence®) and subsequently characterized for its lipid composition. To develop the LE loaded-NEs (LE–NEs), the lipid phase (1 wt%) was formulated by incorporating the LE into either medium-chain triglyceride (MCT) oil or sunflower (SUN) oil, while the aqueous phase (99 wt%) contained rhamnolipids as a biosurfactant (0.05 wt%). NEs were then produced using a two-step process: pre-homogenization followed by high-energy ultrasonication. Control NEs were prepared without LE for comparative analysis. The physicochemical properties of NEs were assessed by measuring particle size (PS), polydispersity index (PDI), zeta potential, and stability under varying pH conditions. The antioxidant activity of LE and NEs was evaluated using standard DPPH and ABTS assays.
Results indicate that LE–NEs exhibited favorable characteristics, including small PS (MCT: 137.4±2.6 nm; SUN: 164.7±2.9 nm), low PDI (MCT: 0.205±0.026; SUN: 0.237±0.014), and stable zeta potential (MCT: –70.9±1.9 mV; SUN: : –70.2±3.3 mV), suggesting good colloidal stability. The composition of the lipid phase influenced the physicochemical properties of the LE–NEs, with notable differences between MCT- and SUN-based formulations. Notably, LE–NEs displayed smaller PS compared to NEs controls, indicating a structuring effect of the LE. Furthermore, LE–NEs demonstrated superior resistance to pH-induced destabilization (pH 2.5–9), outperforming unloaded NEs, thereby highlighting their potential for incorporation into diverse food matrices. Encapsulation also significantly enhanced the antioxidant activity of the LE, as evidenced by an increase in $ABTS^{\bullet+}$ (MCT: 45.2%; SUN: 39.4%) and DPPH• (MCT: 23.2%; SUN: 13.6%), further confirming the protective role of the emulsion system.
In conclusion, the successful encapsulation of algal lipids in NEs reinforces their potential as an effective delivery system for functional food ingredients. The developed formulations exhibited promising stability characteristics and bioactive properties. Future research will focus on evaluating whether the encapsulated extract in nanoemulsions exhibits higher bioavailability compared to the non-encapsulated extract, as well as assessing the functional performance of the emulsions in real food systems.

## KEYWORDS
Macroalgae, Microalgae, Food

# 11005 | EVALUATION OF POTENTIAL USES OF MICROALGAE EXTRACTS IN COSMETICS: TARGETING SKIN MICROBIOTA AND MICROBIOME FOR DEVELOPMENT OF SUSTAINABLE DERMATOLOGICAL AND COSMETICS SOLUTIONS

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## ABSTRACT
The human skin microbiota and microbiome have been increasingly subjects of studies in recent years. Staphylococcus epidermidis and Cutibacterium acnes, two commensal and abundant bacteria present in the skin, are involved in dysbiosis processes in this organ. C. acnes is particularly known to contribute to the development of acne vulgaris (AV) and is also implicated in scalp disorders such as androgenetic alopecia (AA). For treatment of AA there has been research where compounds' evaluation has been performed and found to restore healthy scalp skin and consequently not only prevent hair loss but also promote hair growth. Regarding AV, even though there are responses for treatment with topical and/or oral antibiotic, resistance tends to occur. Due to these reasons, there is a demand to find sources with bioactive compounds that show antimicrobial activity or at least enhance the potency of already established antibiotics.
One of these sources can be algae, more specifically microalgae, or even cyanobacteria commonly known as blue-green algae. Both these organisms tend to have compounds with antioxidants, anti-inflammatory and antimicrobial activities beneficial for dermatological and cosmetics applications. Our ongoing study involves a screening of extracts using from microalgae such as Tetraselmis chui and Haematococcus pluvialis, and the cyanobacteria Spirulina platensis using different solvents (methanol, ethanol and acetone) produced by bead beating. Previous research has reported antimicrobial activity of extracts from some of these organisms against bacteria involved in human skin microbiota. To assess their antimicrobial' potentials a disc diffusion assay was performed against C. acnes strains ATCC 6919 and DSM 30738, and S. epidermidis strain DSM 20044 according with CLSI guidelines.
The results showed that using around 0.6 mg of crude extract from Spirulina platensis acetone and methanol there was inhibition on all tested bacteria. The methanol extract compared to the acetone presented a 11 vs. 9 mm and 10 vs. 9 mm inhibition zone for both S. epidermidis and C. acnes strains DSM 30738, respectively. However, the opposite was found for ATCC 6919 strain with a 16 vs. 10 mm for acetone and methanol extracts, respectively. While current research links this latter strain with AV by being present in high concentrations, no specific phylotype has been identified in AA. Once the active compounds responsible for antimicrobial activity are identified and purified there is potential to develop targeted formulations for acne and scalp disorders.

## KEYWORDS
Microalgae, Supplements and cosmetics, Algae Marke

# 11008 | ANTI-INFLAMMATORY AND ANTIOXIDANT POTENTIAL OF HAEMATOCOCCUS PLUVIALIS EXTRACT FOR THERAPEUTIC AND COSMETIC APPLICATION

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## ABSTRACT
Chronic inflammation is the main pathophysiological factor in various diseases, such as skin diseases and intestinal diseases, as Cronh's disease. The body is systematically exposed to external factors responsible to produce reactive oxygen species (ROS), which stimulate the inflammatory process in various tissues in the body. Natural products, such as algae and plants, have been increasingly used as potential treatments for various diseases due to their therapeutic benefits and lower impact on the body. The microalga Haematococcus pluvialis has gained relevance in several studies due to its antioxidant and anti-inflammatory activities.
The aim of this study was to evaluate the antioxidant and anti-inflammatory of an apolar extract of H. pluvialis, different from astaxanthin extract, using in-vitro assays in monocytes and fibroblasts to determine cell toxicity, interleukins production and protection from ROS induced with menadione. The MTT assays in monocytes THP-1 and fibroblasts CCD-1064sk, reveals no cytotoxicity. In monocytes the extract inhibited TNF-α by 39%, IL-1β by 86 % and IL-6 by 100%. Antioxidant activity using DPPH assay revelled an antioxidant activity of 37%, nevertheless in fibroblasts was obtained ROS protection with a reduction of 80% regarding to control.
Considering the outcomes obtained in in-vitro assays has been performed studies in-vivo using Drosophila melanogaster model to demonstrate the extract efficacy in the inflammatory process. Assays of survival, oxidative stress markers, gene expression, and gut histology have been conducted to determine extract application in irritable bowel diseases.
The results of this work highlight the promising antioxidant and anti-inflammatory properties of the Haematococcus pluvialis apolar extract. Its ability to inhibit important pro-inflammatory interleukins and reduce oxidative stress in in-vitro models suggests its potential therapeutic application in inflammatory-related diseases.

## KEYWORDS
Microalgae, Supplements and cosmetics

# 10571 | BIOREMEDIATION OF RESTAURANT WASTEWATER USING EXTREMOPHILIC GALDIERIA SULPHURARIA IN SUB TROPICAL WEATHER CONDITIONS: AN APPROACH CONTRIBUTING TO CIRCULAR BIOECONOMY AND ENVIRONMENTAL SUSTAINABILITY

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**ABSTRACT**
Ecological pollution is a critical global problem with harmful actions on human health in addition to reducing useful environmental resources. Wastewater also has a biohazard effect on the biological ecosystem due to the high concentrations of inorganic, organic and heavy metals pollutants. Bioremediation is the removal of chemical contaminants by using microorganisms, such as microalgae, fungi, and bacteria. This method enables effective ecological biorefinery with no harmful effect, if the provided microorganisms do not interfere with the existing biodiversity. In addition to the efficiency of microorganisms to overcome high concentration of heavy metals. Microorganisms carry out waste heavy metals in one of two ways: either by oxidizing or reducing the harmful substances and metal ions, to dissolve the surrounding minerals of the target metal ion to acquire the pure metal. Microalgal bioremediation of wastewater possesses the following advantages nutrient uptake including TN, TP, and K, pollutants removal such as COD, BOD, and FOG, carbon dioxide (CO2) fixation, and biomass generation. Thereby contributing to circular bioeconomy and environmental sustainability Algal-based wastewater treatment (WWT) was explored for its potent bioremediation ability and recovered biomass, which can be reutilized in various applications. When considering microalgae cultivation's role in integrated production systems, especially when using wastewater and gaseous effluents, the hunt for new potential strains is crucial. This research study explored the potential of microalga Galdieria sulphuraria 074 W (NIES-3638) to bioremediate raw restaurant wastewater due to its distinct characteristics, including high temperature (45–56 °C) and acidic pH (0-4) settings. The cultivation conditions were subject to three cultivation modes (i.e. mixotrophic, heterotrophic, and autotrophic) for 14 days. During the cultivation of G. sulphuraria, various evaluations, including optical density (OD), specific growth rate, and biomass productivity, were examined. Furthermore, the bioremediation efficiency of G. sulphuraria was examined for the removal of pollutants, including chemical oxygen demand (COD), biochemical oxygen demand (BOD), fats, oil, grease (FOG) and nutrient uptake like ammoniacal-nitrogen (NH4+-N), total-nitrogen (TN), total-phosphorus (TP), and potassium (K). G. sulphuraria grown with restaurant wastewater scored 0.15 day-1 for specific growth rate and 39 mg L-1 d-1 biomass productivity. The maximum removal efficiencies for COD, BOD, FOG, NH4+-N, TN, TP, and K were 71%, 80%, 66%, 96%, 93%, 99%, and 75%, respectively. Overall, this study revealed a promising treatment of restaurant wastewater using G. sulphuraria for removing pollutants, uptake of nutrients and enriched biomass that can be further utilized to produce secondary metabolites.

**KEYWORDS**
Microalgae, Environmental solutions/ Circular Economy, Production

# 11023 | EXPLORING BIOTECHNOLOGICAL POTENTIAL OF QATARI PORPHYRIDIUM PURPERUM

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**ABSTRACT**
The exploration of Qatar's unique biodiversity aims to discover novel algae species with significant biotechnological potential. Through a comprehensive bioprospecting initiative, we successfully isolated unique and promising microalgae strains. Notably, the halotolerant Porphyridium purpureum demonstrated exceptional growth rates of 0.235 $day^{-1}$ under 60 ppt salinity, yielding 0.635 g/L of biomass. The strain achieved a maximum phycoerythrin (PE) output of 33.85 mg/g and extracellular polysaccharide (EPS) production of 3.7 g/L.
Furthermore, this strain exhibits a complete profile of essential amino acids and omega-3 fatty acids, including eicosapentaenoic acid (EPA), enhancing its nutritional and pharmaceutical value. In a two-month, in-lab semi-continuous cultivation, the strain consistently produced high-value products, particularly phycoerythrin, across multiple cycles. Subsequently, it was gradually scaled up to pilot scale using fence photobioreactors outdoors and in greenhouses, progressing from 10 L to 35 L, then to 120 L, 350 L, and finally 750 L.
The strain maintained its ability to produce significant amounts of phycoerythrin and EPS across scales. Comparative analyses between photobioreactors (PBR) and open raceway ponds (ORP) revealed that ORP conditions enhanced EPS and secondary pigment production. After harvesting, the supernatant was used for EPS production, while the biomass underwent aqueous extraction to isolate phycoerythrin. The residual biomass was utilized for EPA extraction. Additionally, the full biomass was valorized for animal feed production and biofertilizer applications, contributing to sustainable agriculture.
This exploration of Qatar's native biodiversity has unveiled a highly promising strain suitable for the food and feed industries, as well as biorefinery applications. It offers a sustainable pathway to reduce production costs while maximizing value extraction from a single strain.

**KEYWORDS**
Feed, Agriculture, Biorefinery, Microalgae

# 11025 | OPTIMISING THE BIOLOGICAL ACTIVITY OF NATURAL PRODUCT USING NANOTECHNOLOGY

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## ABSTRACT
Nanoparticles (NPs) are considered a promising approach for the administration of bioactive compounds. With dimensions that can vary between 10 and 1000 nm, NPs are widely used as drug carriers, allowing in vivo stability and controlled release of bioactive compounds with antioxidant, antimicrobial and many other benefits, thus offering significant potential for the development of innovative healthcare products.
This work aims to explore the potential of nanotechnology, specifically silver nanoparticles (AgNPs), to improve the biological properties of bioactive compounds extracted from seaweeds, a rich and eco-sustainable source of bioactive compounds. The main objective is to investigate how AgNPs improve the delivery and stability of the bioactive compounds present in the seaweed extract, with a particular focus on optimizing their antimicrobial properties and other health applications, such as dermatological skin problems, in particular skin regeneration.
Three species of seaweed, green, Ulva sp., brown, Fucus vesiculosus, and red, Gracilaria sp., were used to prepare extracts which were analysed for their total phenolic content (TPC), antioxidant activity and chromatographic profile using HPLC-DAD analysis. Preliminary results showed that the red seaweed extract containing 0.76 mg TPC/mg dry extract performed better in all analysed parameters, namely antioxidant activity (27.4%) and bioactive compounds profile in HPLC-DAD analysis, so it was selected for further testing and preparation of AgNPs using different formulations.
The results of the characterization of the different formulated AgNPs by advanced techniques (FTIR and AFM), evaluation of the stability and safety of both the extract and the nanoformulations will be presented. In addition, the AgNPs health beneficial properties will be reported, namely their antimicrobiological activity and the capacity to permeate the skin barrier using a model of human cell lines.

## KEYWORDS
Macroalgae, Environmental solutions/ Circular Economy

# 11026 | FROM ALGAE TO NANOPARTICLE SYNTHESIS: A SUSTAINABLE APPROACH

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## ABSTRACT

The ocean is the largest ecosystem on Earth, estimated to be the home of approximately 90% of all living organisms. In this ecosystem, numerous bioactive compounds are found, each with unique chemical and physical properties, such as pigments, polyphenols, polysaccharides, minerals, among many others. These compounds can be obtained from various marine sources, namely microorganisms, crustaceans and algae.

Recently, the use of marine bioactive compounds, particularly those derived from micro and macroalgae, has been extensively investigated, due to their diverse biological activities, sustainability and potential applications in biotechnology and medicine. One of the areas with a growing interest in their application is in the nanotechnology field, more specifically in the synthesis of nanoparticles (NPs). NPs have gained significant attention, due to their unique properties, such as biostability, biodistribution, bioavailability, as well as their ability to overcome biological barriers. Consequently, they have been extensively used in many fields, being more prominent in the medical field, as they are used for diagnosis, as biomarkers and as drug delivery systems (DDS).

With the growing interest in NPs formulation, various synthesis methods have been widely explored. One promising approach involves using marine bioactive compounds for the synthesis of metallic NPs, offering an eco-friendlier and more efficient alternative to the conventional chemical and physical synthesis methods. There are several methods used to synthesize metallic NPs, one in which the NPs are formulated within the algae cells, without the need of pre-treatment, whereas other methods are based on extracting compounds from the biomass, using several methodologies.

In addition to their potential for synthesizing metallic NPs, algae can also be used to extract bioactive compounds with various properties, such as polysaccharides. These polysaccharides, namely fucoidan, can serve as core materials for NPs formulation and these can be used as DDS. Furthermore, fucoidan can be combined with other polysaccharides, also derived from marine sources, such as chitosan, through various methods. Recent studies have highlighted the excellent properties of these polysaccharide-based NPs from marine sources, as well as their promising applications as DDS.

Hence, in this work, a review will be presented of the several methods used to synthesize metallic NPs, derived by marine sources, as well as their vast potential applications in health and well-being. Additionally, the potential of the polysaccharides extracted from algae and their application as DDS will also be presented. This work aims to demonstrate the great potential of algae in the formulation of NPs, offering an innovative and environmentally friendly alternative, with a circular economy perspective in comparison to the traditional approaches.

## KEYWORDS

Microalgae, Macroalgae, Environmental solutions/ Circular Economy

# 11027 - SUSTAINABLE TECHNOLOGIES APPLIED TO SEAWEED ULVA SP- EVALUATING ITS APPLICATION POTENTIAL

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**ABSTRACT**
Seaweeds have gained increasing recognition, both for their high nutritional value and for the potential of their bioactive compounds, which has stimulated growing interest and research into these natural resources.
Among them, *Ulva sp.,* often know as sea lettuce, a green seaweed is an abundant and fast-growing species with significant ecological and economic potential. Its sustainable cultivation offers an alternative to the overexploitation of marine resources, providing a renewable resource and versatile biomass for various applications, including food, pharmaceuticals, and biomaterials. By applying eco-friendly and sustainable technologies, this project explores the utilization of *Ulva sp.* in alignment with circular economy strategies, contributing to environmental conservation while simultaneously enhancing profitability and its market value.
In this study, *Ulva sp.* biomass was used to obtain extracts through several green methodologies. These extracts were characterized to identify and quantify bioactive compounds, particularly phenolic compounds and polysaccharides, which are known to be abundant in seaweeds. These bioactive molecules are often reported to possess significant potential for various fields, including health and wellness, cosmetics, agriculture, biotechnology among others.
The findings from this study will provide the profile of the different extracts in their total phenolic and polysaccharide content, as well as their chemical profile by high-performance liquid chromatography with diode array detection (HPLC-DAD) and nuclear magnetic resonance (NMR). The results from the antioxidant activity, toxicity, and safety will also be discussed for supporting the potential applications of these extracts in various fields. Additionally, the reuse of the residual biomass remaining after extraction will be discussed as it may present an opportunity for further valorisation contributing to a circular approach to this seaweed utilization.

**KEYWORDS**
Macroalgae, Environmental solutions/ Circular Economy

# 11028 - ASSESSING BIOACTIVITY OF A. PLATENSIS EXTRACTS OBTAINED THROUGH DIFFERENT EXTRACTION METHODS

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## ABSTRACT
*Arthrospira platensis* (spirulina) is a known photosynthetic cyanobacteria, used as an alternative protein source (70%, w/w), and bioactive compounds such as long-chain polyunsaturated fatty acids, phenolic compounds and carotenoids. Along with these bioactives, the presence of phycobiliproteins, namely c-phycocyanin, exerts potential antioxidant, anti-hypertensive, anti-inflammatory and anticancer effects.
Within the framework of the FAMAP project, the aim of this study was to recover c-phycocyanin from *Arthrospira platensis* (spirulina) following different methods and correlate their composition with promising bioactivities.
Spirulina was extracted using conventional extraction with biocompatible solvents such as phosphate buffer and sodium chloride solutions, along with various mechanical extraction procedures such as, bead milling, ultraturrax, ultrasound, freeze/thawing cycles, and intermittent vortex with a freeze/thawing cycle. Alternatively, supercritical $CO_2$ extraction techniques will be assessed to maximize the extraction of lipophilic compounds. The extracts of spirulina were characterized for its c-phycocyanin content (by spectrophotometry) and phytochemical composition. These results were correlated to different bioactivities namely, i*n vitro* antioxidant capacity (ORAC), anti-proliferative effect in HT29 cells, and anti-hypertensive activity.
From all the conventional extraction methods, the bead milling was the least time-consuming, and the sodium chloride solution selected as the biocompatible solvent. The c-phycocianin was charcaterized by a maximum absorbance at 620nm. In what concerns the ongoing bioactivity assays, so far, the *in vitro* antioxidant activity was quite variable ranging between 46.14 ± 9.17 and 156.61 ± 15.64 µmol Trolox Equivalents Antioxidant Capacity (TEAC) per gram of dry weight.
This study improves the knowledge on the extraction and bioactivity of spirulina-derived compounds. The findings support the development of innovative and sustainable extraction techniques that maximize the recovery of bioactive compounds while maintaining their functional integrity.
Acknowledgments
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## KEYWORDS
Microalgae, Food, Feed

# 11084 - DEPURASHELL: A NOVEL STERILE MICROALGAE DIET FOR ENHANCED RELAYING AND DEPURATION OF THE OYSTER MAGALLANA GIGAS

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## ABSTRACT
Bivalves harvested or reared in areas with high microbiological contamination require depuration in clean seawater without food for 1–3 days, or longer in relaying facilities, to ensure safe human consumption. However, this starvation process can reduce survival, compromise health, and diminish nutritional value, negatively impacting their marketability. Thus, it is essential to integrate microbiologically safe, nutritionally balanced diets for depuration and relaying systems to sustain bivalve quality, welfare, and the producer's revenue. This study aimed to develop a novel sterile microalgal diet (DepuraShell) to improve survival, physiological condition, and nutritional quality of the oyster *Magallana gigas* during the depuration process and shelf-life storage. Low-temperature long-time pasteurization (LTLT) was the disinfection treatment selected for the diet due to its effectiveness in reducing bacteria, without causing cell aggregation, sedimentation, or degradation of key photosynthetic pigments. DepuraShell was formulated as a liquid concentrate (8% dry weight, DW) of the microalga *Tetraselmis chui*, enriched with *Schizochytrium* sp. powder, and carbohydrates-rich ingredients such as cornstarch. A 28-day trial was conducted in three closed 250L depuration modules with ultrafiltered, UV-treated recirculating seawater (15°C, salinity 35) and a protein skimmer. Oysters were allocated to three feeding treatments: (1) live microalgae (*Tisochrysis lutea* and *Tetraselmis* sp., 3:2 ratio; (3% of oyster DW(g) in algal DW(g)/day), (2) LTLT-treated DepuraShell diet; (8% of oyster DW(g) in diet DW(g)/day), and (3) a no-food control. Oysters were fed twice daily for 21 days and then stored at 4°C for 7 days (shelf-life). Daily survival was recorded, *Escherichia coli* levels were quantified at 0 and 18h, and weekly assessments included condition index (CI), proximate composition (proteins, glycogen, lipids, total energy), and biometric parameters (wet weight, length, width, thickness). Results showed effective depuration in all treatments, with *E. coli* dropping from 1300 to <18 MPN/100g in 18h. Survival was near 100% across all treatments. Fed oysters exhibited significantly higher CI, increased wet weight and width compared to basal levels. DepuraShell-fed oysters accumulated higher lipid and total energy levels compared to unfed oysters, mitigating the typical lipid depletion seen in food-deprived bivalves during depuration. During shelf-life, survival remained at 100%, and DepuraShell-fed oysters maintained the CI while preserving protein, lipid, and total energy. In conclusion, DepuraShell is a nutritionally balanced diet for *M. gigas* during depuration that effectively preserves physiological condition and nutritional quality, thereby enhancing bivalve commercial value and ensuring microbiological safety for human consumption.
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## KEYWORDS
Microalgae, Feed, Production

# 11087 - INNOVATIVE MAA RECOVERY FROM MARINE ALGAE: THE POWER OF BIOSOLVENTS

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## ABSTRACT
Marine algae are a sustainable source of high-value biomolecules, offering rapid growth, minimal resource needs, and $CO_2$ absorption without competing for land or freshwater. To align with the 2030 Sustainable Development Agenda, innovative, eco-friendly, and highly efficient extraction techniques are crucial. This includes utilizing alternative solvents, such as bio solvents derived from renewable sources, to minimize the environmental impact while optimizing the recovery of valuable compounds. Rich in bioactive molecules like pigments, proteins, lipids, and carbohydrates, algae have applications in food, pharmaceuticals, and biotechnology. Mycosporine-like amino acids (MAAs) are particularly valuable for their UV-absorbing and antioxidative properties, making them ideal for sunscreens and skincare. Ongoing research aims to optimize algae-derived compounds for sustainable biotechnological solutions, advancing a greener bioeconomy.

This study aims to enhance the value of *Gelidium corneum* by developing a simple and sustainable extraction process using biosolvents to recover MAAs. Since this specie is primarily used for agar extraction, this research considers both the raw algae and the residual biomass left after agar extraction. Firstly, COSMO-RS was used to screening the most effective solvents for extracting MAAs. These calculations allowed for the selection of biosolvents with the highest extraction efficiency potential. Following this in-silico approach, the selected pure biosolvents were experimentally tested in a solid-liquid extraction process to evaluate their performance. The experimental tendencies were then compared with the COSMO-RS predictions to assess their correlation and validate the computational approach. Subsequently, extraction conditions—including solid-liquid ratio, temperature, contact time, and water content—were systematically evaluated using a response surface methodology to optimize the process.

To harness the biological properties of the extracted compounds, a hydrogel membrane is being developed for eczema treatment. Various formulations, including pigment incorporation for aesthetic enhancement, will be tested. Once the optimal composition is identified, a comprehensive evaluation of its rheological and mechanical properties will be conducted.

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## KEYWORDS
Macroalgae, Biorefinery, Supplements and cosmetics, Environmental solutions/ Circular Economy

# 11180 - EFFECT OF EXTRACTION SOLVENT SYSTEMS ON THE ANTIOXIDANT ACTIVITY OF SELECTED MACRO- AND MICROALGAE: A RELATION TO THEIR TOTAL PHENOLIC CONTENT

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**ABSTRACT**
Algae are rich sources of natural antioxidants. They can synthesize a diverse class of secondary metabolites capable of free radical scavenging activity. These molecules include phycobiliproteins, sulfated polysaccharides, carotenoids, phenolic compounds, and vitamins, among others, that can counteract the negative effects of free radicals on biological systems. Hence, the interest in using algae and algae-derived products as a source of bioactive compounds has increased recently, reinforcing the need to find efficient and cost-effective methods to extract these molecules.
Phenolic compounds constitute one of the most numerous and widespread groups of algae secondary metabolites. These components are important to the normal growth and development of algae, providing defence mechanisms against external factors, particularly environmental and stress conditions (desiccation, high salinity, UV radiation, nutrient deprivation, extreme pH, and temperature). Phenolic compounds have attracted great interest due to their biological relevance and potential health-promoting properties (antioxidant, anti-inflammatory, anti-diabetic, immunomodulatory activities, etc). Therefore, in recent years, there has been an outstanding demand for the search of phenolic compounds from macro- and microalgae.
Solvent extraction is the most commonly used extraction procedure for phenolic compounds, mainly due to its ease of use and low processing cost. The solvent choice is critical and often a determinant on the extraction yields and subsequent antioxidant activities of algal extracts, due to solvent influence in the solubilization of antioxidant compounds. Polar solvents, such as methanol, ethanol, and acetone (usually combined with water at different proportions), are found to be effective in recovering phenolic compounds from algae.
Recognising the importance of this class of metabolites, the present work has focused on evaluating different solvent systems to obtain phenolic-rich extracts of representative species from macro- and microalgae, namely *Palmaria* sp., *Porphyridium* sp., *Haematococcus* sp., *Phaeodactylum* sp., *Tisochrysis* sp., *Fucus* sp., *Tetraselmis* sp. and *Ulva* sp. The samples were evaluated regarding extraction yield and *in vitro* antioxidant activity (evaluated by the ABTS and DPPH radical scavenging assays). The total phenolic content of algae extracts was determined by the colourimetric Folin-Ciocalteau method and correlated with the potential antioxidant properties.

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**KEYWORDS**
Microalgae, Macroalgae

# 11185 - MICROALGAE FERMENTATION AS A STRATEGY TO IMPROVE FLAVOUR

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## ABSTRACT

Microalgae Fermentation as a Strategy to Improve Flavour
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## KEYWORDS

Microalgae fermentation, *Lactobacillus* sp., *Hematococcus pluvialis*, *Porphyridum cruentum*, flavour

Ensuring global food security while preserving natural resources is one of the major challenges of the coming decades. In this context, microalgae emerge as sustainable food ingredients due to their high nutritional value, including proteins, lipids, carbohydrates, vitamins, minerals, carotenoids, and essential fatty acids. However, their sensory acceptance remains challenging due to the volatile organic compounds (VOCs) responsible for undesirable fishy and algal flavours [1]. Fermentation has been investigated as a potential solution to improve the organoleptic properties of microalgae by modifying precursor compounds that impact sensory perception [2]. This study evaluated the effect of fermentation on the VOC profile of *Haematococcus pluvialis* and *Porphyridium cruentum*. Biomasses provided by GreenCoLab were individually fermented with *Lactobacillus plantarum*, *Lactobacillus sakei*, and *Leuconostoc carnosum* at 30 °C for 48 hours without agitation (0.1 LAB: 1 biomass; $10^6$ CFU/mL LAB). VOCs were analysed using gas chromatography-mass spectrometry (GC/MS) with solid-phase microextraction (SPME). Before fermentation, 42 VOCs were identified in *P. cruentum*, including β-ionone (C1), 4-ethyl-6-hepten-3-one (C2), hexanal (C3), and heptadienal (C4), which are linked to fishy and algal notes. Fermentation significantly ($p<0.05$) reduced these compounds, with L. plantarum eliminating C2 and reducing C1 to 0.1453 mg/L. 22 VOCs were detected in H. pluvialis, including C3 (0.3115 mg/L) and C4 (0.4189 mg/L), both significantly ($p<0.05$) reduced by *L. plantarum*. Interestingly, fermentation with *L. sakei* led to the emergence of 2,4-decadienal, associated with seaweed-like aromas.These results demonstrate that *Lactobacillus plantarum* fermentation is a promising strategy to enhance the sensory profile of microalgae by reducing undesirable VOCs, facilitating their application in food products. Future studies should explore the sensory perception and consumer acceptance of these improvements.

# 11186 - USING DEUTERATED WATER FOR DE NOVO LIPOGENIC FLUX ASSESSMENT IN MICROALGAE – FOCUS ON OMEGA-3 FATTY ACIDS

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## ABSTRACT

The consumption of essential fatty acids, namely *omega*-3, has been increasingly linked to major health benefits. Currently the main dietary source of these highly valuable fatty acids are small oily fish and their derivatives. Their metabolic capabilities to synthesize these compounds is limited, as is in most vertebrates, and their rich composition derives from biomagnification processes along the marine trophic chains. These originate in microalgae, the primary producers of such long-chain high-value fatty acids. Lipids are an important component of microalgae cells, allowing them to thrive in diverse environments. As such, understanding the metabolic pathways and lipogenic fluxes of these organisms is extremely relevant particularly if the goal is to optimize and maximize their yields. Deuterated water ($^2H_2O$) has systematically provided reliable lipid biosynthetic flux estimates, validated in several different animal models. The incorporation of deuterium ($^2H$) into cells follows well-defined metabolic steps and positional $^2H$-enrichments can be traced by deuterium Nuclear Magnetic Resonance ($^2H$-NMR). In order to validate its utilization, this study aimed to determine if $^2H$-enrichment of the medium interferes with microalgae growth, while assessing the effectiveness of fatty acid $^2H$-labelling in microalgae. To achieve this, *Munda aquilonaris* ACOI 2424 was cultivated in three distinct $^2H$ concentrations, while growth was monitored through cell counting. While 5% enrichment impacted microalgae growth, 10% enrichment had no significant impact on *M. aquilonaris* proliferation. Lipids extracted from the resulting biomass were analyzed using NMR, acquiring both $^1H$ and $^2H$ spectra. The results showed that $^2H$ was successfully incorporated into the metabolic pathways enabling the distinction of the *de novo omega*-3 fatty acid synthesis. These findings pave the way for innovative metabolic studies using this stable isotope to trace *omega*-3 lipogenic fluxes in microalgae. This could enhance the production of essential fatty acids and uncover new possibilities for applications in human and animal nutrition.

## KEYWORDS

Microalgae, Food, Feed, Supplements and cosmetics

# 11189 - SCALING-UP MICROALGAE CULTURES: UNLOCKING BIOCHEMICAL COMPOSITION AND ANTIOXIDANT POTENTIAL OF NOVEL STRAINS

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## ABSTRACT
The ongoing annual population growth is a highly complex concern, with significant health and social impacts. Overpopulation, aligned with the emergence of new diseases, the lack of new bioactive compounds, source scarcity, and multi-drug resistance make a very challenging scenario. In response to these concerns, the scientific community has turned its attention to finding new bioactive compounds and that be developed into new drugs. Historically, most drugs come from or were inspired by nature underscoring its impact on the development of new active ingredients based on natures' rich diversity of chemical compounds. In this context, microalgae represent a sustainable alternative to address these challenges. In this work, three microalgae strains (T13, T18, and T27) recently isolated by the MarBiotech group (CCMAR) were produced in 120L plastic bubble column photobioreactors and biochemically characterized. Additionally, bioactivity assays were performed to assess the presence of antioxidant compounds able to scavenge ABTS radicals for further anti-enzymatic assays. For that purpose, biochemical analysis was performed, and T13 presented more than 30% of lipids in its total composition, while T18 and T27 presented 6.19%, and 5.73%, respectively. To assess antioxidant activity, extracts were prepared from dried biomass using acetone and ethanol 96%. Extraction yields were as follows: T13 – 4.28% for acetone, and 9.02% for ethanol 96%; T18 – 5.28% for acetone and 7.65% for ethanol 96%; and T27 – 3.04% in acetone and 12.31% in ethanol 96%. These extracts were analysed using the ABTS assay, where T13 acetone extracts presented the highest efficiency in antioxidant production compared to T18 and T27, since T13 extracts in acetone presented $IC_{50}$ of 0.74 ± 0.19, and ethanol extract presented $IC_{50}$ of 0.06 ± 0.01. Overall, the selected microalgae strains presented relevant biochemical composition, highlighting T13 exhibiting high lipid content, concomitant with significant antioxidant properties, and providing wide biotechnological applications, particularly to the pharmaceutical and cosmeceutical industries. To further explore its potential, additional studies are needed to delve deeper and complement this initial work.

## KEYWORDS
Microalgae, Supplements and cosmetics, Food

# 11191 - STRONG ANTIOXIDANT PROPERTIES IN ALGAE WORLD: UPLC LIPIDIC VITAMIN QUANTIFICATION vs. ANTIOXIDANT BIOACTIVITIES

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## ABSTRACT
Algae are promising bioresources for the bioeconomy as a model of sustainable development for society's use. New circular business models have been created with the support of stakeholders and value chains involved in the sector, accelerating innovation and scientific growth. The biodiversity of algal strains and their rich chemical diversity have proven valuable in food, biomedical, cosmeceutical, nutraceutical, feed, and other areas. Algae can grow in freshwater or marine systems and are valuable feedstocks for the valorization of proteins, lipids, fatty acids, polysaccharides, sugars, sterols, pigments and vitamins. In addition, the components present in algae and their secondary metabolites make them a great source of bioactive compounds with strong antioxidant, anticancer, antiviral, antidiabetic, anti-obesity, anti-inflammatory properties, among others. These biochemical components make algae a potential candidate for natural-based products praised for their value, commonly used as active agents in the formulation of skin care products or as ingredients/additives in nutraceutical health companies. Fat-soluble vitamins and their chemically related compounds 'Vitamers' showed significant interest in the scientific community because of their bioactivities. Regarding antioxidant properties, Vitamin C (non-lipidic vitamin) is well-known for presenting high activity. Nonetheless, Vitamin E (*α*-Tocopherol) and their vitamers *β*,*δ*,*γ*-Tocopherols and Tocotrienols, are also important molecules, along with Provitamin A *(α* and *β*-Carotene), which present not only anti-ageing and photoprotective skin properties, but antioxidant capacity too. The aim of this work is to highlight the antioxidant properties of the lipidic vitamins and their vitamers found in micro and macroalgae species, taking into account the different groups (red, green and brown algae). The screening profiles and quantification of Vitamin E (*α*-Tocopherol) and *β*-Carotene were performed in algae methanol extracts with a precise and accurate analytical UPLC method. The obtained results were correlated with values generated in bioactivity assays (DPPH and ABTS) in the same extracts, helping the selection of the best algal candidates with antioxidant properties for different added-value biotechnological applications.

## KEYWORDS
Vitamin E, *β*-Carotene, UPLC, algae, antioxidant bioactivity

## FUNDING
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## KEYWORDS
Microalgae, Macroalgae, Supplements and cosmetics, Food

# 11192 - ALGAE BIOMASS SUGAR PROFILE IN HPLC

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**ABSTRACT**
Algae are a group of photosynthetic organisms widely known for their role in oxygen production and serving as the food base of many aquatic organisms, but they also offer diverse benefits to humans. They are a valuable source of food nutrition and are used in the production of a wide range of pharmaceutical and industrial products. This is due to their richness in high-value compounds, including pigments, fatty acids and carbohydrates, which present different interesting properties, including antioxidants. Carbohydrates play a crucial role in algae's growth and function, contributing to their distinct physical, chemical and biological properties. Algae carbohydrates can be found in the form of 1) polysaccharides, serving as energy reserves, structural components and protective agents, or 2) monosaccharides, playing an essential role in metabolism and energy production. Among the different monosaccharides, algae can metabolise glucose, galactose, fructose, xylose, rhamnose, fucose and mannitol, depending on the genera and species. For instance, brown algae contain fucose and mannitol. These two monosaccharides present immune, prebiotic and anti-inflammatory potential, as well as antioxidant activity, respectively. Green algae contain rhamnose and xylose, which are linked to anti-inflammatory and anti-cancer properties, along with prebiotic effects, respectively. Red algae are rich in galactose (as well as mannitol), which is particularly valued for its prebiotic effects. Recognising the importance of these algae groups and their respective monosaccharides, the present work aimed to identify and quantify key monosaccharides, including glucose, galactose, fructose, xylose, rhamnose, fucose and mannitol in different algal species, including *Fucus*, *Phaeodactylum*, *Tisochrysis*, *Ulva*, *Tetraselmis*, *Haematococcus, Palmaria* and *Porphyridium,* which was achieved by performing a profile analysis in HPLC-RI. Considering the diverse beneficial properties of monosaccharides, biochemical characterisation studies are key to exploring the potential applications of different algae feedstocks as bioactive components.

**KEYWORDS**
Carbohydrates, Monosaccharides, HPLC-RI, Sugar profile, Algae

**ACKNOWLEDGMENTS/FUNDING**
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**KEYWORDS**
Microalgae, Macroalgae, Supplements and cosmetics, Food

# 11206 - UNVEILING THE BIOACTIVITY OF ALGAL EXTRACTS ON FUSARIUM OXYSPORUM DISEASE MANAGEMENT

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**ABSTRACT**
*Fusarium oxysporum* is a species complex that includes many strains that cause vascular wilt diseases of important crops, reducing the quality and yield of agricultural products and leading to significant economic impacts for plant producers. As traditional agricultural inputs continue to decline, biostimulants and biofungicides are gaining recognition as effective tools for advancing sustainability goals. Among these, algae stand out for their bioactive metabolites that promote plant growth and protect plants against pathogens, displaying promising potential for integrated disease management strategies within agricultural systems. In this project, we will explore the bioactivities of algae to develop a biopesticide targeting *F. oxysporum* and investigate its mode of action. Fifteen algae belonging to the three main algae phyla, Chlorophyta, Rhodophyta, and Phaeophyta, will be tested *in vitro*, *ex vivo* and *in vivo* against *Fusarium oxysporum* to evaluate their effectiveness. For the *in vitro* tests, a Green Fluorescent Protein (GFP)-expressing *F. oxysporum* pathogenic strain will be created to perform high-throughput screening to select the best-performing algae with inhibitory activity, whereas *F. oxysporum* spores will be inoculated in lettuce leaves pre-treated with algal extracts for the *ex vivo* tests. For these tests, the plants' transcriptome with and without algal treatment will be assessed to evaluate the effect of the treatments on the plants' defence system; afterwards, the plants will be infected with the fungi, and biochemical and physiological analyses will be performed on infected algae treated plants to measure fungi growth, the suppression and disease symptoms.

**KEYWORDS**
Microalgae, Macroalgae, Agriculture, Environmental solutions/ Circular Economy

# 11207 - ENHANCING MICROALGAE ANTI-INFLAMMATORY ACTIVITIES BY FATTY ACIDS INDUCTION THROUGH CULTIVATION FACTORS

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## ABSTRACT
Microalgae are promising sources of bioactive compounds with antioxidant and anti-inflammatory properties, such as fatty acids. The H2020-funded Algae4IBD project explores this potential to develop commercial products for Inflammatory Bowel Disease (IBD) prevention and treatment using aquatic natural biological resources. Ultimately, the project aims to offer a nature-to-bedside approach, using the entire value chain to discover new algae-based biotherapeutic solutions. This study aims to optimize the cultivation method of several microalgae species to promote target-bioactive compound induction by modulating nitrate and phosphate. Different cultivation modes, typically used in industry, such as batch (adding nutrients once in inoculation) and fed-batch (daily nutrient adjustment) are known to modulate microalgae bioactivities. Total lipids and fatty acids induction through nutritional modulation was investigated in AIBD47 and AIBD233 strains. AIBD47 strain was cultured at 22ºC and AIBD233 at 19ºC in a volume of 100 mL ($n$=3), using NutriBloom® Plus as culture media during 7 days. In the nitrate trial, AIBD47 was cultured in batch, fed-batch (2 mM $NO_3$) and in the phosphate trial the same cultivation modes were tested (0.25 mM $PO_4^{3-}$). The same conditions were applied for the trial with AIBD233. Overall, specific productivity ($\mu$) of AIBD47 was higher than AIBD233 AIBD47 $\mu$ was negatively affected by the nutrient's limitation under batch growth but similar between fed-batch cultivation mode. AIBD233 $\mu$ did not reveal significant differences in growth between conditions. The fed-batch cultivation mode promoted higher total lipids accumulation than batch mode in both strains. The fatty acids content and productivity of each microalga cultured with each treatment were evaluated, namely palmitoleic acid (C16:1), palmitic acid (C16:0) and eicosapentaenoic acid (EPA) (C20:5$n$-3). This work will contribute to the species and cultivation mode selection that allows the enhancement of microalgae bioactivities associated to lipids and fatty acids, relevant for inflammation bowel disease alleviation. The use of fed-batch cultivation mode of AIBD47 and AIBD47, that promoted higher total lipids content, can be easily applied in industrial scale. The bioactivities of the biomass will be further evaluated. The selection of the microalgae cultivation mode for metabolites induction is essential for the further development of sustainable algal-based and high-quality bioactive compounds for IBD prevention and treatment. The capacity to produce microalgae with enhanced bioactivity, that allows the prevention and alleviation IBD, enhances the biomass value.

## KEYWORDS
Microalgae, Production, Food

# 11213 - EXPLORING ALGAL EXTRACTS AS TO INCREASE DROUGHT STRESS TOLERANCE IN TOMATO SEEDLINGS

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## ABSTRACT
Drought stress is a significant challenge in horticulture, reducing productivity, disrupting photosynthesis, nutrient uptake, and water-use efficiency. With increasing water scarcity and the pressing need to conserve water resources, finding innovative strategies to enhance crop resilience is essential. Algae, with their bioactive compounds and stress-modulating phytohormones, present a promising hypothesis for improving water-use efficiency and root development under drought conditions [1].
The aim of this study was to assess the potential of algae extracts to increase the tolerance of crops under drought stress.
The experiment was conducted in a greenhouse at the Universidade do Algarve – Faculdade de Ciências e Tecnologias under natural photoperiod conditions. Tomato seeds (*Solanum lycopersicum* L. 'Red Cherry') were sown in 200 mL pots filled with a substrate containing NPK and were moistened to field capacity. After germination, the pots were divided into three irrigation treatments: 100% field capacity to represent optimal growing conditions, and 50% and 25% field capacity to simulate moderate and severe drought stress, respectively. Five algae extracts were tested, including neutral and acidic extracts derived from the tops of *Saccharina latissima* (SLT-N, SLT-Ac), neutral and alkaline extracts obtained from the stipes of *Saccharina latissima* (SLS-N, SLS-Ak), and an acidic extract produced from factory by-products of *Ascophyllum nodosum* (ANBP-Ac). Three concentrations (1, 3 and 5 L $ha^{-1}$) were tested and applied via foliar spray once a week, for a total of three applications. The biostimulant effect was compared to a negative control (C-, water) and a positive control (C+, a commercial product, ALGAMAN B). The experiments concluded one week after the final application, and six plants were selected for physiological (measured non-destructively using the SPAD chlorophyll meter) and morphological (plant height and number of leaves) analysis. The fresh and dry biomass of the shoot was measured.
In non-stressed plants, the application of SLS-Ak at a rate of 3 L $ha^{-1}$ exhibited a biostimulant effect compared to the negative control, resulting in a statistically significant increase in fresh weight. Under moderate drought stress conditions, the application of SLT-Ac resulted in a statistically significant increase in chlorophyll content in young leaves compared to the negative control. Under conditions of severe drought stress, several extracts exhibited biostimulant activity, significantly enhancing fresh weight, SLT-N, SLT-Ac, SLS-N, and ANBP-Ac when applied at rates of 5, 3, 5, and 1 L $ha^{-1}$, respectively.
The results suggest that these extracts have the potential to alleviate the adverse effects of drought stress on tomato seedlings. However, further studies are needed to evaluate their effectiveness throughout the entire crop cycle.

## KEYWORDS
Microalgae, Macroalgae, Agriculture, Environmental solutions/ Circular Economy

# 11214 - INSIGHTS ON NOVEL ALGAE WITH BIOACTIVE EFFECTS FOR INDUSTRIAL PRODUCTION

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## ABSTRACT
The biotechnological potential of cyanobacteria and microalgae targeting health endures as a subject to be fully uncovered. Align with this, currently 6.8 million people suffer from inflammatory bowel disease (IBD), yet an effective treatment remains lacking. To address this issue, the Algae4IBD EU-project (grant agreement nº 101000501) focus on developing functional foods and drugs by screening more than 130 macro- and microalgae and cyanobacteria strains. Under this framework, five microalgal strains from the UNINA culture collection were cultivated at GreenCoLab facilities (Algae4IBD codes 1008, 1005, 465, 361, and 1025). These were grown in Bold's Basal media (BBM) at 24 °C with aeration and 100 µmol $m^{-2}$ $s^{-1}$ light intensity and further scaled up to 5 L reactors. Optical density (OD) and dry weight (DW) were continuously monitored. Strain 1005 showed exponential growth, reaching OD 750 of 1.4 and DW of 3.5 g $L^{-1}$ after 8 days. Strain 465 showed slow growth with a 2.6-fold OD750 increase after 8 days, and acidified strain cultures were unviable after 4 days. Strains 465 and 361 achieved biomass productivity of 0.0429 and 0.0643 g $L^{-1}$ $d^{-1}$, respectively, over 8 days. The harvested biomass was used to produce ethanol (ET), ethyl acetate (EA) and hexane (H) extracts, for each strain and yields were estimated. Overall, ET extracts presented higher extraction yields, particularly strains 1005 and 465 (19%), followed by EA (3.7-12.1%) and H extracts (2.2-6.1%). All extracts were screened for their effects on inflammatory-related cytokines by gene reporter high throughput methods and cell viability was assessed. Several extracts exhibited promising anti-inflammatory effects without cell toxicity and will move forward in the project pipeline, to fully characterize their anti-inflammatory efficacy against IBD. In the end, this work highlights the relevance of widening the panel of algae strains prospected for biotechnological applications, particularly in the development of novel algae-based solutions against IBD.

## FUNDING
ALGAE4IBD project (grant Agreement/EC/H2020/101000501/EU)

## KEYWORDS
Microalgae, Production, Supplements and cosmetics

# 11217 - MODULATORY EFFECTS OF PAVLOVA GYRANS AND TISOCHRYSIS LUTEA ON FISH GUT HEALTH-ASSOCIATED GENES IN SPARUS AURATA USING AN EX VIVO MODEL

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## ABSTRACT
Algae possess functional properties such as immunostimulant, antioxidant, and anti-inflammatory effects, making them promising gut health modulators in aquafeeds. *Pavlova gyrans* is a valuable microalga due to its high levels of polyunsaturated fatty acids (PUFAs), particularly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), which support fish lipid metabolism, growth and health. Additionally, its sterols contribute to membrane integrity, and its pigments, such as fucoxanthin, add to the functional potential for aquaculture species. Similarly, *Tisochrysis lutea* is rich in DHA, fucoxanthin, and phenolic compounds with antioxidant, antimicrobial, and anti-inflammatory properties, potentially promoting stress resistance and immune function in fish.
This study applied an *ex vivo* model to analyze the gut mucosal response to these microalgae considering their modulatory effects in terms of immunity, barrier integrity, and antioxidant response. *P. gyrans* and *T. lutea* biomass were processed through a biorefinery pipeline where several processes were applied in a stepwise manner, including water extract, protein, and carbohydrates hydrolysis, resulting in seven fractions that were tested at a single dosage in a seabream (*Sparus aurata*) intestinal *explant* assay. The expression of genes related to immune response (e.g., *COX2, IL1B, IL8, TNFa*), antioxidant response (e.g., *NFR2, CAT, GPX*), and epithelial integrity (e.g., *TJP1, CLD12, OCL*) were evaluated.
Results showed that *T. lutea* had no significant effects in any tested fraction. In contrast, the processed biomass of *P. gyrans*, particularly the fraction after carbohydrate hydrolysis, significantly upregulated immune-related genes, indicating its potential as a functional ingredient for gut health improvement. Biochemical characterization of the fractions is ongoing to deepen the composition and correlate with the results obtained in the *ex vivo* screening, supporting the decision process before application in functional aquafeeds. Further analysis will proceed with a dedicated *in vivo* study to assess the selected algae-derived ingredient efficacy when incorporated into commercial aquafeeds as a mucosal health enhancer and robustness booster in aquaculture.

## ACKNOWLEDGMENTS
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## KEYWORDS
Biorefinery, Microalgae, Feed

# 11218 - TETRADESMUS OBLIQUUS FUNCTIONAL ENHANCEMENT TOWARDS GUT HEALTH THROUGH BIOREFINERY FRACTIONATION PROCESS

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## ABSTRACT
*Tetradesmus obliquus* is a freshwater microalga with fast growth rates and high resilience, being able to grow in different types of wastewaters and under fluctuating environmental conditions. Moreover, this microalga is a source of high-value bioactive compounds such as pigments, polyphenols, fatty acids, and polysaccharides. These compounds exhibit potent antioxidant, antimicrobial, and immunomodulatory properties, making *T. obliquus* an attractive functional aquafeed additive. However, the bioavailability of these compounds is often limited due to the rigid cell wall and complex biochemical matrix. Therefore, this study aimed to explore an algae biorefinery approach to optimize the extraction of *T. obliquus* bioactive properties to promote the intestinal health status of gilthead seabream (*Sparus aurata*), using an *ex-vivo* model. Frozen *T. obliquus* biomass was processed through a multi-product biorefinery pipeline, integrating enzymatic hydrolysis either preceded (or not) by high-pressure homogenization (HPH) and followed by centrifugation or membrane microfiltration. The resulting algae fractions (F1-10) were used as potential ingredients and tested in a gilthead seabream intestine explant, under standardized conditions. Both fractions and control treatment (CTRL - no algae addition) were tested in triplicate, and intestinal explants were incubated with each algae fraction at a single dosage. Tissue response was evaluated by transcriptional analysis of a panel of genes related to innate immune response, antioxidant response, and epithelial integrity and permeability. Overall, these results showed that fractionation of *T. obliquus* maximized the bioactivity of this algae on fish immune response, when compared to whole biomass and CTRL group. A modulation was observed in genes associated with pro-inflammatory cytokines (*IL8*, *IL1b*) and cyclooxygenase2 (*COX2*), and with the transcription factor (*NRF2*), which regulates cellular defence against oxidative stress, particularly pronounced in fractions F4, F6, F7, F8, and F9. Both membrane-filtrated fractions (F7, F8, F9) and centrifugation-derived fractions (F4, F6) showed promising results in stimulating fish health. Additionally, fractions derived from HPH-treated biomass (F9 and F6), exhibited immune-stimulatory effects; however, their cost-effectiveness for large-scale aquafeed applications requires further evaluation. Overall, this study highlights the potential of microalgae biorefinery strategies in enhancing the bioavailability of functional compounds, positioning *T. obliquus* as a promising additive for aquaculture feeds.

## ACKNOWLEDGMENT
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## KEYWORDS
Microalgae, Biorefinery, Feed

# 11223 - ALGAE-BASED CAVIAR: OPTIMIZATION AND CHARACTERIZATION OF MICROALGAE BEADS

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## ABSTRACT

Algae-based caviar: Optimization and characterization of microalgae beads

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Microalgae offers a versatile and sustainable approach to food innovation, enhancing products with their natural pigmentation, marine flavours, and properties to create unique textures. In addition to their traditional applications, microalgae are being explored in novel vegan alternatives, such as the innovative algae-based caviar, where the spherification technique transforms microalgal biomasses and extracts into uniquely appealing sensorial and nutritive spheres. In this context, this study aimed to optimize the process of microalgae spherification in order to achieve the ideal conditions for producing microalgae beads with a texture and appearance similar to caviar. Microalgae beads were formulated and correlated through the design of experiments (DOE) using a Box-Behnken design methodology with three independent variables: microalgae biomass concentration (45, 55, 65 w/v), sodium alginate concentration (1.4, 1.7 and 2% w/v) and residence time in calcium chloride bath (1, 3 and 5 min) resulting on fifteen different assays in order to determine which variables better define and differentiate the microalgae bead. The dependent variables related to physical properties were evaluated over time during days (0, 5, 10, 15 and 30), including: i) sphere diameter was evaluated with a digital caliper, ii) texture through hardness and stress at compression in a texturometer, iii) permeability of the calcium alginate by weight loss, and iv) colour with a colourimeter (CIELAB* system). Obtained results revealed that the microalgae beads' hardness increased with the alginate concentration, or the time of exposure to calcium chloride, or with a low concentration of microalgae (45 g/L). In addition, the permeability of the calcium alginate membrane exhibited a time-dependent decrease over time, resulting in a decrease in the diameter of the bead and its weight. Overall, after 4 weeks of storage, the caviar containing 60 g/L microalgae and 1.7% sodium alginate with 5 min residence time was found to be more acceptable.

## ACKNOWLEDGMENTS

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## KEYWORDS

Microalgae, Food, Algae Market

# 11224 - MICROALGAE BIOREMEDIATION: AGRICULTURAL DRAINWATER AS A SOURCE OF NUTRIENTS FOR ALGAE METABOLISM

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## ABSTRACT
Intensification of agriculture and heavy fertilizer use have led to the generation of wastewater rich in nutrients, particularly nitrogen and phosphorus. To address surface and groundwater pollution, the EU has implemented directives limiting nutrient concentrations in discharges. Common compliance methods include chemical treatment and drainwater (DW) dilution. The use of DW for microalgae cultivation presents a valuable opportunity to contribute to sustainable water purification. Research indicates that microalgae can produce high-value compounds, such as fatty acids, pigments, and proteins, which have applications in food, feed, cosmeceuticals, and pharmaceuticals. Environmental factors, such as the composition of the culture medium, may influence the metabolic pathways and production of these compounds. Microalgae use inorganic N sources like nitrate and ammonium to produce organic compounds and P for the synthesis of proteins, lipids, and nucleic acids. Thus, to understand the impacts of DW in biomass biochemistry, it is vital to analyze both media and biomass, particularly due to DW variability. As part of the REALM project, this study aimed to: 1) assess the impact of DW as water and nutrient sources for microalgae growth, and, 2) evaluate the influence of agricultural DW composition on the biochemical composition of microalgae. To answer these goals, DW sourced from hydroponic raspberry cultures was used for the growth of microalgae species, *Chlorella* sp., *Tetradesmus obliquus*, and *Limnospira platensis*. Water analysis was conducted during two growth phases: non-nutrient-limited (NNL) and nutrient-limited (NL). $N\text{-}NO_3$, $N\text{-}NH_3$, and $P\text{-}PO_4$ were analyzed using a continuous and segmented flow analyzer (Skalar®), while minerals were assessed via MPAES after digestion. Biomass samples were analyzed for proximate composition, carbohydrates, amino acids, pigments, and phenolics content. The findings indicated that the DW composition supported the growth of all studied microalgal species. Nutrient consumption was observed in all nutrients during the transition from NL to NNL phase. Notably, *L. platensis* demonstrated effective N assimilation, with increased concentrations of glutamic acid + glutamine correlating with its growth rate. Pigment composition showed no significant differences among species. In NNL, all species accumulated carbohydrates, with *L. platensis* exhibiting a 14% increase. This species also displayed a remarkable 78% increase in phenolic compounds, consistent with its carbon assimilation and growth. Total fatty acid concentrations peaked during the NL for both *Chlorella* sp. and *L. platensis*, with the latter being particularly rich in PUFAs. To harness microalgae for enhancing DW quality and producing valuable biomass, understanding the intricate relationships between nutrient uptake, growth, and synthesis of valuable compounds is essential. This study underscores *L. platensis* as a promising candidate for these applications.

## KEYWORDS
Microalgae, Production

# 11229 - ENHANCING RASPBERRY PRODUCTIVITY WITH ALGAE BIOMASS

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**ABSTRACT**
The use of algae biomass to produce biofertilizers and biostimulants represents an important strategy for reducing the dependency on synthetic and inorganic agrochemicals. This approach is an integral part of promoting the sustainability of national and European agricultural systems, aligning with the ambitious objectives of the Green Deal framework established for 2030 [1].
In this context, an experiment was conducted to evaluate the biostimulant effects of algal biomasses on the productivity of raspberry plants. The study was conducted in a greenhouse at Agrivabe – Produção Agrícola, located near Luz de Tavira, Portugal. Raspberry plants (*Rubus idaeus* L., cv. “Diamond Jubilee”) were transplanted in December as long canes into 4.8 L pots filled with coconut fiber, with two canes per pot. The fertigation protocols implemented throughout the experiment were optimized by the company, employing in-house technologies that ensured consistent nutrient availability for the crops during the entire growing cycle. Six algal biomasses (N19.1f, NG4.1e, N15.1f, AP12.2g, IA9.1g, and N21.1f) were tested at three concentrations (0.5, 1.25, and 3.125 g $L^{-1}$). Two commercial algae-based biostimulant products, AlgaFert® and Algaman B®, were used as positive controls, while water served as the negative control. The trial had a total of 21 treatments arranged in randomized blocks with four replicates per treatment, 672 plants. The applications began in January and were conducted on a weekly basis for a period of 17 weeks. Each treatment was administered via irrigation, with a volume of 375 mL of the respective suspension being applied to each pot. The biostimulant effects were assessed by measuring the total daily harvest of ripe fruits (kg $m^{-2}$) over 6 weeks, and at the end the total fruit yield was determined for each treatment.
The results demonstrated that NG4.1e applied at 3.125 g $L^{-1}$, significantly increased fruit yield compared to the negative control (water), with an approximate increase of 1kg per square meter highlighting the notable biostimulant potential of this algal biomass.

**KEYWORDS**
Biostimulant, macroalgae, microalgae, *Rubus idaeus*, yield

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**ACKNOWLEDGMENTS**
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**KEYWORDS**
Macroalgae, Agriculture, Microalga

# 11233 - MICROALGAE AS A SOURCE OF BIOACTIVE COMPOUNDS FOR ADVANCED SKINCARE FORMULATIONS

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**ABSTRACT**
Microalgae and cyanobacteria are untapped sources of powerful bioactive compounds for the cosmetic industry, their diverse metabolites, including polyphenols, fatty acids, and carotenoids, exhibit exceptional antioxidant potential, photoprotective properties, and anti-inflammatory effects.
With higher consumer demand for more natural and safer ingredients in cosmetic products, microalgae are a compelling alternative to synthetic ingredients present in the market. The ability to mitigate oxidative stress, protect against UV-induced skin damage, and modulate inflammatory responses makes microalgal extracts highly suitable for advanced skincare applications.
This study will analyse extracts from four microalgae and cyanobacteria species, produced at an industrial scale by Necton, Algarve, to assess their antioxidant potential using DPPH and ABTS assays and their relevance for anti-ageing skincare applications. Specific targets include anti-collagenase, anti-elastase and anti-tyrosinase activities, which are crucial for maintaining skin elasticity and reducing wrinkle formation and hyperpigmentation. Additionally, the antibacterial potential of these extracts will be evaluated for their suitability in formulations aimed at preventing bacterial acne. Active extracts demonstrating bioactivity will undergo further testing in cell-based assays using human macrophages, keratinocytes, and melanocytes. This phase will assess their anti-inflammatory effects in keratinocytes and macrophages, and photoprotective, antioxidant and anti-lipid peroxidation activities in keratinocytes. Furthermore, melanin production in human melanocytes will be analysed to explore potential skin-brightening and pigmentation-modulating effects.
Beyond bioactivity studies, this research will include the inclusion of promising microalgal extracts and the assessment of the formulated products' stability, in collaboration with Papillon Cosmetic Unipessoal Lda. Ensuring the stability of active compounds is critical for maintaining efficacy and extending shelf life, essential for commercial viability.
By integrating scientific research with industrial collaboration, this project aims to unlock the full potential of microalgae in cosmeceutical applications, paving the way for innovative, safe, and highly effective skincare products.

**KEYWORDS**
Microalgae, Supplements and cosmetics

# 11235 - ISOLATION, CHARACTERIZATION, AND BIOTECHNOLOGICAL POTENTIAL OF HALOPHILIC MICROALGAE

Authors
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## ABSTRACT
Costal saltworks are exceptional environments to study and isolate well-adapted microorganisms to various environmental conditions, since in a confined area we find from seawater, the most abundant ecosystem on Earth, to salt saturation ponds, one of the most extreme. The halophilic microorganisms inhabiting these habitats have to cope with other extreme conditions, such as elevated temperature or UV radiation, in addition to the high salinity. Halophiles are widespread in the three domains of life; however, there are few halophilic eukaryotes able to thrive in extreme salinity conditions compared to prokaryotes. In this sense, halophilic microalgae living in these harsh conditions may be an extraordinary source of unique metabolites with increasing interest in biotechnology. In this work, we first characterized the eukaryotic microbial population living in Odiel Saltworks (Huelva, SW Spain) by a metataxonomic approach, observing the great dominance of green microalgae of the genera *Picochlorum* and *Dunaliella* at medium (7-15%) and high salinity (>30%), respectively. Thereafter, we carried out photosynthetic biomass enrichment from water samples in controlled conditions (temperature, aeration, and light) prior to colony isolation on agar plates. Several colonies were isolated and identified, according to their 18S rRNA coding gene sequence, as new strains of *Picochlorum* and *Dunaliella*. The pigment profiles of these two strains were characterized and the effect of nitrogen starvation on carotenoid composition was analyzed, observing the stimulation of the levels of lutein and β-carotene in *Dunaliella* and zeaxanthin in *Picochlorum.* The high content of the carotenoids β-carotene, lutein, and zeaxanthin indicates that these microalgae could be a good source of natural vitamin supplements for the eyes. Diverse extracts from *Dunaliella* and *Picochlorum* were tested *in vitro* to study their antioxidant potential by the ABTS method, and their antitumor activity in colon tumor cell lines T84 and HCT15. The best antiproliferative results were obtained in cell line HCT-15 with the ethanolic fractions for both species, and the highest antioxidant capacity was also observed in ethanolic extracts. These results highlight the importance of exploring halophilic microalgae in the search for bioactive compounds for the development of novel therapies through the analysis of functional extracts of microalgae. Finally, a method for the rapid genetic manipulation of microalgae is being optimized, which aims to improve the synthesis of the desired metabolites for diverse applications.
Funding: This research was funded by Campus de Excelencia Internacional Global del Mar (CEI-Mar 2022) (Project CEI-JD-19.1 and CEI-JD-19.2) and Agencia Estatal de Investigacin (grant PID2022 140995OB-C21 by MICIU/AEI/10.13039/501100011033 and ERDF/EU). P.G-V acknowledge a Juan de la Cierva contract from MICIU/AEI /10.13039/501100011033 and EU NextGenerationEU/PRTR.

## KEYWORDS
Microalgae, Supplements and cosmetics

# 11243 - EXPLORING MICROALGAE AND CYANOBACTERIA AS BIOTECHNOLOGICAL RESOURCES IN METABOLIC DISEASE RESEARCH

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## ABSTRACT
By 2035, nearly half the world's population will have obesity, leading to metabolic diseases like diabetes, steatosis, and cancer. Existing treatments are invasive, costly, or ineffective, highlighting the need for new strategies. The vast aquatic environment holds untapped resources, with cyanobacteria and algae known for producing bioactive metabolites. Here demonstrate how organic extracts from cyanobacteria, micro and macro-algae have great potential for novel compounds discovery for metabolic disease research. Using a transgenic zebrafish model [Tg(ins:YFP-T2A-NTR3, cryaa:mcherry)], we showed that dichloromethane/methanol (DCM/MeOH) extracts prepared from dried *Scenedesmus oblíquos*, *Arthospira platensis*, *Nanochloropsis oceânica*, *Nanofrustulum shiloi*, *Phaeodactylum sp.*, *Chlorococcum sp.* Biomass increased the pancreatic β-cells number compared to the metronidazole ablation group. Using wildtype zebrafish we also showed that aqueous extracts of *Nannochloropsis*, *Nanofrustulum* and *Porphyridium* lowered lipid accumulation. Also ethanolic extracts of *Scenedesmus* and *Tetraselmis chui* increased glucose absorption and reduced/increased food intake aqueous extracts of *Arthospira platensis*, and *Tetraselmis chui* and *striata* suppressed appetite. Moreover, lipidic extracts of *P. Gyrans* and *P. tricornutum* and aqueous *T. chui* undissolved sample after proteolysis reduced lipid acumulation in zebrafish larvae. Lipidic extracts of *P. gyrans, S. platensis, N. gaditana* also showed appetite reduction. In addition, undissolved sample from *T. chui* aqueous extraction increased glucose uptake. We also employ bioactivity-oriented molecular network using LC-MS/MS and bioactivity data for the discovery of singletons or families of compounds with bioactive properties. Our results highlight the potential of organic extracts from cyanobacteria, microalgae, and macroalgae for novel therapeutics in metabolic diseases and nutraceuticals, adding value to these aquatic resources.

## KEYWORDS
Algae Market, Microalgae, Supplements and cosmetics

# 11252 - THE EFFECT OF EXTRACTS FROM MICROALGAE GROWN IN DRAINWATER AS BIOCONTROL AGENTS AND BIOSTIMULANTS IN AGRICULTURE

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## ABSTRACT
With the continuous increase in human population, a higher pressure is put on food services to surge production, which can lead to over-application and reliance on chemical products. However, in agriculture, efforts are being made to decrease the dependency on chemical fertilizers, driving a demand for natural-based products. Among the several types of bioproducts and biostimulants are microalgae-based products, which have been shown to have biostimulant activities related to germination stimulation, improved seedling growth and increased biomass productivity [1]. Agriculture has also shifted to a more sustainable model, using soilless plant production systems, offering higher productivity and lower water requirements. Nonetheless, about 30% of the water used in these systems is still discharged, containing high levels of nutrients. Therefore, implementing a co-production system where microalgae can treat the discharged water (drainwater) while generating biomass for biofertilizers and biostimulants aligns with circular economy principles.
With this in mind, two microalgae, *Tetradesmus obliquus* and *Raphidonema monicae*, were grown in a 19-$m^3$ tubular photobioreactor in drainwater until reaching a stationary phase or having removed nitrates below current legal limits. The biomass was harvested, and a biorefinery approach was implemented using high-pressure homogenization, enzymatic hydrolysis, micro- and ultrafiltration, and ethanolic extraction, to generate eight different fractions. These fractions were tested *in vitro* as biocontrol agents against five plant pathogens, resulting in the highest inhibition against *Sclerotium rolfsii* (27.5% with a *R. monicae* fraction and 8.1% with a *T. obliquus* fraction). The fractions were also tested in germination trials with arugula and tomato seedlings, showing a higher germination index when using the fraction containing the pellet from ethanolic extraction after microfiltration. It was also possible to see a higher germination index when using the fractions of *R. monicae*, compared to that of *T. obliquus*. One fraction from each strain was selected and tested in an *in vivo* trial with strawberry and lettuce plants. The results suggest that the selected extracts are a viable application to increase food production and quality, aligning with the EU commitment to decrease the dependency on chemical compounds.
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## KEYWORDS
Microalgae, Agriculture, Environmental solutions/ Circular Econom

# 11253 - VALORIZATION OF MACROALGAE AS A SUSTAINABLE SOURCE OF VITAMIN K1 FOR SUPPLEMENTATION AND SKIN HEALTH

Authors
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## ABSTRACT
Macroalgae are a rich source of bioactive compounds, including polyphenols, pigments, and vitamins. Among these, vitamin K1 is particularly relevant due to its essential role in blood coagulation, vascular and bone health, as well as in inflammatory skin conditions with emerging evidence of anti-inflammatory and antioxidant properties. Currently, most commercially available vitamin K1 is synthetically produced raising concerns about the presence of menadione traces and the formation of inactive Z-isomers, which may reduce its effectiveness. Given the rising consumer demand for natural and sustainable supplements, we aimed to explore macroalgae as a potential natural source of vitamin K1 for supplementation to improve skin health. Additionally, several invasive macroalgae species are negatively impacting local ecosystems, fisheries, native seaweed populations, and tourism. Valorisation of these species could offer a sustainable solution by transforming problematic biomass into valuable resources. In this study, we screened eight macroalgal species for their vitamin K1 content: Cladostephus spongiosus, Dictyota cf. dichotoma, Cystoseira usneoides, Codium tomentosum, Sargassum muticum, Caulerpa prolifera, Asparagopsis armata, and Rugulopteryx okamurae. To optimize extraction, we compared hexane-based extraction (EDGE) with supercritical fluid extraction using CO2 (ScCO2). Vitamin K1 was quantified through RP-HPLC and its structure was confirmed through LC-MS/MS. The anti-inflammatory and anti-lipid peroxidation properties of vitamin K were evaluated in human keratinocytes using the HaCaT cell line. For enhanced stability and bioavailability, vitamin K1 was microencapsulated by the spray dryer technique using a fucoidan-based matrix. Our results showed that ScCO2 extraction was the most efficient and sustainable method, yielding the highest selectivity, and requiring less solvent and energy. All vitamin K1 extracted from macroalgae had the same retention time and mass-to-charge spectrum as the analytical standard. From the analyzed species, R. okamurae exhibited the highest vitamin K1 content while D. dichotoma had the lowest. In the human keratinocyte cell line HaCaT, pretreatment with vitamin K1, MK-4, and MK-7 at concentrations ranging from 1 -100 µM reduced IL-8 levels following inflammation stimulation with TNF-α. Furthermore, the reduced form of vitamin K1 and MK4 exhibited lipid peroxidation antioxidant activity in HaCaT cells. Our findings support the potential of macroalgae, particularly R. okamurae, an highly proliferative and invasive macroalgae in our Portuguese coas,t as a sustainable and natural source of vitamin K1 with potential application for dietary supplementation and the prevention of inflammatory skin diseases. Additionally, our approach offers an environmentally responsible strategy to mitigate the ecological impact of invasive macroalgae through biomass valorisation.

## KEYWORDS
Macroalgae, Supplements and cosmetics

# 11258 - RELATIVE ANTIOXIDANT CAPACITY INDEX (RACI) AS A TOOL TO IDENTIFY PROMISING ALGAL EXTRACTS WITHIN THE ALGAE4IBD PROJECT

Authors

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## ABSTRACT

Since the beginning of the EU-funded Algae4IBD project (grant agreement no. 101000501) hundreds of organic extracts have been produced and distributed among project partners for bioactivity assessment, including antioxidant, pain relief activity and cell-based and gene reporter anti-inflammatory assays. Under the project's umbrella, antioxidant results derived mostly from six different methods, *i.e.*, DPPH, ABTS, oxygen radical absorbance capacity (ORAC), ferric reducing antioxidant power (FRAP) and iron (ICA) and copper (CCA) chelation assays. Albeit antioxidant data was not used as a discriminatory factor *per se*, it was continuously valuable to complement the bulk of anti-inflammatory experiments and support sample selection on moving forward in the project pipeline. Due to the large set of data collected, an approach that could easily and efficiently distinguish the most promising algal extracts was needed; hence, the relative antioxidant capacity index (RACI), widely applied to rank the antioxidant power of foods (1) and later extended to other biological matrices, such as macroalgae (2,3), was used. This statistical model is based on the calculation of the average of standard scores, from the raw data of each assay, yielding a numerical value highly correlated to the most frequently used antioxidant methods (1). Thereof, in this work, the antioxidant activity of a set of 21 macro- and microalgae strains, comprising 60 organic extracts (ethanol, ethyl acetate and/or hexane), was assessed through DPPH, FRAP, ABTS, ORAC, ICA and CCA, and RACI values calculated for each sample. Results were grouped by organisms and expressed either as individual assays or RACI. Overall, macroalgae exhibited stronger antioxidant capacity and, consequently, higher RACI values in comparison to microalgae. Among macroalgae, samples 1a-ET and H, 15-EA, 1b-EA and 48-H ranked highest in RACI; for the microalgae group, strain 1099 was highlighted, regardless of the extraction solvent, followed by 114-ET and H extracts. In the end, RACI was indeed a valuable tool for a rapid and visual identification of the most effective extracts and strains, which in combination with further anti-inflammatory data greatly contributes to an improvement of the decision-making process, whenever dealing with large sums of antioxidant results.

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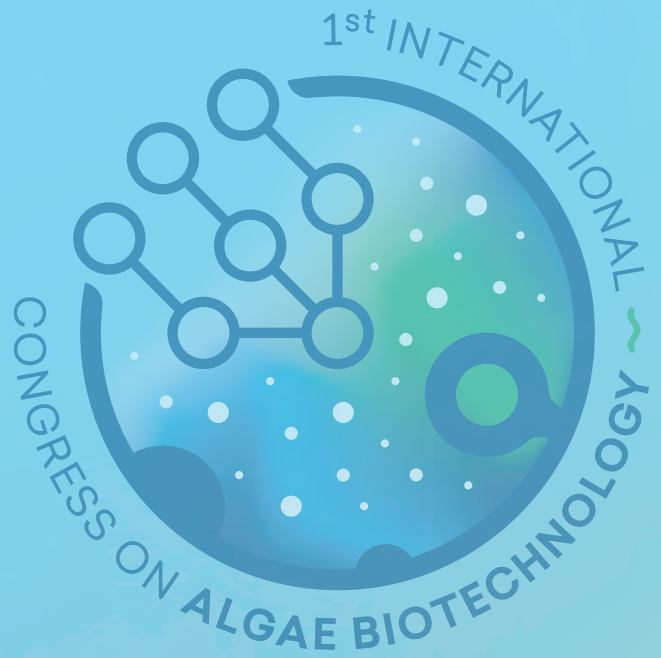
## KEYWORDS

Microalgae, Macroalgae, Food, Supplements and cosmetics




# POSTER SESSION

# ALGAE EMERGING TECHNOLOGY: AI, MACHINE LEARNING, DEEP LEARNING AND NEURAL NETWORKS

# 10544 - ALGAL GENOMICS IN BIOTECHNOLOGY

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**ABSTRACT**

In our rapidly changing world, decoding nature is our path ahead. Genomes encapsulate life's secrets, including the intricate mechanisms organisms employ for adaptation and survival. Algae, crucial constituents of aquatic ecosystems, exhibit remarkable adaptability across diverse environments. By unraveling and interpreting key elements within algal genomes, we unlock the potential to select, prospect and develop algal strains with myriad industrial applications, mimicking the efficiency of natural processes. However, despite the growing demand for algal production, standardized genome assembly procedures are lacking, with only a limited number of macroalgal genomes available. This gap has now been bridged by the latest research (Nelson & Mystikou et al., 2024), which provides the genomes of 120 macroalgae from diverse climates, habitats, and taxonomic phyla and constitutes the largest macroalgal genomic resource. Universal and unique genetic markers linked to salinity tolerance and oxidative stress responses have been identified through this resource. The distinct genomic signatures found in macroalgae from the UAE particularly highlight the intricate connection between their genetic makeup and the specific climatic conditions of the region. These findings not only deepen our understanding of macroalgal resilience in the face of global climate change but also pave the way for future biotechnological applications across multiple industries—such as pharmaceuticals, energy, cosmetics, and nutrition—that can harness these unique adaptive traits.

# 11052 - NEW METHODOLOGY FOR THE ASSESSMENT OF GAMETOPHYTE SURVIVAL AND GROWTH IN THE KELP LAMINARIA OCHROLEUCA

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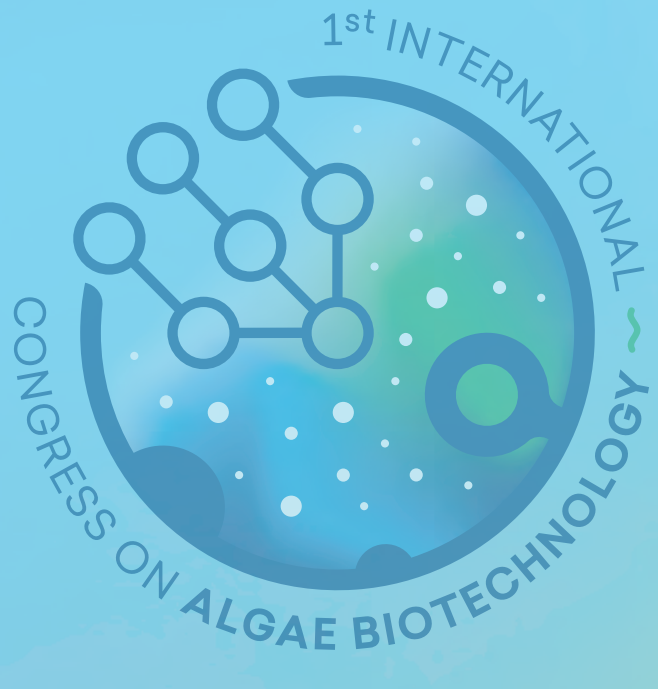
## ABSTRACT
Viability analysis of kelp microscopic gametophytes is currently done with subjective methodologies. Current techniques mainly rely on visual analysis of bright-field (BF) microscope images to count live/dead gametophytes, their areas, length and pigmentation index. Fluorescence techniques have been employed but require staining samples with potentially toxic dyes, such as fluorescein diacetate and neutral red which invalidate the usage of these replicates in prolonged experiments. Moreover, fluorescence microscopy (FM) may induce gametogenesis if blue/UV light intensity is too high. This study aimed to develop a non-invasive and accurate methodology for assessing gametophyte viability over time, using FM observation of the autofluorescence signal emitted by the photosynthetic apparatus of live gametophytes. For this, 6 isolated gametophyte strains of *Laminaria ochroleuca* (Messina, Italy) maintained at the CCMAR Biobank were used in triplicate. The gametophytes were ground, passed through a 100 µm sieve and then cultured (female, male, and both combined) in Petri dishes containing 10 mL of half-strength Provasoli's enriched seawater medium, under red light (16:8 LD, 7 µmol photons $m^{-2}$ $s^{-1}$), at 16 ºC, for 1 month. After 3 days of recovery, survival and growth were assessed on days 1, 7 and 14 by taking photos of 20 fields-of-view, both in BF and FM (n=40 photos). Photos were taken with a 10x objective in an inverted fluorescence microscope [Observer D1, with Red filter (Ex BP 560/40 | EM BP 630/75)]. The Petri dishes were then moved to white light (10 µmol photons $m^{-2}$ $s^{-1}$) to induce gametogenesis and test whether the autofluorescence analysis (AFA) method had any impact on gametophyte reproduction capacity. Image analysis was done using FIJI software (Java) by manually counting live gametophytes (survival) and measuring their areas (growth). In addition, a machine-learning (ML) model was developed using Fiji's WEKA segmentation plugin, to analyze the FM images automatically. The results revealed that manual analysis of FM images was more sensitive than BF. Moreover, the FM image analysis by the ML model was faster and even more accurate than manual analysis, as expected. After 5 days under white light, antheridia were visible in males and, at day 7, both eggs and sporophytes were present in some combined male and female Petri dishes. Our AFA analysis method had no impact on gametogenesis, providing an objective technique to assess gametophyte viability over time. Since it uses open-source machine learning tools, the AFA method is time-saving and accessible, while delivering more accurate and reliable data. This promising methodology can be applied to other photosynthetic species with pigments emitting autofluorescence in the red spectrum or be adapted to use with different microscope settings for organisms with pigments emitting in a different spectrum.

## KEYWORDS
Macroalgae




## POSTER SESSION

# ALGAE IN ENVIRONMENTAL SUSTAINABILITY

# 10900 - SCENEDESMUS SP. GROWTH FOR EFFICIENT BREWERY WASTEWATER TREATMENT AND BIOMASS UPCYCLING

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## ABSTRACT
In Europe, medium and large-scale breweries (>17600 hectolitres per year) must treat their effluents before being disposed of in the sewage system, and most large-scale breweries have an *in-situ* wastewater treatment plant. This process is costly and time-consuming for beer producers, and this effluent must comply with local regulations regarding the limitation of nutrient release. Microalgae-bacteria consortia are an alternative to conventional wastewater treatment as they upcycle nitrogen and phosphorus into valuable biomass. The objective of this study was to find the best operational parameters for a semi-continuous production system of *Scenedesmus* sp. treating brewery effluents. The culture was scaled in triplicate to a 4.5 L reactor, with 220 µmol $m^2$ $s^1$ on a 16h:8h light: dark cycle, pH set at 8.5, mixing, aeration and $CO_2$ dosing. The brewery effluent composition was 1450 mg/L of TOC, 52.5 mg/L of TN, and 36.5 mg/L $PO_4^{3-}$. The maximum biomass productivity achieved was 1.5 g/L, and the maximum specific growth rate was 0.019 $h^1$. Concerning nutrient recovery, $PO_4^{3-}$, TN, and TOC removal rates were 100%, 85% and 71%, respectively. The growth dynamics of *Scenedesmus sp.* were modelled using the Verhlust equation, predicting a steady-state biomass concentration of 0.77 g/L. The hydraulic retention time for maximum productivity was determined at a dilution rate of 3.2 d. The findings of this study demonstrate the significant potential of *Scenedesmus sp.* for simultaneous brewery wastewater remediation and biomass production.

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## BIO
Belén Villarreal Toribio is a PhD candidate in The Group of Environmental Engineering and Microbiology (GEMMA) at the Department of Civil and Environmental Engineering (DECA) of the Universitat Politècnica de Catalunya (UPC). She has expertise in microalgae culture at laboratory and industrial scales, focusing on scaling up processes, operational conditions, parasite identification, and biomass quality assessment. Since 2024, Belén Villarreal Toribio has been working at UPC in the cultivation of microalgae in brewery wastewater, aiming for the scalability of a bioremediation system and the development of high-value microalgae biomass enriched in protein utilising random mutagenesis techniques to improve microalgae strains.

## KEYWORDS
Microalgae, Production, Food, Environmental solutions/ Circular Economy

# 10911 - SEASONAL DISTRIBUTION, DIVERSITY, AND ENVIRONMENTAL INFLUENCES ON MACROALGAL COMMUNITIES ALONG THE ATLANTIC COAST OF DOUKKALA

Authors
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## ABSTRACT
Monitoring macroalgal diversity is essential for evaluating the health of marine ecosystems. This study, conducted along the Atlantic coast of Doukkala, focused on assessing macroalgal species diversity, their seasonal distribution in the intertidal zone, and the impact of physicochemical factors on their distribution.
Sampling was carried out at four sites over one year using the quadratic transect method. Macroalgal species were identified using identification keys, while environmental parameters such as salinity, temperature, pH, nitrate ($NO_3$), orthophosphate ($PO_4$), and dissolved oxygen were measured. Ecological indices were also calculated, and principal component analysis (PCA) was used to examine the relationship between macroalgal diversity and environmental factors.
A total of 206 macroalgal species were identified, including 151 Rhodophyta, 29 Phaeophyta, and 26 Chlorophyta. Species richness was highest in the spring season. Environmental factors, including temperature, salinity, nitrate, orthophosphate, and dissolved oxygen, were found to influence macroalgal diversity across the sites.
This study highlights the dynamic nature of macroalgal communities and their response to environmental changes, offering valuable insights into the health and stability of marine ecosystems along the Atlantic coast of Doukkala.

## KEYWORDS
Doukkala coast, Macroalgae, Diversity, Intertidal zone, Seasonal variation

## KEYWORDS
Macroalgae

# 10917 - ENHANCING RETAIL FOOD WASTE POTENTIAL THROUGH ENZYMATIC PRETREATMENTS FOR HETEROTROPHIC MICROALGAE CULTIVATION

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## ABSTRACT

In 2022, it was estimated that approximately 1.05 billion tons of food were wasted, highlighting the need to identify new and sustainable solutions to address the problem of food waste (FW). The nutrient-rich composition of food waste makes it an attractive feedstock for microalgae cultivation, offering a sustainable route for food waste management and nutrient recovery while promoting a circular economy. However, due to the heterogeneity and complexity of food waste, it is often necessary to implement a pretreatment step that induces structural changes of the biomass and alters its chemical composition, ultimately improving the efficiency of bioconversion.

The present work focused on enhancing the potential of different retail food waste formulations through enzymatic pretreatments to support the cultivation of heterotrophic microalgae. To achieve this, 8 different enzymatic cocktails - Pectofruit Ultra IF; Cellofruit IF; Glucacel AXC; Glucalyase; Velluto; 10 ICS clair; AMG; Alphamyl PF NaCl - were tested on 3 different FW formulations (FWa, FWb, FWc ) composed of several food categories – fruits, vegetables, bakery, dairy, meat, and fish - in order to increase the reducing sugars and glucose content of these substrates for microalgae cultivation. The results showed that Alphamyl PF NaCl yielded the highest concentration of reducing sugars: 39.10 ± 0.95 g/L; 30.28 ± 3.26 g/L, and 25.18 ± 4.01 g/L in FWa, FWb, FWc, respectively. However, only 12.39 ± 0.39 g/L; 8.59 ± 0.33 g/L, and 6.92 ± 1.50 g/L, respectively, was glucose. In contrast, when AMG was tested, it showed lower total reducing sugars concentrations of 32.38 ± 4.33 g/L, 15.54 ± 0.74 g/L, and 11.89 ± 1.41 g/L for the respective FW samples. Nevertheless, this enzymatic cocktail produced the highest concentration of glucose compared to all other cocktails tested: 22.53 ± 0.96 g/L, 11.38 ± 3.53 g/L, and 10.86 ± 0.62 g/L, respectively. To validate these findings, *Chlorella sorokiniana* was cultivated in FWa pretreated with AMG - since this condition provided the highest concentration of glucose - and supplemented with 50 % of both the macro- and micronutrients present in the commercial medium (control condition) and 100 % of the vitamins, resulting in approximately half of the growth when compared to the commercial medium.

The aforementioned results have proven that the enzymatic pretreatment process developed in this work successfully increased reducing sugars and glucose content in the retail FW, delivering a promising alternative to support *C. sorokiniana* cultivation.

## KEYWORDS

Food, Environmental solutions/ Circular Economy, Microalgae, Production

# 10926 - MICROALGAE AS A STRATEGY TO VALORIZE WINERY WASTEWATER – CLOSING THE LOOP

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## ABSTRACT
With the world's population growth, expected to reach almost 10 billion people by 2050, competition for freshwater resources is becoming more intense. Industries are under pressure to adopt more sustainable practices and sectors such as winemaking significantly contribute to water use and pollution, further exacerbating the global water crisis. Winery wastewater is challenging due to its high organic load, presence of phenolic compounds, acidity, and seasonal variability. Therefore, managing this wastewater is one of the most pressing challenges, since traditional treatment methods often fail to meet sustainability objectives, leading to the search for alternative solutions. Microalgae have emerged as an innovative biotechnological tool for wastewater treatment, offering several advantages, such as low energy consumption, pollutant removal, nutrient recycling, and high-value biomass production potential.
This study aimed at developing a bioremediation strategy for the treatment of winery wastewater, enabling its safe discharge into water bodies by effectively removing nutrients and pollutants. For this purpose, the microalga *Chlorella vulgaris* was inoculated into the wastewater and the effluent was subjected to different dilution levels to optimize the treatment conditions. The efficiency of *Chlorella vulgaris* in nutrient and pollutant removal was assessed by monitoring key parameters, including chemical oxygen demand (COD), nitrate ($NO_3^-$), ammonia ($NH_3$), and phosphate ($PO_4^{3-}$) levels, ethanol concentration, and total phenolic content (TPC). Both untreated and treated wastewater were analyzed to evaluate the reduction of organic load and nutrient concentrations, providing insights regarding the potential of this algal-based treatment for large-scale applications. Different dilutions resulted in different *C. vulgaris* growth, ranging from 0.49 to 0.61 $g.L^{-1}$. It should be noted that this effluent had high concentrations of ethanol. Thus, in dilutions of less than 1/4, it was not possible to obtain any growth of this microalga, indicating that the concentration of ethanol remained toxic. Regarding nutrient and pollutant removal, efficiencies exceeding 86 %, 73 %, and 54 % were achieved for $NO_3^-$, COD, and TPC, respectively. However, in the case of phosphate assimilation by microalgae, high removal rates were not observed and, in some cases, an increase in its concentration was detected. Generally, the 1/5 dilution achieved the best removal percentage rates for the analyzed pollutants, along with the highest cell concentration.
Based on these results, the effectiveness of *C. vulgaris* in the bioremediation of winery wastewater is highlighted, showing a sustainable solution for the treatment of wine effluents.

## KEYWORDS
Microalgae, Environmental solutions/ Circular Economy

# 10975 - ALGAE-BASED CIRCULAR ECOSYSTEMS: UTILIZING AQUACULTURE SIDE STREAMS FOR SUSTAINABLE MICROALGAE CULTIVATION IN NORWAY

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## ABSTRACT

Norway is Europe's largest aquaculture producer, surpassing the entire European Union in both volume and value (1). This sector consumes significant amounts of freshwater and generates nutrient-rich side streams. In 2019, the Norwegian sea-based farming industry discharged approximately 224,000 tons of carbon, 66,000 tons of nitrogen, and 14,000 tons of phosphorus (2). Algae have demonstrated substantial potential in reducing nutrient loads from various industrial effluents, offering added value across diverse market segments (3-4).

The EU project LOCALITY aims to establish algae-based circular ecosystems by utilizing side streams from the fish industry as a growth medium for microalgae cultivation. This innovative approach integrates the entire ecosystem within a single industrial facility or a confined geographical area, demonstrating a strong symbiotic relationship within a circular system. The project holds the potential for scaling nationally and internationally and to other industries.

As part of this initiative, ten different side streams were collected from land-based fish farms for smolt production and seafood processing facilities across Norway and analyzed for physicochemical characteristics, including nutrient content, toxic compounds, and other relevant components. Based on nutrient profiles, specific streams were selected for further screening. The Norwegian Culture Collection of Algae (NORCCA), managed by NIVA, maintains over 2,000 algal strains. Using a high-throughput screening system in 96-well microplates, 16 Spirulina strains and 24 *Chlorella* sp. strains from NORCCA were evaluated for growth potential into the side streams.

The nutrient analysis revealed that all side streams contained varying levels of nitrogen, phosphorus, and trace elements essential for algal growth. However, nutrient content and seasonal variations indicated that not all streams were optimal for cultivation. Three side streams were selected for algae growth experiments. Five strains exhibited higher growth rates. Those strains were further identified through molecular methods as *Chlorella* sp., *Chlorella vulgaris*, and *Arthrospira platensis*. These strains are now being scaled up in laboratory settings for secondary selection and further optimization.

This study highlights the feasibility of integrating microalgae cultivation into aquaculture facilities, providing a pathway for sustainable resource utilization and nutrient recovery.

Keywords: microalgae, industrial side streams, aquaculture, algae cultivation, growth potential

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## KEYWORDS

Microalgae, Environmental solutions/ Circular Economy

# 10997 - BIOPOLYMERS PRODUCTION FROM MICROALGAE USING WASTE STREAMS

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**ABSTRACT**
Plastic pollution and other waste streams represent critical global challenges, projected to worsen significantly in the coming decades. This escalating issue highlights the urgent need to develop sustainable strategies to mitigate pollution and promote circular economy initiatives. Microalgae and cyanobacteria have emerged as promising candidates for the bioconversion of waste streams into valuable bioplastics, such as polyhydroxyalkanoates (PHAs), which possess properties comparable to traditional petrochemical plastics.
This project focuses on transforming waste-derived nutrients into bioplastics using microalgae and cyanobacteria, leveraging waste streams as feedstocks. By doing so, it aims to reduce reliance on fossil fuels and promote environmental sustainability through innovative waste valorisation approaches. Microalgae and cyanobacteria offer multiple advantages, including $CO_2$ sequestration, efficient nutrient uptake, and the production of co-products such as proteins, exopolysaccharides (EPS), lipids, and pigments with bioactive properties. These co-products can be integrated with the produced bioplastics to create multifunctional, high-value materials.
Three microalgae/cyanobacteria species — *Anabaena* sp. PCC 7120, *Nostoc* sp. PCC 9202, and *Porphyridium purpureum SAG 1380-1a*—were identified as the top EPS producers. An innovative culture medium derived from waste streams was developed to optimize their growth at the laboratory scale. This medium significantly enhanced EPS production, achieving up to a 17-fold increase compared to conventional media. PHA production was also demonstrated, with yields ranging from 12.3% to 14.1% (w/w).
Future pilot-scale studies will assess the feasibility and scalability of this approach, paving the way for a sustainable, waste-to-bioplastic production pipeline that aligns with circular economy principles.

**ACKNOWLEDGMENTS**
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**BIO**
MSc in Chemical and Biochemical Engineering, currently a PhD student at NOVA FCT and LNEG. She obtained her master's in November 2022, studying the production and characterization of protein fractions from different microalgae species in a biorefinery concept, at A4F. She optimized biorefinery process operations such as proteins' extraction and stabilization and introduced techniques such as SDS-PAGE for proteins molecular weight characterization. Rebeca worked at ALGAESYS as a Process Engineer. She integrated projects with the aim of treating wastewater through an innovative technology that uses microalgae and other phototrophic organisms, while producing PHA's.

**KEYWORDS**
Microalgae, Environmental solutions/ Circular Economy

# 11053 - CCMAR BIOBANK: A MARINE BIOLOGICAL RESOURCE PROVIDER FOR INDUSTRY, RESEARCH, AND SOCIETY

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## ABSTRACT
CCMAR biobank was created as part of the Portuguese Blue Biobank, a network of national marine biological collections to position Portugal at the forefront of knowledge and conservation of marine biodiversity. Located in Faro (Portugal), CCMAR biobank is a bioresource provider that establishes, maintains, phenotypes, genetically characterizes and facilitates the sustainable, transparent, and regulated access to biological samples of macroalgae, and microorganisms associated with marine organisms. The biological collection is made of samples from worldwide ecosystems, with a strong presence of the endemic Portuguese species. The core mission is to preserve and study marine biodiversity, focusing on ecologically and economically important Portuguese macroalgal species with high potential for restoration and/or aquaculture. Some of the services offered by the biobank include the provision of starter cultures from different genetic populations, isolation of strains and microbiome, taxonomic identification through morphology and DNA barcoding, and providing juvenile macroalgae starting material for diverse end users (e.g.: research, aquaculture industry, habitat restoration and other environmental or sociological applications). Scientific and industrial consulting services on algae cultures are also available. The CCMAR biobank team created a Macroalgae and Bacteria Catalogue that aims to facilitate access to the existing culture collection at the biobank, providing crucial information regarding each specimen, from the collection to isolation and laboratory maintenance. This collection currently holds over 404 strains, representing 63 species. These organisms belong to 7 phylum and comprise 47 genera. Seaweeds account for 60% (252 strains) of the collection, while bacteria (152 strains), sampled from corals, represent 53 species. This catalogue features strains isolated mainly from marine habitats in Portugal (63%), and also from France, Italy, Morocco and Norway. The strains are characterized by genotypic and phenotypic-based approaches. To date, 56% of the CCMAR Biobank strains have barcoding sequences deposited in GenBank. The Biobank also has 244 samples of preserved tissue in silica from four kelp species: *Phyllariopsis purpurascens*, *Saccorhiza polyschides*, *Laminaria ochroleuca* and *Laminaria hyperborea*. In addition, 101 samples of spore pools from individual sporophytes are also preserved alive to further isolate more strains and to provide samples with higher genetic diversity. The CCMAR biobank actively works to deliver knowledge underpinning macroalgae ecology, physiology, and genetics, therefore helping in the management of wild macroalgal populations, successful habitat restoration, biotechnological applications, and sustainable seaweed aquaculture, being committed to the protection of national marine resources and their economic valorization, both nationally and internationally.

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## KEYWORDS
Macroalgae, Algae Market, Production

# 11059 - ALGAEBOOST: BIOSTIMULANT AND BIOPESTICIDE ACTIVITY SCREENING OF MACRO AND MICROALGAL EXTRACTS

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**ABSTRACT**
Global agricultural land is diminishing due to urbanization and climate change, while food production must double by 2050 to meet rising demand. Traditional farming practices, including the excessive use of fertilizers and pesticides, have contributed to soil degradation and biodiversity loss. Alternative solutions are crucial, not only to safeguard the planet but also to meet Europe's Green Deal targets for reducing their use. A potential approach involves converting biomass waste into products that promote crop growth and protect plants from pests, addressing both short-term and long-term environmental challenges. Micro- and macroalgae are widely utilized across various industries for their bioactive compounds, some of which are known to have biostimulant activity. However, the extraction processes often lack efficiency and leave behind residual biomass that contain valuable components. This project focuses on the valorization of industrial waste from the polysaccharide extraction of *Fucus vesiculosus* and *Sargassum* species, as well as utilizing discarded fractions of *Phaeodactylum tricornutum* after the extraction of fucoxanthin. Enzymatic treatments were optimized to maximize the release of bioactive compounds from the biomasses (up to 30% of total carbohydrates and 41% of total protein), which were later tested in biostimulant trials with lettuce and tomato under nutritional stress. Additionally, the antifungal potential of the products was evaluated *in vitro* against fungi commonly responsible for reducing crop yields. In this way, waste can be converted into a valuable resource, utilizing algae to boost both crop productivity and environmental sustainability through the creation of multi-product biorefineries that maximize resource efficiency.

**KEYWORDS**
Agriculture, Biorefinery, Environmental solutions/ Circular Economy, Macroalgae, Microalgae

# 11102 - LIFE CYCLE ASSESSMENT OF INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA) SYSTEM: EVALUATING THE SUSTAINABILITY OF THE SEAWEED VALUE CHAIN

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## ABSTRACT

The Integrated Multi-Trophic Aquaculture (IMTA) systems represent an innovative approach to sustainable aquaculture, combining multiple species to create a closed-loop and balanced ecosystem. Environmental concerns related to conventional aquaculture, such as waste disposal, nutrient pollution and disease outbreaks, have positioned IMTA as an environmentally responsible alternative. This study quantified the environmental impact of IMTA processes within a circular economy framework, focusing on the sustainable production of fishery products from different trophic levels, including seaweed, halophyte plants and fish. Life Cycle Assessment (LCA) is a methodology employed to provide a comprehensive evaluation of environmental impacts throughout the production cycle. The LCA of an IMTA system was performed using OpenLCA 2.3.1 software, supported by the Ecoinvent v3.10 database. The Environmental Footprint method (EF v3.1) was used for the assessment. This method covers 16 impact categories, incorporating the latest scientific developments and industry best practices. The LCA considered all the production processes up to the final products, including seaweed biomass (*Ulva* sp., *Gracilaria* sp*.,* and *Fucus vesiculosus*), halophyte plants (*Salicornia ramosissima*) and fish production (sea bass and sea bream). The cradle-to-gate boundaries incorporated all operational stages, productivity metrics and system inputs/outputs, including emissions (water, nitrogen and phosphorus). A seasonal comparison (winter vs. summer) was conducted to assess environmental performance variations. These data will serve as a decision-making tool for industrial units, identifying key bottlenecks and improvement opportunities in IMTA farming systems. Additionally, the study provides valuable data for commercial-scale production and guides new strategies for IMTA units regarding environmental sustainability.

Keywords: Environmental assessment; IMTA; Seaweed; Circular economy; Environmental impact.
Acknowledgement: This work was financially supported by “Pacto da Bioeconomia Azul” (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line “Agendas for Business Innovation” through the funding scheme C5 - Capitalization and Business Innovation.

## KEYWORDS

Macroalgae, Production, Environmental solutions/ Circular Economy, Algae Market

# 11135 - NEW RECORDS OF FRESHWATER ALGAE FROM JORDANIAN AQUATIC SYSTEM

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**ABSTRACT**
Although planktonic algae play a significant role in freshwater ecosystems, our knowledge of their variety and species distributions is still rather limited in Jordan. Due to its diverse morphology, hydrology, and geographic variation (latitudinal, longitudinal, and altitudinal gradients), the Jordanian environment has a high capacity to host a diverse array of algae. Therefore, in this study we identified ten species for the first time. The description of the freshwater algae's biodiversity in Jordan is essential for the creation of conservation initiatives. The identification of these species emphasizes the need for more research to advance understanding of the richness and ecology of this hydrographic system. A total of 20 phytoplankton samples were collected from three sites in Jordan. Ten species representing new records for the freshwater algal flora of Jordan were identified.

# 11170 - VALORIZATION OF INDUSTRIAL FOOD WASTES AS CULTURE MEDIA FOR MICROALGAE: OPPORTUNITIES AND CHALLENGES

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## ABSTRACT
The use of industrial waste streams has been considered a sustainability critical point for microalgae cultivation, both as key to a circular bioeconomy, as well as to potentially lower production costs.
As part of Project ZeroW, the potential of various food-derived waste streams to support microalgae growth was assessed. Their nutritional composition, scalability, and regulatory compliance for food applications were also evaluated. Among the liquid and solid residues tested combined in different pretreatment strategies to ensure microbial safety and nutrient bioavailability, some demonstrated high suitability as an alternative culture media, while others posed significant technical challenges such as sterility concerns, increased process complexity, and fluctuating composition.
Despite the expectations that industrial waste streams would offer a cost advantage, additional processing steps and regulatory constraints often introduce unexpected costs. The potential solution to accommodate this increase in CAPEX and OPEX could be to attain the EU Organic labelling that the public associates with sustainable products. Nevertheless, despite the strict quality control of substrates used for food-grade microalgae cultivation imposed by *End-of-Waste* and *By-Product* classifications under the EU Waste Framework Directive, the Organic EU regulation even further limits the range of usable substrates. Indeed, to comply with this regulation, higher-cost industrial substrates need to be bought, hindering the main sustainability goal of the organic cultivation mode itself.
This work highlights both the feasibility and limitations found in experimental trials of integrating food wastestreams, sidestreams, or by-products into microalgae bioprocesses, emphasizing the need for regulatory harmonization, standardized pre-treatment protocols, and cost-benefit analyses to optimize industrial implementation.

## KEYWORDS
Microalgae, Environmental solutions/ Circular Economy, Food, Production

# 11171 - ON THE PURSUIT OF CIRCULAR ALGAE-BASED ECOSYSTEMS IN THE BALTIC AND NORTH SEAS

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**ABSTRACT**
Sustainable resource management is becoming increasingly essential to prevent environmental degradation and resource scarcity, and the concept of a circular economy has gained significant attention as a solution to address these challenges. The overarching goal of the EU-granted LOCALITY project is to establish algae-producing (microalgae and seaweed) regional circular industrial ecosystems: [1] North Sea algae-greenhouse, [2] Nordic algae-aquaculture, and [3] Baltic algae-textile. In this context, 7 industrial and 4 academic partners joined forces to set the following plan into motion: a) assessing >12 different side streams from the greenhouse plant production, aquaculture, and textile sectors, b) screening and selecting microalgal strains suitable to the studied sidestreams, c) improving control systems at prototype and pilot scales, d] tailoring businesses cases in cooperation with the consortium, and e) producing biomass of different species for biorefinery and product prototyping. Our preliminary results identified potential cases for all three ecosystems. Discussions to challenge the process design(s) were performed to identify bottlenecks and the necessary inputs to develop mature business cases. Then, it was indicated the potential business models, challenges for scalability, and how to become a blueprint for transferring circular algae-based to other sectors.

**KEYWORDS**
Microalgae, Macroalgae, Production, Environmental solutions/ Circular Economy

# 11176 - SUSTAINABLE CULTIVATION OF LIMNOSPIRA SP. IN AGRICULTURAL DRAINWATERS: BIOREMEDIATION POTENTIAL AND BIOMASS APPLICATIONS

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## ABSTRACT

The integration of microalgae cultivation with agricultural waste streams offers a sustainable strategy to address regulatory and environmental challenges while promoting circular economy solutions. This study focuses on industriophile *Limnospira* sp. strains, exploring their potential for bioremediation and biomass production using nutrient-rich effluents from soilless fruit production systems in central Portugal. *Limnospira* spp. is particularly suited for this purpose due to its adaptability to high alkalinity and non-sterile conditions, making it ideal for industrial-scale applications.

Agriculture effluents may contain elevated nitrogen and phosphorus levels, potentially exceeding EU discharge limits (Directive 91/271/EEC, Regulation 2020/741), as well as pesticide residues. Laboratory-scale experiments will assess *L. platensis*'s ability to uptake and metabolize or accumulate these contaminants. These will be followed by pilot-scale trials at the Algae Vertical project's Demonstration Unit at Allmicroalgae's facilities, to validate performance under real-world conditions. While Spirulina is widely produced for food, its cultivation in agricultural drainwaters remains unapproved for human consumption due to regulatory gaps (EU Regulation No. 1379/2013). However, its high-value potential in pharmaceuticals and cosmetics offers a promising alternative. Thus, biomass samples from the proposed experiments will be shared with partners within AlgaeNet4AV project framework, which investigates microalgae-derived bioactive compounds for high-value non-food applications, including antiviral potential.

By integrating wastewater treatment with valuable biomass production, this research demonstrates the dual potential of microalgae for bioremediation and contributing to sustainable industrial and environmental strategies.

## KEYWORDS

Microalgae, Agriculture, Environmental solutions/ Circular Economy

# 11184 - WHEN LIFE GIVES YOU DRAINWATER, GROW MICROALGAE

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**ABSTRACT**
The growing demand for sustainable water management and biomass production has led to a renewed interest in using agricultural drainwater for microalgae cultivation. Agricultural drainwater, or runoff from crop plants, is a promising yet underutilized resource often rich in macronutrients like nitrogen (N) and phosphorus (P). This nutrient-rich effluent presents an opportunity to recover valuable resources, mitigate environmental pollution, and reduce the costs of producing microalgal biomass. Several studies have shown that microalgae, such as *Chlorella vulgaris* and *Tetradesmus obliquus*, can achieve removal efficiencies of almost 100% for both total nitrogen and phosphorus, making them highly effective for wastewater remediation. In addition to nutrient removal, microalgae can sequester pesticide residues and heavy metals, further enhancing their role in wastewater treatment. This review consolidates current knowledge on the application and potential of plant-derived agricultural runoff as a source of water and nutrients for microalgae cultivation. It examines key factors such as the species of microalgae and cyanobacteria used, cultivation systems, biomass productivity, nutrient uptake efficiencies, and the reuse and applications of treated water and algal biomass, respectively. Furthermore, pre-treatment strategies like filtration and dilution are evaluated to optimize nutrient availability and reduce toxicity. Despite its potential, several challenges remain, including variability in nutrient composition, seasonal fluctuations, and the presence of contaminants and pesticides that can affect microalgal productivity and biomass quality. This review also assesses how microalgal-based treatments align with current legislative frameworks, such as the revised Urban Wastewater Treatment Directive (2024/3019), the Water Framework Directive, and the Circular Economy Action Plan, evaluating their suitability as scalable and efficient approaches for wastewater valorisation. By integrating microalgal-based approaches into circular bioeconomy models, agricultural runoff can be transformed from waste into a valuable resource. Future research should focus on optimizing species selection, improving nutrient recovery efficiencies, and enhancing biomass valorisation strategies to maximize this approach's economic and environmental benefits. Overall, this review assesses current advancements and identifies research gaps that contribute to developing environmentally responsible and economically viable microalgae-based solutions.

**KEYWORDS**
Microalgae, Production, Agriculture, Environmental solutions/ Circular Economy

# 11200 - CULTIVATION OF A YELLOW MUTANT OF CHLORELLA VULGARIS ON FOOD WASTE UNDER HETEROTROPHIC CONDITIONS

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## ABSTRACT
Microalgae are a promising alternative to conventional protein sources, such as meat, fish and soy, with a lower areal footprint, namely regarding land and water usage. In addition, microalgae are able to thrive when cultivated in adequate industrial sidestreams, which not only contributes to their bioremediation, but also to a more sustainable production process. On the other hand, some species, as *Chlorella vulgaris*, have the ability to grow under heterotrophic conditions, which enable reaching high-cell concentrations and biomass productivities 10-100 times higher than autotrophic cultivation. Recently, the sensory properties of wildtype strains have been improved through methodologies as random mutagenesis, which with the combined use of metabolic inhibitors, led to the isolation of chlorophyll-deficient strains, as the yellow mutant, 7Y, used in this study. Furthermore, several sidestreams were screened for developing a more sustainable process, out of which food wastes and corn molasses were selected as the most promising sources of essential nutrients, with 23-30% of nitrogen and 502 g $L^{-1}$ of glucose, respectively. Thus, a waste-based medium was formulated by adjusting the concentration of each sidestream to the nutritional requirements previously established for this yellow strain. The growth of this mutant with this formula was compared to that of the inorganic optimised medium and the same biomass productivity and growth rate, of approximately 14 g $L^{-1}$ $d^{-1}$ and 0.8 $d^{-1}$, respectively, were attained in 7-L reactors. Then, the process was scaled-up to 200-L reactors, along with higher nitrogen supplementation in the feeding solution, which enabled to reach productivities of 22 g $L^{-1}$ $d^{-1}$ of biomass and 6.3 g $L^{-1}$ $d^{-1}$ of protein. Lastly, an alternative formulation of this waste-based medium, with the replacement of corn molasses by organic glucose, has allowed to develop an application to the European Organic Certification, which might increase the biomass value by up to 30%. Thus, these two approaches create distinctive features for the same product: a more sustainable and environmentally-friendly version and a higher-value version with certification, both with increasing demand in the current market.

## KEYWORDS
Microalgae, Food, Environmental solutions/ Circular Economy, Production, Algae Market

# 11227 - IMPROVING THE SUSTAINABILITY OF MICROALGAE BIOMASS FREEZE-DRYING PROCESS

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## ABSTRACT
Inflammatory bowel disease (IBD is a chronic gastrointestinal disorder influenced by genetic, immune, and environmental factors. The growing interest in alternative treatments has highlighted microalgae as a promising solution. *Tisochrysis lutea*, a microalga rich in *n*-3 polyunsaturated fatty acids, phenolic compounds, proteins, and fucoxanthin, presents potential therapeutic benefits, including anti-inflammatory effects and the ability to modulate gut microbiota [1]. However, the commercial production of microalgae faces several challenges, especially regarding drying processes. Freeze-drying is considered the gold standard for preserving microalgae's nutritional and structural integrity, but it is energy-intensive and costly. Optimizing freeze-drying conditions for specific algae species may help reduce costs while improving biomass stability. This study evaluates the effects of different freeze-drying temperatures on the stability of *T. lutea* biomass under various storage conditions.
The algae were freeze-dried at 18.5°C, 22.5°C, and 27.5°C, followed by storage at -20°C and 20°C, with subsets stored under vacuum and non-vacuum conditions. Biomass stability was assessed through measurements of chlorophyll, carotenoids, pheophytin-*a* (a chlorophyll degradation product, and fucoxanthin, as well as monitoring color and humidity. Samples were analysed immediately post-freeze-drying, and after one, three and six months of storage.
After freeze-drying, total chlorophylls ranged from 23.6 to 18.3 µg/mg and carotenoids ranged from 18.4 to 14.0 µg/mg which corresponded to the 18 and 27.5°C dryings, respectively. chlorophyll-*c* made up 7.5±4.7% of total chlorophylls. Fucoxanthin levels ranged from 13.4 µg/mg (27.5°C to 12.9 µg/mg (22.5°C.
Decrease in pigment concentrations were detected just after 1 month of storage. After three months, fucoxanthin levels where more affected by the storage temperature than by the temperature at which the biomass was freeze-dried. The results show that freeze-drying temperature, storage temperature, and oxygen exposure all impact biomass stability. Lower storage temperatures slowed pigment degradation, and vacuum storage was most effective for biomass stored at 20°C, when compared to biomass stored at -20°C.
These findings suggest that optimizing freeze-drying and storage processes can preserve bioactive compounds, like fucoxanthin, essential for the properties of *T. lutea*. This approach could reduce energy consumption and improve the efficiency of microalgae production, supporting a more sustainable and cost-effective method for producing microalgae-based therapeutics. This research offers insights into using microalgae as a viable alternative for managing IBD while enhancing the sustainability of microalgae-based products.

## KEYWORDS
Microalgae, Production, Environmental solutions/ Circular Economy

# 11231 - SELECTION AND ADAPTATION OF MICROALGAE FOR ENHANCED RESISTANCE TO FLUE GAS AND DIGESTATE TOXICITY AND INCREASED LIPID CONTENT

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## ABSTRACT
The excessive use of fossil fuels and the worsening climate change crisis have exponentially risen along with the increasing population and its energy demands, thus being the cause for worldwide concerns in recent years. For this reason, new ways to support these needs while alleviating their impact on the environment are increasingly being searched. With regards to this, photosynthetic biological organisms, such as microalgae, have been proposed as a potential solution; these eukaryotic microorganisms can capture inorganic carbon dioxide ($CO_2$) and use it in the production of organic biomass, enriched in high-value bioactive compounds. For instance, lipids extracted from microalgae biomass can be applied to the production of biofuels and biogas, therefore minimizing the environmental impacts often associated with energy production. In addition, microalgae can have high growth and photosynthetic rates and, unlike traditional plant crops, do not require large amounts of arable land or freshwater, since they can be grown in wastewater sources, further reducing costs and waste production. Considering this, the main aim of the COSEC project is to use microalgae, grown in wastewater effluents supplemented with biogenic flue gas and digestate, to mitigate $CO_2$ emissions, resulting from bioenergy production, to obtain lipid-enriched biomass to use in the production of renewable energy sources, such as biocrude and biogas. To accomplish this, CCMAR will focus on the selection of microalgal strains that can grow on the selected effluents (waste from hydrothermal liquefaction and anaerobic digestate) and are associated not only with elevated $CO_2$ fixation but also with high lipid content. To fulfil this goal, several freshwater and saltwater strains with known high lipid content were initially cultivated in high nutrients concentration to assess if the high lipid content still hold in these conditions. The most promising were then progressively adapted to increasing concentrations of $NO_X$, $SO_X$ compounds and $CO_2$ supplementation to improve their resilience to flue gas digestate toxicity. In parallel, random mutagenesis will be applied to produce strains with concomitant resistance and improved lipid production.

## KEYWORDS
Microalgae, Environmental solutions/ Circular Economy

# 11232 - THE UPCYCLING OF NITROGEN-RICH INDUSTRIAL EFFLUENT AND THE NITROGEN TO PHOSPHORUS RATIO IMPACT ON NANNOCHLOROPSIS SP. PRODUCTION

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## ABSTRACT
The potential of microalgae to produce and accumulate a variety of bioactive compounds has led to growing interest in the algae production sector. However, the high production costs related to the use of expensive fresh culture medium can be a major barrier. To mitigate this issue, alternative production strategies, such as integrating effluent streams and optimizing media formulation may help reduce these costs.

This study aimed to investigate the impact of nitrogen to phosphorus (N:P) ratio in culture media formulated with a nitrogen-rich industrial effluent on the growth of *Nannochloropsis* sp.. The experiments were conducted in batch mode using 1L bubble column reactor, continuously illuminated (389±13 $\mu mol.s^{-1}.m^{-2}$) and kept at room temperature while supplemented with filtered air enriched with $CO_2$ (0.5% $v.v^{-1}$). The initial and average pH values were similar throughout the trials at 7.9±0.2 and 7.6±0.2, respectively. The experimental conditions included three N:P mass ratios: 4:1, 16:1 (test conditions), and 9:1 (control condition) for a total nitrogen content of 8mM. We characterized biomass productivity, nutrient-specific consumption, and biochemical composition (lipids and fatty acids profiles) to identify necessary adjustments for medium formulation and potential process limitations for future pilot scale tests.

Both test conditions (N:P 4 and N:P 16) and control achieved similar biomass productivities (0.15-0.17 $g_{DW}.L^{-1}.d^{-1}$). We observed no significant differences in nitrogen and phosphorus specific consumption between the tested conditions. Despite the diverse nitrogen sources present in the nitrogen rich industrial effluent, phosphorus consumption remained consistent across experiments. Additionally, the total lipid content did not vary with the different conditions. Among the major fatty acids detected in the biomass across all tested conditions (C14:0; C16:1; C16:0; C20:4n6; C20:5n3), only the C16:0 content was slightly lower in test condition with an N:P ratio of 4:1 compared to the other conditions.

This study helps identify possible process limitations for future tests at the pilot scale. Additionally, it demonstrates that using nitrogen-rich effluent as a nutrient source can effectively reduce the dependence on traditional nutrient solutions in microalgae production, while still maintaining the quality of the biomass. This method fosters a more economical and sustainable production process and offers a practical environmental solution for industrial effluent within the framework of a circular bioeconomy.

## ACKNOWLEDGMENTS/FUNDING
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## KEYWORDS
Microalgae, Production, Environmental solutions/ Circular Economy

# 11234 - RHE-MEDIATION EUROPEAN PROJECT: FIRST EFFORTS FOR THE INSTALLATION OF THE GREENDUNE SYSTEM

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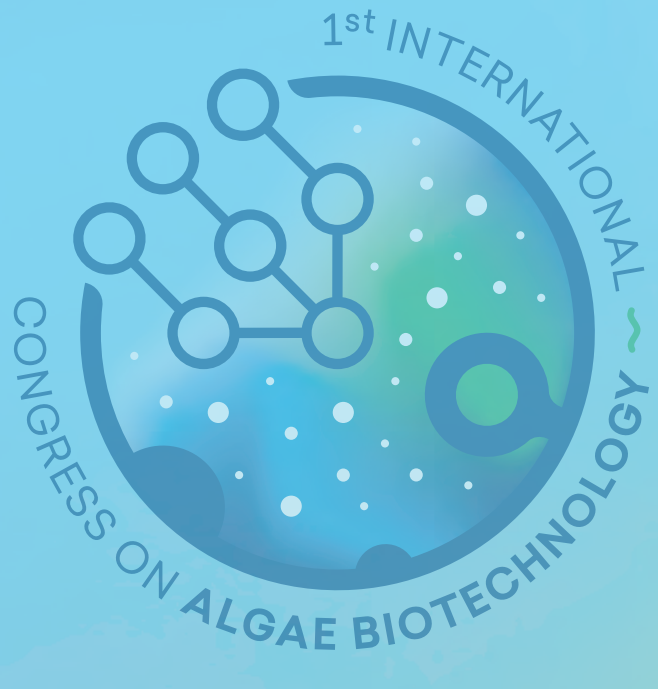
## ABSTRACT
Today, the entire water cycle is facing unprecedented stress from decades of human-induced pollution and unsustainable practices, which have severely degraded marine ecosystems [1]. Restoring and protecting the Mediterranean from chemical contamination is an urgent challenge. In pursuit of this goal, the EU mission "Restore our Ocean and Waters by 2030" aims to safeguard aquatic ecosystems, prevent and eliminate pollution, and transition the blue economy to a climate-neutral and circular model through research, innovation, citizen engagement, and strategic investments. One innovative action under this umbrella is designed to establish a responsive hub with long-term governance aimed at reducing chemical pollution in the Mediterranean thanks to microalgae bioremediation. This effort specifically targets contaminants such as heavy metals, pesticides, and “forever chemicals” like PFAS —substances known for their persistence that disrupt the delicate balance of the Mediterranean ecosystem. The strategy involves intercepting and removing these pollutants before they can enter the sea. The approach includes deploying advanced remediation technologies using microalgae coupled with wastewater traditional treatment systems. On the scope of RHE-MEDiation, a Mediterranean Lighthouse EU project, microalgae photobioreactors were installed at the Thriasio Wastewater Treatment Plant, in Greece, integrating the pilot system as a tertiary wastewater treatment process. This enhancement is intended to improve the efficiency of wastewater treatment before discharge into the Elefsis Gulf. Wastewater analysis was conducted, with particular attention given to nitrogen content, a crucial factor in promoting robust microalgae growth. This analysis played a vital role in determining the optimal placement of the system inlet at the demo site, ensuring sufficient nutrient availability for efficient microalgae growth. Furthermore, key monitoring points were identified to assess both microalgae production and the system’s efficiency in removing nutrients and pollutants. During the first weeks, the removal rate of Total Nitrogen ranged from about 4% to 42%. Regarding Total Phosphorous, the values ranged from 12% to 100%, however the concentration in the inlet water was lower than the one of Nitrogen (8.5 and 0.5 mg/L respectively). Several sensor locations were selected to provide real-time data on parameters such as pH, turbidity, chlorophyll levels, ammonium concentration, conductivity, redox potential, and temperature. Contributions were also made to the establishment of operational thresholds for these sensors, which were utilized to optimize the $CO_2$ injection process, control biomass recirculation, and decouple sludge retention time from hydraulic retention time. Considering that the GreenDune system is an open system, the weather changes and the high variability of the sourced water, these preliminary results are crucial to evaluate the limits of the system.

## KEYWORDS
Environmental solutions/ Circular Economy, Microalgae




## POSTER SESSION

# ALGAE PROCESSES AND BIOREFINERIES

# 10863 - ULTRASONIC-ASSISTED WATER-RICH NATURAL DEEP EUTECTIC SOLVENTS FOR SUSTAINABLE POLYPHENOL EXTRACTION FROM SEAWEED: A CASE STUDY ON CULTIVATED SACCHARINA LATISSIMA

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**ABSTRACT**
This case study introduces a green, 1 h single-step method using water-rich natural deep eutectic solvent (WRNADES) for ultrasound-assisted extraction (UAE) of polyphenols from *Saccharina latissima*, a commercially cultivated brown seaweed. The extraction efficiency was evaluated using a selective quantitative NMR method (s-qNMR) and the traditional nonselective colorimetric total phenolic content assay (TPC). Initial 6 h extractions in traditional solvents (methanol, ethanol, acetone, and ethyl acetate) showed a 40–60% increase in polyphenolic yields in 50% aqueous solutions measured by the TPC method. Six different water-rich (50%) NADES (WRNADES) combinations were tested (choline chloride/betaine with lactic acid, citric acid, and 1,3-butanediol), with betaine and 1,3-butanediol (1:1) proving most effective. Parameters for the WRNADES were optimized using Box–Behnken design response surface methodology, resulting in a 1:20 w/w biomass to solvent ratio and a 1 h extraction time at 50 °C. The WRNADES extraction process was refined into a scalable, single-step procedure and compared with traditional solvent extractions (6 h, 50% aqueous methanol and acetone). A final XAD-7 polyphenol recovery step was included in all extractions. The optimized WRNADES extraction yielded 15.97 mg GAE/g of the dry weight recovered polyphenolic extract (s-qNMR), exceeding the 6 h 50% aqueous methanol (12.4 mg GAE/g) and acetone (11.4 mg GAE/g) extractions. Thus, the UAE-WRNADES method presented in this case study provides a cost-effective, sustainable, and eco-friendly alternative for the extraction of phenolic compounds from seaweed. It promotes the development of environmentally friendly production processes within the seaweed biorefinery.

**KEYWORDS**
seaweed, water-rich NADES, polyphenols, qNMR, marine sustainability, blue bioeconomy, Macroalgae, Biorefinery, Supplements and cosmetics, Environmental solutions/ Circular Economy

# 10974 - ALGAE BASED REFRESH - TURNING LAUNDRIES TO CIRCULAR KEY PLAYERS

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**ABSTRACT**
The Re:society is the acceptance of the concepts of *reuse, recycle, reduce* and *repair* in people's common-day use of material resources. The latter includes textiles, ubiquitous in human life, where 16 kg of textile waste per person are generated yearly in the EU. From 1 January 2025, EU Member States must put separate collection systems in place for textiles. Waste could be minimized and virgin resources spared if the Re:society would come closer to realization. For textiles a Re:approach is *refresh*. Refresh means prolonging lifetime of products by efforts such as shaving for a pilling free surface or re-dyeing bleached out pieces of garment. This make the garment aesthetically, psychologically and socially attractive for use and avoids the consumption - and connected production - of virgin materials.
Algae could play a vital role for textile refresh. Algae being photoactive organisms produce pigments that can be extracted for used as textile dyestuff in refreshing either in a home setting or at a large, industrial scale. Further, algae, when treated strategically, is a renewable alternative to fossil-based dye.
We here suggest industrial laundries as drivers rather than a costly, necessary evil, for forming regional circular loops of textiles. Effectively washing is “producing” a new product each time an item is washed. This is done to a fraction of the environmental cost of making a product out of virgin resource. We show the potential for industrial laundries to take this one-step further and also offer regular refreshment in terms of strengthening the existing hue for bleached out garments or re-dyeing ones from one hue to another to fit new usage regimes. Such industrial laundries should have long-term contracts with textile intensive actors such as hospital. The distance laundry-user(s) should not be long avoiding causing high environmental transport costs.

For this, we *measure* output wastewater from industrial laundry and *cultivate* 20 algae strains. The processed water turns out not to be toxic. Furthermore, algae grow in this media implying its use in a circular algae-involved process.
For the necessary condition for establishing an algae-based refresh station, we successfully *dyed* cotton fabric with algae. Cotton is a common textile material at hospitals. We characterize the industrial circular system for textiles that includes refreshing as a vital component and build a predicative model.Out of this, we predict the spread of algae refreshed products in the system and the pace of needed amount of supply of algae. We show how algae based refresh *prolongs the lifetimes* of the involved textiles considerably.
Thus, algae could add to refreshing, a key enabler in a Re:society.

**KEYWORDS**
Microalgae, Biorefinery, Environmental solutions/ Circular Economy

# 11006 - NOVEL PROCESS FOR EXTRACTION OF XYLAN AND XYLO-OLIGOSACCHARIDES FROM PALMARIA PALMATA

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## ABSTRACT
Xylan, the second most abundant plant polysaccharide on Earth, is a component of a number of red and green macroalgae, including *Caulerpa, Bryopsis, Bangia, Porphyra,* and *Palmaria spp.* This polysaccharide, and in particular its breakdown products, xylo-oligosaccharides and xylose, are of much industrial interest with potential for application in the food, feed, industrial, chemical, pharmaceutical, and medical fields. Nevertheless, these compounds remain underexploited, partially as a result of an unavailability of sustainable, environmentally friendly methods for their production at high levels in a purified form. Almost all xylan, xylo-oligosaccharides and xylose studied to date have been isolated from land sourced lignocellulosic feedstocks via costly multi-step processes employing various hazardous chemicals, harsh physical treatments and/or enzyme(s) hydrolysis. We have developed and optimised a simplified, more environmentally friendly method for extraction of these compounds from *Palmaria palmata*. This process is based on a thermal treatment and aqueous extraction, avoiding use of hazardous chemicals. A xylan yield upwards of 80% was obtained with a final product purity of ~90% xylan. Importantly also, the compounds produced are expected to display a novel structure as compared to hitherto studied variants and therefore should display different properties and applications. Future studies will be focused on the investigation of the structure, function and in particular the bioactivities of these novel purified products.

## KEYWORDS
*Palmaria palmata*, xylan, xylo-oligosaccharides, component extraction, high-value products, Macroalgae, Biorefinery

## ACKNOWLEDGMENTS
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## BIO
Diogo Coelho (DC) is a Geneticist and Biotechnologist with a PhD in Veterinary Sciences with specialisation in Biological and Biomedical Sciences (2022, University of Lisbon). He is currently an Invited Auxiliary Researcher at the Centre of Molecular and Environmental Biology, University of Minho in the scope of the project "Blue Bioeconomy Pact". DC has published 26 peer-reviewed articles, 5 book chapters and 2 provisional patents. He has participated as team member in 2 scientific projects, co-supervised 3 BSc projects, received 2 awards, and participated in several scientific events and outreach activities.

# 11007 - TURNING ULVA RIGIDA TO BIODEGRADABLE PLASTICS

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## ABSTRACT
The environmental issues caused by petrochemical plastics, along with the growing awareness of society on these matters, highlight the urgent need to develop materials with similar properties that are both environmentally and economically viable[1]. Macroalgae can be the source for these materials.
Sulfated polysaccharides, such as ulvan from *Ulva* genus (7-29 % d.w.basis)[2] [3] emerge as alternatives for film production [4]. However, to ensure their practical application, namely in food packaging solutions, it is necessary to develop formulations to improve film properties such as low mechanical resistance and water-solubility[5].
On the other end the biopolyesters- polyhydroxyalkanoates (PHA), produced by bacteria are excellent candidates, offering physical and mechanical properties comparable to conventional plastics [6]. However, they are not economically viable, as the primary cost driver is the carbon sources required for bacterial growth[7].
In this study, *Ulva rigida* carbohydrates were upgraded to ulvan films and PHAs. Ulvan was extracted from the cell walls through hot water treatment. The ulvan was recovered via precipitation using ethanol and integrated into a film matrix along with sodium carboxymethyl cellulose (CMC), pectin or sodium alginate and glycerol as plasticizer. The films composed of ulvan, CMC, and glycerol demonstrated the best mechanical properties. However, ulvan alone did not exhibit the ability to form viable films.
The remaining seaweed carbohydrates were pre-treated by autohydrolysis in a pressure reactor and the recovered solids enzymatically treated to glucose-rich hydrolysates. These were incorporated into culture media as the sole carbon source in preliminary shake flask assays using *Halomonas halophila* as PHA-producer. These assays have shown this halophile to be tolerant towards potential inhibitors produced during the hydrolysis (HMF- hydroxymethyl furfural) and to have a high capacity to produce PHAs. Fed-batch cultures in 2L bioreactors using Ulva hydrolysates as feed are currently going-on.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Macroalgae, Biorefinery, Environmental solutions/ Circular Economy

# 11069 - HETEROTROPHIC CULTIVATION OF EUGLENA GRACILIS TO OBTAIN HIGH CELL DENSITY

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## ABSTRACT

Aquaculture production is increasing year-over-year and is predicted to provide approximately 53% of the world's seafood supply by 2030. It is estimated to reach 140 million tons by 2050, two times the global production in 2010 [1]. This is a crucial sector providing efficient and high-quality animal protein, sustaining the livelihood of billions worldwide [2],[3].

Microalgae are known for their potential applications in aquaculture. They are capable of absorbing nutrients from wastewater, such as nitrogen and phosphorus and of mitigating eutrophication [4]. This capability benefits the environment while improving the economic viability of aquaculture and it supports the creation of a new ingredient, suitable for various aquatic species, offering a sustainable alternative to fishmeal, soybean, cornmeal, and other costly or nutritionally deficient options. [5]. On the other hand, microalgae produce different high-value products, such as carbohydrates, that benefit the immune system of fish enhancing health and helping to prevent disease outbreaks. Among these are *β*-glucans, compounds known for their prebiotic activity [8]. In this way, microalgae-based feeds can be used as alternatives to antibiotics in aquaculture.

*Euglena gracilis* is a unicellular motile microalga, rich in essential nutrients, including vitamins, minerals, amino acids, and fatty acids, making it a promising candidate for functional foods and animal feed. Of particular interest is paramylon (β-1,3-glucan), a polysaccharide produced by *Euglena* spp., that offers numerous health benefits, including immune enhancement and gut health [12]. *Euglena* grows under autotrophic, mixotrophic and heterotrophic conditions [13]. Thus, *Euglena gracilis* is a good candidate for aquaculture applications, namely to tackle the excessive use of antibiotics.

The present study explores the potential of *Euglena gracilis* heterotrophic production, through cultivation optimization, towards high cell density. Medium optimization was performed through a Design of Experiment (DoE) approach resulting in a global productivity improvement by 67% (from 2.34 to 4.00 g $L^{-1}$ $day^{-1}$) and the specific growth rate by 15% (from 0.96 $day^{-1}$ to 1.10 $day^{-1}$). Scale-up was demonstrated in 7L stirred-tank reactor, achieving a maximum biomass concentration of 45 g $L^{-1}$.

*E. gracilis* biomass presented high carbohydrate content of 66.59%, 20.8% of protein content, 8.51% of lipids and 4.11% of ashes. These results highlight the untapped potential of metabolically versatile microalgae to produce functional ingredients for aquaculture applications.

This approach supports the sustainable and efficient heterotrophic production of reliable, high quality aquafeed ingredients, by enhancing yields of bioactive compounds and improving nutritional profiles, all while maintaining a low water and areal footprint.

## KEYWORDS

Microalgae, Feed, Production

# 11090 - REMOVAL OF MICROCONTAMINTS IN URBAN WASTEWATER TREATMENT ON MICROALGE SYTEMS AND COMPARISION WITH MEMBRANE BIOREACTOR N ACTIVATE SLUDGE

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**ABSTRACT**
There is a growing concern about occurrence and release of new pollutants that can potentially affect human health and the environment. In Europe, the contaminants of emerging concern (CECs) needing observation are published by the European Commission's (EU), establishing the priorities and methods for determination. The new ‘Directive (UE) 2024/3019 concerning urban wastewater treatment’ discusses micropollutants, focusing on pharmaceuticals, which are of increasing concern for water quality. The Directive therefore proposes that certain urban wastewater treatment plants should install additional treatment systems for disposal and stresses the need for significant efforts to ‘overcome’ old practices by adopting innovative treatment methods.
In this end, the removal efficiency of 39 target pharmaceuticals from urban wastewater was studied to compare two different treatment systems, high-rate algal ponds and activate sludge with membrane bioreactor. To this end, urban wastewater was treated with microalgae on a laboratory and pilot scale in the wastewater treatment plant (5,000 person equivalents) located in a small town in the province of Soria (Spain). The two microalgae systems were operated with similar hydraulic retention time (5 d) and different light sources, sun and led light without ultraviolet light. The removal efficiency ranged from more than 50% to nearly 100% depending on the compound and the treatment system. Our results suggest that bioadsorption and photodegradation are the most important elimination pathways in microalgae systems, although the Outdoor Algae has higher efficiencies due to direct photodegradation by ultraviolet light. The membrane bioreactor had very high performances for activated sludge systems, which may be due to the higher aeration, sludge age, and solid concentration in biological reactor. The pathogen concentration reached in the final effluent was compatible with the reclaimed water standards normative class B. In compliance with the new Directive (UE) 2024/3019 concerning urban wastewater treatment, microalgae treatment met an elimination performance greater than 80% for the 6 compounds analysed out of the 12 that the law comprises.

**KEYWORDS**
Microalgae, Biorefinery

# 11174 - EFFECTS OF NUTRIENTS COMPOSITION AND WATER RECIRCULATION ON PORPHYRIDIUM CRUENTUM GROWTH

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## ABSTRACT
Microalgae are essential photosynthetic microorganisms in marine environments, playing a crucial role in ecosystems dynamics and serving as a promising resource for industrial applications due to their capacity of produce and store valuable compounds for the food, feed, cosmetics, and pharmaceutical industries. *Porphyridium cruentum* is a red unicellular microalga recognized for its ability to synthesize bioactive compounds such as polyunsaturated fatty acids, exopolysaccharides, and phycobiliproteins. This study focused on investigated the influence of nutrient composition of the culture medium of *P. cruentum* growth by assessing the effects of different nitrogen sources and phosphorous and nutrient concentration on the growth, to enhance sustainability and cost efficiency while maximizing biomass production. The results demonstrated that nitrogen source selection significantly affects biomass production. Among the tested sources, sodium nitrate supported the higher biomass productivity (0.23 $g \cdot L^{-1} \cdot day^{-1}$), surpassing sodium nitrite (0.18 $g \cdot L^{-1} \cdot day^{-1}$) and ammonium chloride (0.14 $g \cdot L^{-1} \cdot day^{-1}$), while urea proved unsuitable for sustaining growth. Furthermore, increase phosphorous concentration which conducted in a reduction of N:P ratio below the Redfield ratio (N:P ratio of 16:1) did not significantly impact biomass yield. Although, the reduction of phosphorous demand by 20% with N:P ratio of 20:1 yielded the highest biomass concentration (4.5 $g \cdot L^{-1}$ after 14 days), enhancing productivity by 20%. The reduction of nutrient concentration revealed that decreasing calcium, magnesium, and other micronutrients by 90, 20, and 20%, respectively, did not affect the biomass production. However, reusing the exhausted culture medium posed challenges. In this word, the increment of recirculation rates led to a decline in biomass productivity. At higher recirculation higher the accumulation of organic carbon and bacteria in the medium together with an increase of the viscosity and turbidity in the culture. While water recirculation offers a viable strategy for reducing resource consumption, proper treatment methods of the recirculated supernatant are required to not affect the growth.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Microalgae, Production, Food

# 11179 - HARSH OR MILD PRE-TREATMENT OF NANNOCHLOROPSIS OCEANICA: WHAT IS THE IMPACT ON THE RELEASE OF PHENOLIC COMPOUNDS AND ANTIOXIDANT ACTIVITY?

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## ABSTRACT

Microalgae are considered promising biomass sources of different added-value ingredients for nutrition, cosmetic and pharmaceutical applications. However, the most important biomolecules are enclosed inside microalgae cells, and their extraction can be challenging. The complex composition of microalgae cell walls, particularly in species with rigid, hard-to-break structures, significantly hinders the extraction efficiency.

*Nannochloropsis oceanica* is a photosynthetic unicellular microalgae, particularly known for its high accumulation of polyunsaturated fatty acids (including EPA), and high photoautotrophic biomass productivity. This species is also known to produce other bioactive components, like phenolic compounds, vitamins and carotenoids, with antioxidant activities and other health-promoting properties. However, the efficient extraction of valuable intracellular compounds from *N. oceanica* is restricted due to the small cell size and thick cell walls. Hence, there is a need for pre-treatments before extraction to improve the liberation of target compounds. Several cell disruption methods exist and have already been tested on microalgae, namely ultrasound, microwave, milling, high-pressure homogenization (HPH), and enzymatic treatments, among others. Each method varies in effectiveness depending on the microalgal species and the specific compounds targeted for extraction.

Phenolic compounds are secondary metabolites, generally involved in protective functions, such as defence against ultraviolet radiation, high salinity, extreme pH, nutrient depletion, or aggressions by pathogens. Their ability to neutralize free radicals and mitigate oxidative stress has gained their recognition as compounds with beneficial health-promoting effects, namely antioxidant capacity. This makes phenolic compounds particularly interesting bioactive ingredients for nutraceutical and cosmetic products. The main goal of this work is to assess the impact of two cell disruption techniques, HPH and enzymatic hydrolysis, on the extraction efficiency of intracellular components, particularly in the recovery of phenolic compounds from *N. oceanica*. The total phenolic content (determined by the Folin-Ciocalteau method) of the obtained extracts was used to measure the degree of cell permeabilization efficiency. Additionally, the antioxidant activity of the extracts was evaluated using ABTS and DPPH free radical assays to determine whether the different pre-treatments influenced the antioxidant activity, which could be an indicator of selective extraction or degradation of phenolic compounds during the process.

This work was financially supported by “Pacto da Bioeconomia Azul” (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line “Agendas for Business Innovation” through the funding scheme C5 - Capitalization and Business Innovation.

## KEYWORDS

Microalgae, Biorefinery

# 11181 - CYANOVA - NOVEL BIOREFINERY OF CYANOBACTERIA FOR BIOPLASTIC FOOD VALUABLE COMPOUNDS

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**ABSTRACT**
The CYANOVA project addresses the need for sustainable protein and chemical sources by developing a biorefinery using cyanobacteria. This aims to produce functional proteins and fermentable sugars simultaneously, optimizing processes for cost-efficiency and sustainability. Innovative downstream techniques ensure scalable production, reducing waste and energy use. The research methodology involves biomass characterization, benchmarking biorefinery processes for fermentable sugars and proteins, and integrating these processes into a multi-product biorefinery. Finally, there is a focus on optimizing innovative, scalable, and sustainable techniques to enhance process efficiency, while generating data for LCA and TEA analyses. The CYANOVA project advances carbon-neutral production of glucose and protein, supporting sustainable solutions for the plastics and food industries. Its key societal benefits include reduced environmental impact, lower costs, stable pricing, and minimal competition with food sources. The technology lowers carbon, land, and water footprints, meeting growing demands for eco-friendly innovations.

**KEYWORDS**
Biorefinery, Microalgae, Food, Production

# 11196 - CIRCALGAE: UNLOCKING THE POTENTIAL OF ALGAL SIDE STREAMS FOR A SUSTAINABLE BLUE BIOECONOMY

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## ABSTRACT
Algae represent an untapped resource with immense potential to drive Europe's transition toward a sustainable blue bioeconomy. However, current industrial algae processing discards up to 95% of biomass as waste, limiting its full valorization. The CIRCALGAE project aims to revolutionize algae-based industries by implementing a circular biorefinery approach that converts these side streams into high-value ingredients for the food, feed, and cosmetic sectors.
By integrating green extraction technologies, such as subcritical water extraction (SWE), ultrasound-assisted extraction (UAE), and high-pressure homogenization (HPH), CIRCALGAE maximizes resource efficiency while reducing environmental impact. Three upscaled biorefinery schemes (TRL 7) will demonstrate the feasibility of transforming industrial algae waste into nutrient-rich food additives, bioactive cosmetic ingredients, and sustainable feed formulations. The project will develop 12 demonstrator products, validate their bioactivity, and conduct consumer acceptance studies to enhance market readiness.
CIRCALGAE is a multi-disciplinary effort involving leading universities, research institutes, SMEs, and large industries across Europe. By fostering new business models, circular production systems, and stakeholder engagement, the project aligns with EU policies such as the European Green Deal and Farm-to-Fork Strategy, supporting a low-carbon, resource-efficient, and resilient bioeconomy. With a strong focus on sustainability, scalability, and economic feasibility, CIRCALGAE will play a pivotal role in reshaping Europe's algae industry and reducing reliance on imported biomass.
The project started in October 2022 and, being currently at its 3rd year, several side streams extracts are being characterized and fine-tuned for further application experiments. The present communication intends to present the project concept and an overview of its implementation.

## KEYWORDS
Microalgae, Macroalgae, Biorefinery, Environmental solutions/ Circular Economy, Food, Feed, Supplements and cosmetics

# 11208 - OPTIMIZING MICROALGAL CELL DISRUPTION AND NITROGEN REMOVAL FOR ENHANCED ENERGY BIOMASS PROCESSING AND ENERGY CONTENT

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## ABSTRACT
In order to mitigate $CO_2$ emissions, it is essential to implement technologies that enhance the efficiency of bioenergy production while meeting the high demand for fuels [1, 2, 3]. One promising alternative is biofuels, which offer lower greenhouse gas emissions and high energy density [1]. Microalgal biomass holds high potential for biofuel production due to its superior photosynthetic efficiency and ability to grow in diverse water sources. These characteristics make microalgae a great alternative energy source compared to conventional feedstocks used for primary or secondary biofuels [4]. However, microalgae contain significant amounts of oxygenated and nitrogenous compounds, which can negatively impact bio-oil quality by increasing viscosity, corrosiveness, and nitrogen oxide emissions [5]. Additionally, the rigid cell walls of many microalgal species require energy-intensive disruption methods, leading to higher processing costs [1]. Addressing these challenges requires optimizing biorefinery processes to improve extraction efficiency and reduce operational costs. In particular, effective cell disruption is essential for enhancing nitrogen removal, as the release of intracellular nitrogen compounds can influence biofuel upgrading and nutrient recovery strategies. Refining cell disruption parameters makes it possible to increase energy recovery while minimizing undesirable nitrogen species in downstream processes [3]. Furthermore, integrating valorization strategies for nitrogen-rich fractions can support applications such as biostimulants, contributing to the sustainability of the biorefinery system [6]. This study aimed to optimize cell disruption within a water-based biorefinery process by applying high-pressure homogenization (HPH) to *Scenedesmus* sp. Accordingly, a Central Composite Design (CCD) was employed to evaluate the impact of biomass concentration, homogenization pressure, and number of disruption cycles on (i) turbidity, (ii) the release of nitrogenous intracellular compounds and (iii) soluble protein as indicators of cell disruption efficiency. Overall, the finetuning of operational conditions enhanced biomass disruption, ultimately promoting a more efficient production of biofuel.

## KEYWORDS
Microalgae disruption; Nitrogen removal; Biomassa; Bio-oil.

## ACKNOWLEDGMENTS
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## KEYWORDS
Microalgae, Biorefinery, Environmental solutions/ Circular Economy

# 11215 - MICROALGAE: THE KEY TO CIRCULARITY IN CELLULAR AGRICULTURE

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**ABSTRACT**
Cellular agriculture is an emerging field focused on producing animal and plant products from cultivated cells. This approach is particularly promising for animal protein production, offering substantial benefits that include enhanced sustainability and reduced land and water use without animal slaughter. However, significant technical and economic challenges remain, including dependence on animal-derived sera for cell expansion and differentiation, treatment of spent medium effluents, and development of new cell lines. The INOVACEL project, led by a consortium composed of Necton, S2AQUAcoLAB, CCMAR, and GreenCoLab, addresses these challenges by leveraging microalgae as the cornerstone of a circular integrated production system. First, microalgae cultivation will be optimized using spent medium from cell cultivation, rich in bioavailable nitrogen and phosphorus. Different strains and cultivation conditions will be evaluated to maximize nutrient removal efficiency. Second, the resulting microalgal biomass will be processed through various techniques to create extracts rich in bioactive compounds for testing as partial or complete substitutes for animal-derived serum. Simultaneously, the project will develop new fish cell lines and adapt existing ones using microalgae-based sera, working towards establishing animal product-free cell lines. This integrated approach aims to close both water and nutrient cycles, enhancing process circularity and sustainability while reducing operational costs.

**KEYWORDS**
Microalgae, Production, Biorefinery, Environmental solutions/ Circular Economy

# 11222 - EXPLORING THE BIOSTIMULANT POTENTIAL OF MICROALGAE FRACTIONS FOR AGREENER AGRICULTURE

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## ABSTRACT
The agriculture sector needs to increase productivity to feed the growing population while reducing its environmental impact and preserving natural resources for future generations. Strategies for the future of agriculture should be adopted, and microalgae are attracting interest as potential resources due to their biostimulant and biopesticide properties. Biostimulant activity of microalgal extracts has been associated with the content of different metabolites, such as amino acids, vitamins, phytohormones and polysaccharides. These act on the plant physiology through different pathways, improving nutrient use efficiency, tolerance to abiotic stress, quality traits, the availability of confined nutrients, among many others. In order to increase the bioavailability of the intracellular content of microalgae biomass, a pilot-scale biorefinery was implemented where *Chlorella* sp. and *Tetradesmus obliquus* were used. A total of 4 independent biorefinery processes were carried out where two pipelines were tested: pipeline 1 for *Chlorella* sp., where an enzymatic-protein hydrolysis (EH) coupled with different membrane filtration steps was performed, and pipeline 2 for *T. obliquus*, where a high-pressure homogenization (HPH) before EH was implemented. Two different fractions were obtained for each species, which were then freeze-dried: a soluble hydrolyzed fraction (permeate) and an insoluble residual fraction (retentate). In order to evaluate the biostimulant properties of the different fractions, an agricultural trial was carried out to assess the growth of *Lactuca sativa* var. *longifolia* (romaine lettuce) in hydroponic cultivation and the possible effects of the fractions on the plant. Nine 20-day-old lettuce were distributed per tray (8 treatments and 1 control) with 10 L of water, Hoagland's stock solution and the respective treatments (1 g/L). For 28 days, the plants were kept in a growth chamber at 25°C, humidity between 83 and 85% and a photoperiod of 16 hours of light and 8 hours of dark. Every 7 days, the water was changed with a new addition of Hoagland's solution and the respective treatment at the same initial concentration. Fluorimetry and pH were analysed during the trial and on the 28$^{th}$ day the roots (cm), total plant length (cm) number of leaves were measured. The dry weight (g) of the roots and the dry weight of the plant were also analysed. T. obliquus retentate fraction showed differences in the number of leaves ($p<0.05$) between treatments, with a maximum of 22 leaves. Overall, the application of microalgae fractions derived froand m the biorefinery process has shown positive results compared to control, suggesting a promising alternative to current agrochemicals. Additionally, less promising fractions for biostimulants can be applied in different industries, to continue to valorise the microalgae biomass.

## KEYWORDS
Microalgae, Biorefinery, Agriculture

# 11246 - DEVELOPMENT OF A MULTIPRODUCT BIOREFINERY FOR DIATOM BIOMASS

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## ABSTRACT
Diatoms are an emerging bioresource currently used mainly in the aquaculture sector. The biochemical diversity of diatoms and their ability to produce an array of bioactive/functional compounds, such as fucoxanthin, β-glucans and n-3 PUFA, positions them as a sustainable alternative for the development of nutraceuticals, pharmaceuticals, and functional foods and feeds. Using the full potential of these biomasses requires the development of efficient and scalable biorefinery processes that can be easily applied to different species with similar characteristics, such as diatoms. These biorefinery pipelines should aim to co-extract the compounds mentioned above and develop and generate value from the remaining biomass, thus minimizing waste and maximizing their application potential.
This work describes the development of a multiproduct biorefinery pipeline and its application to different diatoms. It particularly focuses on the optimization of the first unit operation (biomass pre-treatment) of the developed pipeline (high-pressure homogenization), using *Phaeodactylum tricornutum* as a model organism. Different methods were employed to assess and quantify cell disruption to optimize this step, namely, turbidity, intracellular compound release and flow cytometry. The models obtained have allowed us to understand the interplay between two conflicting objectives: maximizing cell disruption and minimizing energy consumption. The best condition for this process reflects the best compromise of the two objectives and resulted in a cell disruption percentage of >70%.

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## KEYWORDS
Microalgae, Biorefinery, Supplements and cosmetics, Feed

# 11247 - EUGLENA GRACILIS BIOREFINERY VALORIZATION TOWARDS PRECISION FUNCTIONAL NUTRITION IN AQUACULTURE

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## ABSTRACT
The growing global population and food demand drive the need for sustainable solutions like aquaculture, which has grown 600% in 30 years. However, challenges to fish performance hinder further expansion, prompting ongoing research and innovation. A novel approach involves positively modulating the gut-microbiota complex to boost fish resilience towards stressors. The gut-microbiota complex, resulting from the synergistic interface between the gut and its associated microbiota, acts as a biological, chemical and physical barrier against a multitude of harmful stressors that can impair fish growth and health. To achieve this modulation, bioactive ingredients could be incorporated in fish feed before stress exposure, ensuring a proactive rather than reactive approach to maintaining and improving fish performance. A potential source of such compounds are microalgae, a robust and diverse class of microorganisms known for their rich and diverse biochemical composition, including high-value and bioactive compounds (e.g., β-glucans, polyunsaturated fatty acids and pigments). Targeted biorefinery approaches provide an optimal strategy to produce fractions enriched in the selected bioactive compounds, while ensuring the sustainability of the process and waste minimization. In this study, we aimed to develop and optimize two simplified and cost-effective pipelines that could produce either an aqueous extract fraction or an insoluble biomass fraction enriched in β-glucans derived from *Euglena gracilis* golden biomass. The biomass was initially disrupted through simplified methodologies, including high pressure homogenization and enzymatic hydrolysis, subsequently being subjected to different fractionation methodologies (centrifugation and micro/ultrafiltration) in tandem with either solubilization or precipitation techniques to enhance and facilitate the targeted compound. The various fractions produced during this pipeline were collected and freeze-dried for detailed chemical and bioactivity analysis. β-glucan levels were quantified as well as proximal biochemical composition for each fraction, followed by bioactivity analysis in an *ex vivo* platform with *Sparus aurata* intestinal mucosa's explant. Here, the ingredient's bioactivity in improving resilience was measured through gene expression modulation correlated with antioxidant capacity, immunomodulation, epithelium integrity, wound healing, and others. The findings from this study provide valuable insights into the potential of microalgal-derived bioactive ingredients for functional aquafeeds, contributing to the advancement of sustainable and resilient aquaculture systems.
Acknowledgments
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## KEYWORDS
Microalgae, Biorefinery, Feed

# 11257 - NOVEL GREEN EXTRACTION STRATEGY FOR MICROALGAE: COMBINING HIGH-PRESSURE HOMOGENIZATION AND NATURAL DEEP EUTECTIC SOLVENTS

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Abstract
The extraction of value-added compounds from microalgae biomass is a critical step for industrial applications. Conventional solvents like acetone, ethanol, and hexane are widely used; but, they pose environmental and safety concerns due to their toxicity, poor biodegradability, and non-renewable nature. As a sustainable alternative, natural deep eutectic solvents (NADES) have gained attention for their low toxicity, biodegradability, and ability to be directly incorporated into food formulations [1]. However, the rigid microalgal cell wall limits solvent penetration, needing a pretreatment step for efficient metabolite recovery. High-pressure homogenization (HPH) is a scalable and efficient technique for disrupting microalgal cell walls in aqueous environments, facilitating metabolite release [2]. However, it lacks selectivity, and conventional solvents are incompatible with the equipment. Combining HPH with NADES could create a more effective green extraction process, leveraging the benefits of both techniques while overcoming their individual limitations. To the best of our knowledge, this combined approach has not yet been explored.
This study investigates a one-step green extraction method by integrating HPH with NADES for the simultaneous disruption and recovery of high-value compounds from microalgae. Preliminary trials have demonstrated the feasibility and compatibility of NADES with HPH equipment at NADES-to-water ratios of 1:0 (pure NADES) and 1:4. Further trials using *Chlorella vulgaris* biomass will be conducted, testing NADES mixtures of varying polarities (based on terpenes, fatty acids, and organic acids and sugars). The influence of HPH pressure (100–1200 bar), NADES-to-water ratios (1:1–1:4), and biomass concentration (10 g/L) on the extraction efficiency of pigments, phenols, and proteins will be evaluated. Additionally, phase separation will be examined to assess biomass fractionation potential based on polarity. Results will be compared against HPH using water as a control under the same conditions to determine extraction efficacy.
The proposed approach provides an innovative and sustainable alternative to conventional extraction methods, thereby supporting the development of greener and more efficient bioprocesses in the microalgae industry.
Keywords: *Chlorella vulgaris*; Pigments; Protein; Bioprocess

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**KEYWORDS**

Microalgae, Biorefinery

# 11266 - PHOTOBIOVALUE PROJECT: ADVANCING MICROALGAL BIOMASS PRODUCTION AND VALORISATION

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## ABSTRACT
Microalgae are photosynthetic microorganisms with great potential for the sustainable production of valuable compounds, including proteins, lipids, carbohydrates, and pigments. Within the PhotoBioValue project, various studies were carried out to optimise Chlorella vulgaris biomass production and biochemical composition by adjusting operational conditions. One study investigated the impact of different light spectra (red, blue, orange, and white), showing that red light maximised growth rates (0.509±0.004 d−1) and carbohydrate accumulation (20.2–23.5% DCW), while blue light enhanced protein content (33.8–39.0% DCW). White light, in turn, enhanced $NO_3$-N uptake, as well as lipid (21.6-24.5% DCW) and pigment accumulation. Another experiment explored the effect of high light intensities (291–1107 µmol m−2 s−1), demonstrating increased growth rates (0.54±0.02 d−1), high nutrient removal efficiencies (>97% for $NO_3$-N and $PO_4$-P), and boosted carbohydrate (30±3% DCW) and lipid accumulation (13.0±0.4% DCW), highlighting the potential for biofuel production. To better the understanding of microalgal growth dynamics different growth kinetic models were compared, focusing on the combined impact of light intensity and biomass concentration. The Bannister and Grima models were identified as effective tools for predicting microalgal growth dynamics, contributing to process optimisation. A separate study investigated salinity levels (0–600 mM NaCl), where 150 mM NaCl optimised biomass production (978±11 mg L−1) without affecting nutrient removal and 300 mM NaCl promoted lipid (24±1% DCW) and carbohydrate accumulation (32.3±0.6%). Furthermore, the combined effects of light irradiance and exposure time were evaluated using a solar simulator, identifying conditions that maximise biomass while preventing adverse effects. Together, these studies provided a comprehensive overview for enhancing microalgal biomass production and composition under diverse conditions. The findings hold significant implications for biofuel production, bioremediation, valuable compound synthesis, and the sustainable management of biomass.

## KEYWORDS
Biochemical composition, Biomass valorisation, Chlorella vulgaris, Cultivation strategies, Operational conditions

## ACKNOWLEDGEMENTS
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# 11275 - MICROALGAE BIOREFINERY TOWARDS THE DEVELOPMENT OF SUSTAINABLE BIOACTIVE HYDROLYSATES

Authors
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## ABSTRACT

Introduction: Microalgae biomasses are rich sources of valuable bioactive compounds with significant health benefits, making them highly promising for food industry, nutraceutical, pharmaceutical applications as antioxidants, antimicrobials, and anti-hypertensive agents, among others. However, despite these advantages, their widespread utilization remains challenging due to factors such as low consumer acceptance, limited digestibility, and restricted bioactive compound accessibility. To overcome these barriers, it is essential to develop sustainable, zero-waste processing strategies that incorporate green extraction techniques and innovative bioprocessing technologies. Enzyme-assisted extraction combined with solid-state fermentation presents a multifunctional and eco-friendly biorefinery approach for enhancing the recovery of bioactive compounds from microalgae, maximizing their potential as novel and sustainable raw materials.

Methodology: This study aims to assess the sequential application of enzyme-assisted extraction using cellulolytic-proteolytic enzymes, followed by fungal solid-state fermentation of the remaining spent residues, to obtain protein-rich hydrolysates from Spirulina platensis (SP), *Chlorococcum* sp. (Chlo), and *Tisochrysis lutea* (TL). The effectiveness of this integrated extraction process, employing Cellulase™ and Alcalase®, was evaluated based on protein quantification (Kjeldahl and Bradford assays), antioxidant activity (FRAP and ABTS), and molecular weight distribution profiling (FPLC). Additionally, the residual biomass was assessed as a potential substrate for fungal bioprocessing with Aspergillus oryzae, focusing on its ability to enhance protein content, antioxidant activity, and the production of specific enzymes (cellulase and protease).

Results: The highest protein content obtained by the Kjeldahl method was from S. platensis (70.2% on a dry weight basis) through enzyme-assisted extraction at 50°C, followed by Chlorella with 50% and Tetraselmis with 45% dw. Antioxidant activity increased up to three times for S. platensis (ABTS assay) compared to the non-hydrolyzed biomass, with similar results observed for Chlorella and Tetraselmis. FPLC analysis revealed that the molecular weight of the recovered proteins ranged between 1 and 5 kDa. The bioprocess demonstrated that S. platensis by-product was the most suitable substrate for microbial development, showing a radial growth rate of 0.325 cm/day. The recovered extracts exhibited a continuous increase in antioxidant activity, which could be attributed to the rise in protein content (up to 60%) and the generation of bioactive peptides of 1–3 kDa detected at 120 hours of fermentation. Additionally, enzymatic activity was observed, with cellulase activity measured at 0.184 U/g and protease activity at 2.28 U/mL.

Conclusion: The study demonstrate the potential of microalgae as a novel source of bioactive compounds. Additionally, the bioprocessing technologies represent an attractive approach for the revalorization of by-products and the development of a zero-waste process, aligning with emerging blue bioeconomy and circular economy trends.

[1] Bautista-Hernández, I., et al. (2022). Food and Bioproducts Processing, 136, 24–35. https://doi.org/10.1016/j.fbp.2022.09.001

## KEYWORDS

# 11284 - BIOCONVERSION OF THE FUNGAL PRETREATED RUGULOPTERYX OKAMURAE INTO POLYHYDROXYALKANOATES BY CUPRIAVIDUS NECATOR

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## ABSTRACT

The production of bioplastic sources is essential for reducing dependence on traditional plastics and mitigating their environmental impact. In this sense, biodegradable plastic materials, such as polyhydroxyalkanoates (PHA) are a promising alternative and could be produced by microbial fermentation from alga biomass (Jeon et al., 2021). This study evaluated the invasive seaweed *Rugulopteryx okamurae* as a substrate for sugar production and subsequent fermentation to generate a kind of PHA: polyhydroxybutyrate (PHB) by microbial processes. For this, the algal biomass was subjected to a biological pretreatment with the fungus *Aspergillus awamori*, to enhance its biodegradability and facilitate subsequent enzymatic hydrolysis and PHB microbial production. These studies were performed with biologically pretreated and non-pretreated alga as a control.

Biological pre-treatment was developed at static conditions, 30ºC, 5 days and 79% of humidity. Enzymatic hydrolysis was developed during 72h at 50ºC using CellicCtec2® as an enzymatic cocktail and phosphate buffer as medium (4.4% w/v). Total Reducing Sugars (TRS), Total Carbon, Total Nitrogen and monomeric sugars were analyzed for process evaluation. The biological pre-treatment and subsequent enzymatic hydrolysis assays were developed in triplicate. The results showed that biological pre-treated algae generate hydrolysates with higher sugar concentrations (1.2 times higher than control), with a 97% glucose concentration and C/N ratio of 13.0.

Both hydrolysates (pretreated and non-pretreated control) were concentrated in sugars to reach optimal concentration (near 12 g/L) to initiate PHB fermentation with *Cupriavidous necator* CECT 4635. The fermentation was performed with 50 mL of pH adjusted (7.2) and supplemented hydrolysates, together with 50 µL of a trace element solution (according to Romero-Vargas et al., 2024) and 2.5 mL of *C. necator* inoculum. The shake flasks were then incubated at 30 °C and 250 rpm for 336 h. Samples were taken throughout the process to control bacterial growth by measuring the optical density at 600 nm, and the analysis of TRS and PHB. The fermentations were performed as well in triplicate.

The results showed that, initially, pre-treated samples favoured the PHB production, avoiding the lag-phase observed in non-pretreated samples. Also, this condition reached maximal PHB production of 2.63 g/L at 144 h, reducing the TRS content by 70%. In contrast, control samples obtained 2.39 g/L at 168h and a reduction of 50% of TRS. The findings of this study indicate that the use of biologically pretreated algae generates more available sugars for posterior PHB fermentation obtaining 259 $mg_{PHB}/g_{alga}$ remarking its use in the biorefinery process proposed for re-valorizing this invasive brown seaweed.

## FUNDING

This study is part of Project TED2021-130891B-I00 funded by MCIN/AEI /10.13039/501100011033 and by European Union Next GenerationEU/ PRTR and of the project PID2019-104525RB-I00 funded by MCIN/AEI/10.13039/501100011033.

This work is also funded by the Department of Economic Transformation, Industry, Knowledge and Universities from the Andalusian Government (Consejería de Transformación Económica, Industria, Conocimiento y Universidades de la Junta de Andalucía) in the call for hiring of PhD research staff by the agents of the Andalusian Knowledge System.

# 11277 - ULTRASOUND-ASSISTED ENZYMATIC HYDROLYSIS OF THE RED SEAWEED PALMARIA PALMATA FOR PROTEIN EXTRACTION

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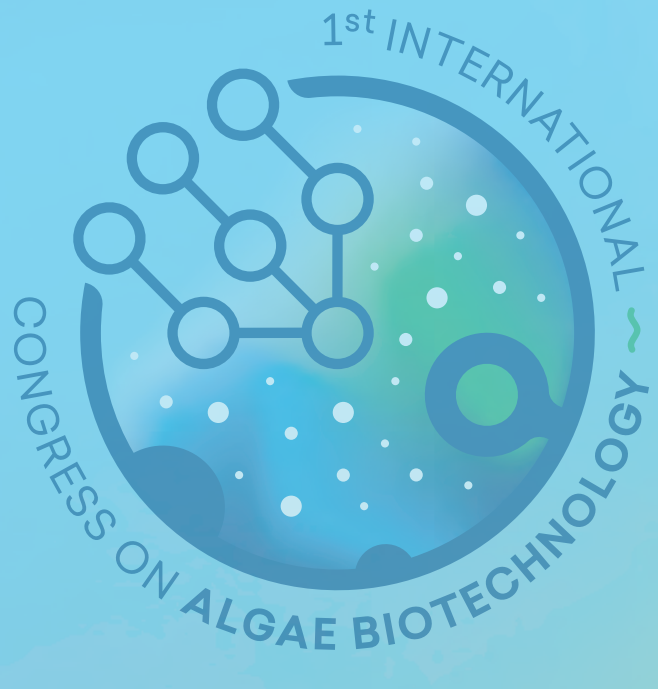
## ABSTRACT
*Palmaria palmata*, a red seaweed, has high commercial value due to its rich protein content (up to 35% dry weight), surpassing most other edible seaweeds (Lopes et al., 2019; Morgan et al., 1980). Enzyme-assisted extraction (EAE) is considered a greener alternative to conventional cell-disruption methods, which are labor-intensive and yield lower amounts of proteins (Sanjeewa et al., 2023). However, EAE alone has not achieved the desired levels of protein extraction efficiency from *P. palmata*. This study explores ultrasound-assisted extraction (UAE) and ultrasound-assisted enzymatic extraction (UAEE) as enhanced methods for protein recovery. A novel approach combining design of experiments (DoE) and response surface methodology (RSM) was used to optimize the extraction process by considering key process variables. UAE achieved a protein yield of 12.9%, outperforming EAE techniques using xylanases and cellulases. UAEE further improved protein extraction, reaching a maximum yield of 33%, significantly higher than the 19% obtained with traditional enzymatic methods under the same conditions. These results highlight the potential of ultrasound-assisted techniques to overcome current extraction limitations. Additionally, we emphasize the importance of optimizing independent factors such as ultrasonic frequency, intensity, enzyme-to-substrate (E/S) ratio, and ultrasonication equipment type to enhance protein recovery. A techno-economic assessment was also conducted to evaluate whether UAEE provides a cost-effective alternative to conventional EAE. Finally, we discuss the potential of other advanced extraction methods, such as microwave-assisted enzymatic extraction (MAEE) and the use of natural deep eutectic solvents (NaDES), to further refine multi-product seaweed biorefineries.

## KEYWORDS
Ultrasound assisted extraction, enzyme assisted extraction, hyphenation techniques, RSM, techno-economic assessment




## POSTER SESSION

# ALGAE-BASED SOLUTIONS FOR THE MARKET

# 10571 - BIOREMEDIATION OF RESTAURANT WASTEWATER USING EXTREMOPHILIC GALDIERIA SULPHURARIA IN SUB TROPICAL WEATHER CONDITIONS: AN APPROACH CONTRIBUTING TO CIRCULAR BIOECONOMY AND ENVIRONMENTAL SUSTAINABILITY

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## ABSTRACT

Ecological pollution is a critical global problem with harmful actions on human health in addition to reducing useful environmental resources. Wastewater also has a biohazard effect on the biological ecosystem due to the high concentrations of inorganic, organic and heavy metals pollutants. Bioremediation is the removal of chemical contaminants by using microorganisms, such as microalgae, fungi, and bacteria. This method enables effective ecological biorefinery with no harmful effect, if the provided microorganisms do not interfere with the existing biodiversity. In addition to the efficiency of microorganisms to overcome high concentration of heavy metals. Microorganisms carry out waste heavy metals in one of two ways: either by oxidizing or reducing the harmful substances and metal ions, to dissolve the surrounding minerals of the target metal ion to acquire the pure metal. Microalgal bioremediation of wastewater possesses the following advantages nutrient uptake including TN, TP, and K, pollutants removal such as COD, BOD, and FOG, carbon dioxide ($CO_2$) fixation, and biomass generation. Thereby contributing to circular bioeconomy and environmental sustainability Algal-based wastewater treatment (WWT) was explored for its potent bioremediation ability and recovered biomass, which can be reutilized in various applications. When considering microalgae cultivation's role in integrated production systems, especially when using wastewater and gaseous effluents, the hunt for new potential strains is crucial. This research study explored the potential of microalga *Galdieria sulphuraria* 074 W (NIES-3638) to bioremediate raw restaurant wastewater due to its distinct characteristics, including high temperature (45–56 °C) and acidic pH (0-4) settings. The cultivation conditions were subject to three cultivation modes (i.e. mixotrophic, heterotrophic, and autotrophic) for 14 days. During the cultivation of *G. sulphuraria*, various evaluations, including optical density (OD), specific growth rate, and biomass productivity, were examined. Furthermore, the bioremediation efficiency of *G. sulphuraria* was examined for the removal of pollutants, including chemical oxygen demand (COD), biochemical oxygen demand (BOD), fats, oil, grease (FOG) and nutrient uptake like ammoniacal-nitrogen ($NH_4^+$-N), total-nitrogen (TN), total-phosphorus (TP), and potassium (K). *G. sulphuraria* grown with restaurant wastewater scored 0.15 $day^{-1}$ for specific growth rate and 39 mg $L^{-1}$ $d^{-1}$ biomass productivity. The maximum removal efficiencies for COD, BOD, FOG, $NH_4^+$-N, TN, TP, and K were 71%, 80%, 66%, 96%, 93%, 99%, and 75%, respectively. Overall, this study revealed a promising treatment of restaurant wastewater using *G. sulphuraria* for removing pollutants, uptake of nutrients and enriched biomass that can be further utilized to produce secondary metabolites.

## KEYWORDS

Microalgae, Environmental solutions/ Circular Economy, Production

# 10951 - SCALE-UP OF ENZYME-MEDIATED MODIFICATIONS IN MICROALGAE: ENHANCING FOOD INGREDIENT QUALITY FOR CONSUMER ACCEPTANCE

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**ABSTRACT**
Microalgae are increasingly recognized as a biological resource for large-scale sustainable production of food and feed, supporting the blue bioeconomy. They represent a potential source of innovative food products, due to their rich content in proteins, vitamins, and lipids. The color and flavor of microalgal biomass, however, limits its inclusion in food products due to sensory qualities and consumer acceptability.
This work aimed at improving the sensory quality of microalgae as a food ingredient by utilizing enzymes from marine bacteria to address two primary organoleptic characteristics of microalgal biomass: the green, dark color resulting from the microalgal pigments; and the fish-like smell linked to volatile compounds.
Following the isolation of several marine bacteria, screening revealed that various species produced enzymes capable of degrading trimethylamine and of removing/converting the green chlorophyll in the biomass. The scale-up to 1L reactors enabled the treatment of 500 mL of a microalgae suspension, simultaneously using trimethylamine from the algae to grow marine bacteria able to also produce enzymes that eliminated/converted the green colour of the algal biomass. The bioprocess thus helped to produce biomass that could be more acceptable to consumers.

**KEYWORDS**
Microalgae, Food, Algae Market

# 11211 - CEN/TC454 ALGAE AND ALGAE PRODUCTS – ORIGIN, HISTORY AND WORK DONE

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**ABSTRACT**
In March 2016 the European Committee for Standardization (CEN) was requested by the European Commission (EC) to draft European standards or European standardization deliverables in support of the implementation of Article 3 of Directive 2009/28/EC for algae and algae-based products or intermediates.
This request also contributes to the Communication on "Innovating for Sustainable Growth: A Bio-economy for Europe", in order to promote energy, bio-based materials and chemicals use from renewable sources.
According to the Mandate M547: “CEN shall prepare the work program indicating all requested deliverables, responsible technical bodies and a timetable for the execution of the work in line with the deadlines set out in by the EC”.
During 2016, the working group CEN Technical Board Working Group 218 “Algae” was established for the execution of this Mandate, M547. In early 2017, the CEN Technical Committee 454 ‘Algae and algae products’ was founded under the management of NEN “Royal Netherlands Standardization Institute”, the NSB (National Standardization Body) of Netherlands.
The first meeting was held in Brussels, 31st of May 2017, being present 11 EU members, and 26 experts. Initially CEN/TC454 started developing its work through 6 working groups, and currently 3 of them have been disbanded, and another 3 have been created.
Since its inception, CEN/TC454 have meet 12 times (Brussels, Delft, Brussels, Brussels, Lisbon, Paris, Zoom, Zoom, Zoom, Berlin, Copenhagen, Zoom) and the next will be held in next September in Delft.
So far, approximately 120 experts from 28 National Standardization Bodies have been involved in the work of CEN/TC454 and 13 documents have been published, between European standards, Technical reports and Technical specifications. There are 7 active working items.
CEN/TC454 have liaisons with several other different CEN and ISO Technical Committees:
• CEN/TC 230, 275, 327, 383, 411, 455, 460, 463
• ISO/TC 217, 234

**KEYWORDS**
Microalgae, Macroalgae, Algae Market, Production, Food, Feed, Supplements and cosmetics

# 11248 - MICROALGAE-BASED SOLUTIONS FOR A SUSTAINABLE AQUACULTURE

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## ABSTRACT
The aquaculture sector plays a crucial role in global food security but faces environmental challenges related to effluent treatment and water resource management. The AQUA4ALL project proposes an innovative circular economy-based approach to optimize recirculating aquaculture systems (RAS through microalgae-based bioremediation. Led by Flatlantic, in collaboration with GreenCoLab, Necton, and S2Aqua, the project aims to develop algae bioremediation solutions to reduce the environmental impact of aquaculture effluents by transforming waste into value-added products. The project focuses on cultivating microalgae to remove nitrogen and phosphorus compounds from RAS effluents, enhancing water quality and promoting its reuse. The resulting algal biomass will be used to create two innovative products for aquaculture: CleanAlgae, a sterilized formulation for live feed and marine fish larvae cultivation, and AquaDefense, a water conditioner with bactericidal and bacteriostatic properties aimed at optimizing the biological performance of aquatic organisms. Expected outcomes include the implementation of an efficient bioremediation process, the sustainable production of microalgae, and the development of innovative solutions for the aquaculture industry. The integration of this technology will reduce effluent discharge, increase production efficiency, and foster sustainability in the sector. With a strong focus on innovation and environmental impact, AQUA4ALL represents a significant step forward in sustainable aquaculture and waste valorization through microalgae biotechnology.

## KEYWORDS
Sustainable aquaculture, microalgae, bioremediation, circular economy, effluent treatment, recirculating aquaculture, Feed, Environmental solutions/ Circular Economy, Algae Market

## ACKNOWLEDGEMENTS
This work was supported by Compete 2030, Algarve 2030, Portugal 2030 and by the European Union within the scope of the project AQUA4ALL - Microalgae for bioremediation of effluents from recirculating aquaculture systems and the development of value-added products, COMPETE2030-FEDER-00582600, ALGARVE-FEDER-00582600. Daniel Figueiredo is pleased to acknowledge his PhD grant FCT 2022.11872.BDANA, respectively, awarded by Fundação para a Ciência e Tecnologia.

# 11249 - OPTIMIZED UV MUTAGENESIS FOR STRAIN IMPROVEMENT IN TISOCHRYSIS LUTEA AND PAVLOVA GYRANS

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**ABSTRACT**
Microalgae serve as versatile organisms in biotechnology, yet their industrial application often requires strain improvement to enhance growth rates, biomass yield, or specific metabolite production. Random mutagenesis is a widely used approach to accelerate strain evolution by introducing genetic variability without genetic engineering. Common methods include UV irradiation, ethyl methanesulfonate (EMS, and N-methyl-N′-nitro-N-nitrosoguanidine (NTG, each with distinct advantages and limitations. UV mutagenesis is a non-chemical, rapid technique that induces pyrimidine dimer formation in DNA, leading to mutations. While effective, its main drawback is high lethality, necessitating careful optimization of exposure parameters. Chemical mutagenesis, using alkylating agents such as EMS and NTG, introduces point mutations by modifying nucleotide bases but is highly toxic and requires detoxification with washing steps. In this study, EMS mutagenesis was evaluated for *Tisochrysis lutea* and *Pavlova gyrans*, but its applicability was highly impacted. The need for centrifugation and sodium thiosulfate washing significantly reduced cell viability due to the fragility of these cells, making EMS less efficient for these species. Given these limitations, UV mutagenesis was optimized as an alternative strategy. Results demonstrated that UV exposure time was the most critical parameter affecting cell viability and, consequently, mutation efficiency, alongside factors such as cell concentration, light intensity, and culture volume. For *T. lutea*, an optimal window of 20–30 seconds was identified, generating approximately 5–20% cell survival, while for *P. gyrans*, 50–70 seconds were required. Mutant strains generated through UV mutagenesis with survival rates below 5% successfully recovered, as confirmed by fluorescence analysis indicating the restoration of photosynthetic activity. These results further support the viability of UV-exposed cells under these conditions. This study highlights UV irradiation as a practical and effective random mutagenesis method for *Tisochrysis lutea* and *Pavlova gyrans*. The insights gained contribute to advancing strain improvement strategies, fostering the development of enhanced microalgae for biotechnological applications.

Keywords: *Microalgae, Random Mutagenesis, UV Irradiation, Tisochrysis lutea, Pavlova gyrans, Biotechnology,* Algae Market

ACKNOWLEDGEMENTS
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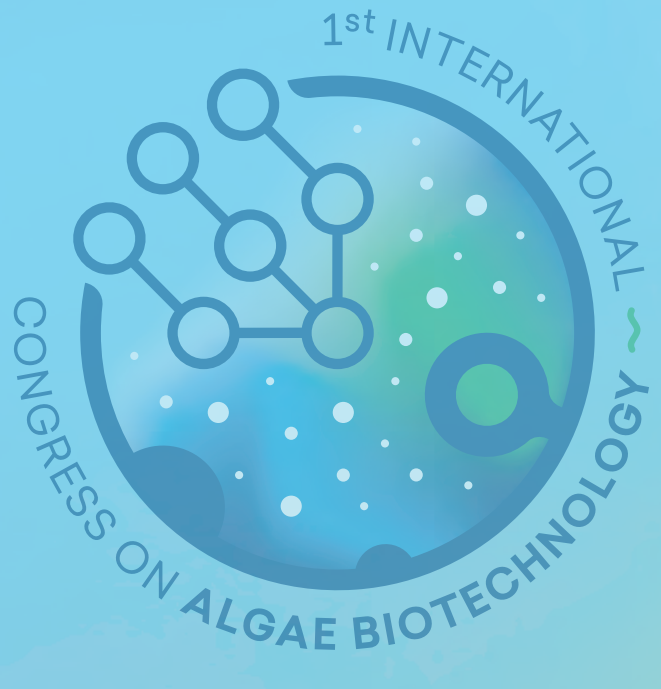


# POSTER SESSION

# ENTREPRENEURSHIP AND BUSINESS SUCCESS MODELS (START-UPS & SPIN-OFFS & LARGER ENTERPRISES)

# 11015 | ASTEASIER: PIONEERING SUSTAINABLE MOLECULES FOR THE NUTRACEUTICAL INDUSTRY

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**ABSTRACT**
With increasing life expectancy, age-related diseases, such as cognitive decline and physical weakness, are expected to rise. Aging gradually deforms physiological functions, making individuals more susceptible to cardiovascular or neurodegenerative diseases and diabetes. Carotenoids, with their potent antioxidant, repair, anti-inflammatory, and anti-aging properties, help prevent diseases associated with oxidative stress and chronic inflammation. Lutein and zeaxanthin are particularly important for eye health, accumulating in the retina and acting as a natural filter. Astaxanthin is also a potent antioxidant with anti-inflammatory properties, useful in treating Parkinson's, Alzheimer's, and cancers. In industrialized nations, many do not meet the recommended intake of carotenoids despite a diet rich in fruits and vegetables. Research shows that 9 out of 10 Americans do not consume enough fruits and vegetables to meet their nutritional needs. Efforts to address nutrient deficiencies include food fortification and supplements. The global carotenoid market was valued at $1.7 billion in 2022. While synthetic carotenoids dominate the market due to lower costs, demand for natural carotenoids is rising. Synthetic carotenoids are produced through chemical synthesis using petrochemical compounds, which are energy-intensive. Additionally, some synthetic carotenoids are not approved for direct human consumption.
Asteasier is a startup focused on sustainable microalgal solutions for producing high-value metabolites, particularly carotenoids like zeaxanthin and astaxanthin. Through genetic engineering, the metabolism of microalgae species such as Chlamydomonas, Nannochloropsis, Synechococcus, and Chlorella has been directed toward the efficient production of these compounds. By combining knockout backgrounds with various enzymatic pathways, Asteasier's patented engineered strains offer tailored pigment profiles for the nutraceutical and feed industries. Additionally, these strains produce essential nutrients, including proteins, phycocyanin, and polyunsaturated fatty acids (PUFAs, which are unavailable from synthetic sources. We tested different growth conditions, such as photobioreactor geometry and medium composition, to determine the best one for each strain, with volumes up to 5 m3. The recovered biomass was then evaluated for several downstream processes, such as pigment extraction in conventional and biocompatible solvents, aquaculture, or medicine applications. Asteasier's products have the potential to transform the nutraceutical and aquaculture sectors by providing cost-effective, natural, and sustainable pigments.

**KEYWORDS**
Food, Feed, Supplements and cosmetics, Algae Market

# 11255 | IBEROBIO: ENHANCING THE GROWTH AND INTERNATIONALISATION OF THE IBERIAN BIOTECHNOLOGICAL SECTOR

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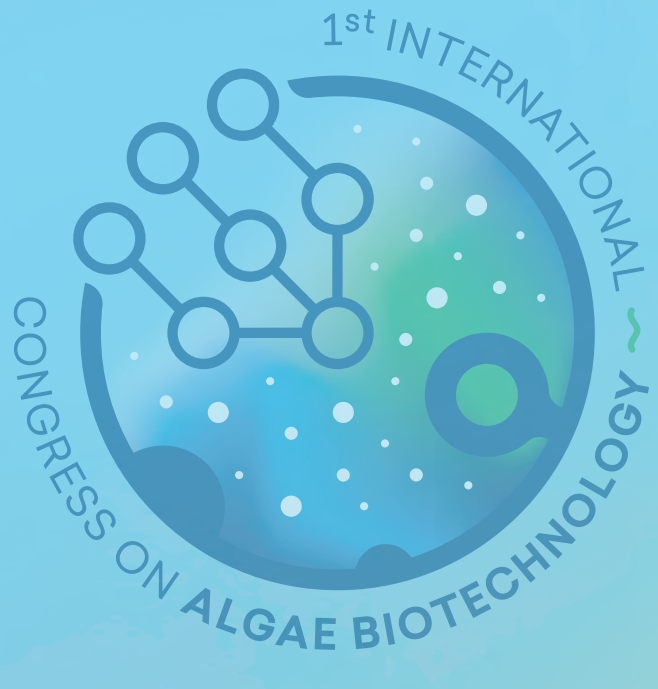
## ABSTRACT
The IberoBio project aims to establish an "Iberian Cross-Border Biotechnology Hub", to promote the growth and international expansion of biotech companies in the Iberian Peninsula. This hub will be developed collaboratively through various activities focused on talent development, sectoral hybridization, and business competitiveness for biotech Small and Medium-sized Enterprises (SMEs, enhancing their ability to compete and expand internationally. This initiative covers the regions of Galicia, Castilla y León, Extremadura, Andalucía, and several areas of Portugal, with an emphasis on different fields within the biotechnology sector, such as health, agriculture, industrial applications, food, marine and environmental biotechnologies. The project aims to provide a diverse range of corporate services to empower biotechnology companies in achieving market success and fostering long-term growth. Key activities include creating a collaborative structure, mapping biotech resources in the Iberian area, and assessing the sector's impact on the regional Smart Specialization Strategies. It will also improve SMEs' access to international markets through training and advisory services, promote open innovation via collaboration, and facilitate funding opportunities by establishing a Fund for identifying and evaluating potential opportunities. Several resources developed within the project will be presented (e.g. BioTalent Program, Biotech Resources Map, Biotech Financing, Campus IberoBio, and over 60 biotech SMEs and companies from key cross-border sectors will receive advanced services during the project, enhancing their competitiveness and improving their access to international markets.
IberoBio is supported by the Interreg VI-A Spain-Portugal Programme (POCTEP 2021-2027 and involves a consortium of academic institutions, business organisations, and research entities from the border regions of Spain and Portugal, led by Bioga - Cluster Tecnológico Empresarial de las Ciencias de la Vida.

## KEYWORDS
Iberian biotechnology sector, competitiveness, internationalisation, corporate services




## POSTER SESSION

# INNOVATIONS IN ALGAE PRODUCTION

# 10756 - EVALUATION OF THE CAPACITY OF THE MACROALGA KAPPAPHYCUS ALVAREZII TO REDUCE BIODEPOSITS FROM THE CULTIVATION OF THE MUSSEL PERNA PERNA IN MAPUTO BAY — INHACA ISLAND AND MACHANGULO

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## ABSTRACT

Title: Evaluation of the Capacity of the Macroalga *Kappaphycus alvarezii* to Reduce Biodeposits from the Cultivation of the Mussel *Perna perna* in Maputo Bay—Inhaca Island and Machangulo Introduction: The cultivation of bivalve mollusks, such as *Perna perna* mussels, plays a significant role in coastal community livelihoods by providing income and employment opportunities. However, this activity can lead to environmental challenges, such as sediment alteration and the accumulation of organic material from feces and pseudofeces. Integrated Multi-Trophic Aquaculture (IMTA systems have emerged as a potential solution to mitigate these impacts. Macroalgae, particularly *Kappaphycus alvarezii*, have demonstrated benefits in reducing excess nutrients and biodeposits, making them an ideal candidate for integration into mussel farming systems.

Objectives: The study aims to evaluate the potential of *Kappaphycus alvarezii* to reduce biodeposits from *Perna perna* cultivation in Maputo Bay, focusing on sediment characteristics, organic matter levels, benthic macrofauna communities, and the quality of cultivated macroalgae.

Methodology: The research will be conducted in mussel farming sites in Inhaca Island and Machangulo under the management of the Institute for Fisheries Development and Aquaculture (IDEPA. The cultivation system employs long-lines to integrate macroalgae and mussels. Sediment and macroalgae samples will be collected biweekly over 45 days at fixed points, with one control point outside the influence of farming activities. Data collection will include sediment granulometry, organic matter analysis, and benthic community assessments. Macroalgae biomass growth and nutrient concentrations will also be monitored.

Expected Results: It is anticipated that the integration of *Kappaphycus alvarezii* with *Perna perna* cultivation will:

Significantly reduce the accumulation of organic matter and biodeposits in sediments.

Enhance macroalgae biomass and nutritional quality.

Promote biodiversity by providing habitat and food for marine organisms, supporting the recolonization of native species.

Significance: This study seeks to contribute to sustainable aquaculture practices by addressing ecological challenges associated with mussel farming. By leveraging the nutrient-absorbing properties of *Kappaphycus alvarezii*, the research aims to demonstrate the environmental and economic benefits of IMTA systems, ultimately supporting the livelihoods of coastal communities in Mozambique.

## KEYWORDS

Macroalgae, Production, Environmental solutions/ Circular Economy, Food

# 10939 - UPCYCLING OF FOOD WASTE BY HETEROTROPHIC CULTIVATION OF CHLORELLA SOROKINIANA

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## ABSTRACT

As the world's population grows, so does food production. Unfortunately, this leads to a significant increase in food waste (FW, with estimates indicating that one-third of the food produced worldwide is wasted, resulting in severe environmental challenges. Therefore, there is a pressing need to shift human perception and look at these wastes as valuable resources, by promoting their valorisation within a circular economy. Given their rich composition, FW might represent an interesting and low-cost nutritional medium for microorganisms, such as microalgae. In this context, microalgae are micro bio-factories that emerge as an interesting solution to recycle such nutrients, due to their higher capacity to uptake and convert them into high-value biomass.

This work assesses the potential of retail FW as a nutritional substrate for the heterotrophic cultivation of microalgae. To achieve the goal of this study, a formulation of retail FW containing different food categories – fruits, vegetables, dairy, and bread - was produced and characterised regarding its biochemical composition, focusing on the carbon content. To promote the bioavailability of glucose on the FW medium, glucoamylases were applied as pretreatment. Afterwards, the heterotrophic growth of the microalga *Chlorella sorokiniana* was evaluated by testing different dilutions of FW formulation, with the supplementation of 50 % of essential nutrients (i.e. macro- and micronutrients and 100 % of vitamins when compared to the control medium (commercial medium.

The analysis of the FW formulation revealed the presence of the essential required nutrients for the cultivation of microalgae in heterotrophic conditions. Highlighting the sugar content, the FW formulation had an initial concentration of 11.50 ± 0.24 $g.L^{-1}$, with only 4.36 ± 0.62 $g.L^{-1}$ corresponding to glucose. However, after the enzymatic pretreatment, the sugar content and glucose increased significantly to 25.73 ± 0.32 $g.L^{-1}$ and 21.94 ± 2.05 $g.L^{-1}$, respectively. Regarding microalgae cultivation, approximately 7.25 $g.L^{-1}$ of *C. sorokiniana* (dry biomass basis was achieved when using the FW medium with half the supplementation of a commercial medium (which contained glucose. Concerning the growth of this microalga using different dilutions of FW medium without the supplementation of external glucose, it was obtained 5.90 $g.L^{-1}$ for lower concentrations of FW medium and 8.20 $g.L^{-1}$ for higher concentrations, which contained more sugars. However, when compared to the cultivation of *C. sorokiniana* with commercial medium, significant differences were observed in each cultivation assay – having around 20.2 % to 41.2 % less biomass. Nevertheless, these results demonstrate that it is possible to use FW-based medium as a nutrient source for the cultivation of *C. sorokiniana* without the need of glucose supplementation, underlining its potential as a low-cost alternative to replace the commercial medium.

## KEYWORDS

Microalgae, Production, Environmental solutions/ Circular Economy, Biorefinery

# 10968 - LOOKING FOR BIOMARKERS TO ASSESS THE STABILITY OF MICROALGAE LIPID EXTRACTS: INSIGHTS FROM FORCED DEGRADATION STUDIES

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## ABSTRACT
Microalgae lipids are emerging as novel high-value compounds with interesting bioactive properties. Their applications range from nutraceuticals as sources of omega-3 polyunsaturated fatty acids (PUFA to cosmetics ingredients with anti-aging and anti-inflammatory properties. *Nannochloropsis* sp. and *Tisochrysis* sp. are recognized for their content in omega-3 PUFA such as eicosapentaenoic acid (EPA, FA 20:5*n*-3 and docosahexaenoic acid (DHA, FA 22:6*n*-3, particularly attractive for cosmeticeutical applications. Despite their potential, the inherent susceptibility of PUFA-rich lipids to oxidation raises concerns about their stability during storage. Understanding the stability of lipids is critical for developing formulations that preserve their nutritional and bioactive properties. Forced degradation tests are used to determine the degradation products of a compound or formulation, using biomimetic systems with extreme conditions, for simulating long-term exposure to light, temperature and others.
In this study we identified degradation biomarkers of lipid extracts from *Microchloropsis gaditana* and *Tisochrysis lutea* under (i thermostability at high temperature (8h at 80ºC, and (ii photostability (3 weeks of light exposure assays. The alteration in the lipid profile was assessed by gas-chromatography mass-spectrometry analysis to determine changes in the fatty acids (FA composition. Our results showed that treatment with temperature does not affect significantly the FA composition of microalgae lipid extracts, contrarily to light exposure. The incubation of lipid extracts from *N. gaditana* and *T. lutea* at 80ºC for 8h resulted in a slight decrease in the amount of PUFA. This decrease was evident in EPA from *N. gaditana* lipid extract decreased from 73.3±6.2 µg/mg to 59.1±1.2 µg/mg of lipid extract. FA and PUFA to undetectable levels in both microalgae lipid extracts. Saturated FA (SFA from *N. gaditana* lipid extracts decreased from 113.7±3.9 µg/mg to 89.1±6.2 µg/mg of lipid extract, while SFA from *T. lutea* lipid extracts decreased from 43.3±3.5 µg/mg to 33.8±1.5 µg/mg of lipid extract. The levels of phytol, a chlorophyl constituent, reached undetectable levels in both lipid extracts under photostability assays.
These results showed that different markers can be used to assess degradation induced by different external conditions. The identified biomarkers can be used to define targeted strategies to develop stable formulations capable of maintaining the bioactive properties of microalgae lipids for added value applications such as cosmetics.
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## KEYWORDS
Microalgae, Supplements and cosmetics, Environmental solutions/ Circular Economy

# 10983 - MICROALGAE BIOACTIVE TO ENHANCE METABOLIC AND BIOCHEMICAL PATHWAYS IN MEDICINAL AND AROMATIC PLANTS: NEW APROACH TO IMPROVE QUALITY AND QUANTITY OF METABOLITES AND ESSENTIAL OILS

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## ABSTRACT
Microalgae, unicellular photosynthetic organisms belonging to the Protista kingdom, have attracted growing interest in the field of agriculture due to their richness in bioactive metabolites including polysaccharides, amino acids, vitamins, phytohormones and antioxydants make them promising candidates for improving plants production. The metabolic systems of the aromatic and medicinal plants are of great significance as they provide these plants with their remarkable therapeutic, aromatic and nutritional properties. Such biologically active compounds such as essential oils, alkaloids, flavonoids, terpenoids and phenolic compounds, among others, exert a variety of activities. Thereof increased understanding of the target metabolome of these plants will facilitate more sustainable and efficient production methods, together with the yield and quality increase of bioactive compounds. The production of desired compounds like essentiel oils can be boosted by increasing intracellular metabolic pathways by changing environmental conditions or by the use of biotechnological means like microalgae extracts, which will enhance both the quality and quantity of the metabolites. In light of these challenges, the use of microalgae extracts is emerging as a promising strategy for optimising metabolites like essential oil production by influencing the physiology and metabolomics of aromatic and medicinal plants. Microalgae provide a natural bioactive of plant stimulants, promoting biochemical and metabolomics pathways related to medicinal plant metabolites biosynthesis. Their interactions with plants can influence the biosynthesis of bioactive compounds, thereby modulating the chemical composition and properties of metabolites including essential oils.

## KEYWORDS
Microalgae, bioactive, aromatic medicinal plants, essential oils, crop improvement, metabolomics, plant-microalgae interactions, plant physiology, growth simulation, Agriculture, Production

# 10990 - A SUSTAINABLE APPROACH TO CULTIVATING MICROALGAE AT HIGH LATITUDES; INTRODUCING A NOVEL LOW-COST LED-INTEGRATED PHOTOBIOREACTOR

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## ABSTRACT

Microalgal biotechnology is growing rapidly due to its vast applications and potential benefits. Photoautotrophic cultivation, which relies on natural sunlight, is the most widely used growth method for producing valuable pigment metabolites due to its economic and environmental benefits. However, especially in high-latitude countries where low and variable light intensity is common at certain times of the year, this method is not reliable. In this case, photoautotrophic cultivation must be supplemented or replaced using artificial lighting. Recently LED lighting system production technologies have been significantly improved and offer many advantages; including the ability to submerge the LED light panels and generate internally illuminated reactors, which reduces light attenuation and further enhances algal culture productivity. In addition, any lighting system must be easy to operate at large-scale and at a low cost, to be feasible and economically viable for scalable algal production. This study introduces a new concept of reactor, the 1,000L “Cube”, covered from an IBC tank, adapted for microalgae cultivation at industrial scale and at low cost. The novel internally illuminated reactor was operated continuously, growing Spirulina culture, with three cultivation cycles over a 78-day period. The reactor operation was kept at a consistent temperature and pH, which ensured optimal growth with robust biomass production without a lag phase. The maximum biomass concentration was 1.4 g $L^{-1}$, maximum specific growth rate was 0.4 $day^{-1}$, and biomass productivity was 80 mg $L^{-1}$ $day^{-1}$. Protein content was measured at 54% and phycocyanin pigment level was 78 mg $g^{-1}$, both paraments were higher than in other commercial samples of biomass. An economic evaluation revealed a capital cost of production was £5,730 per cubic meter of reactor volume, with energy consumption primarily driven by the LEDs and thermal control system. While direct sales of Spirulina biomass may not be cost-effective due to the energy demand, a focus on high-value products like proteins and pigments could generate significant revenue, with a potential annual income of £42,857 and a payback period of six weeks. The ease in scalability, cost-effectiveness, and adaptability of the cube makes it suitable for diverse commercial/industrial and environmental conditions, offering a viable solution for all-year-round microalgae cultivation in low light/temperature regions. This reactor has the potential to revolutionise algal production, contributing to carbon capture, a sustainable future, in the context of the circular bioeconomy.

## KEYWORDS

Microalgae, Production, Environmental solutions/ Circular Economy, Algae Market

# 10992 - SUSTAINABLE PRODUCTION AND VALORIZATION OF MICROALGAL BIOMASS FROM ULTRAFILTRATED LIVESTOCK DIGESTATE

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## ABSTRACT
The management of anaerobic digestate effluent is essential to avoid negative impacts like land and water contamination and eutrophication of water bodies. Microalgae offers a promising solution since
they can recover nutrients from these effluents while capturing atmospheric $CO_2$, converting them in new biomass and high bioproducts.
The integration of digestate into microalgae cultivation reduces the need for external inputs, creating a synergistic loop between microalgae cultivation and anaerobic digestion. This recycling process not only lowers production costs but also enhances the sustainability of the overall system by reducing carbon and water footprint.
The high turbidity of the digestate, the presence of the microbial component and solid suspension presents several challenges. This work describes an innovative ultrafiltration system to separate and concentrate nutrients from digestate effluents, facilitating the successful cultivation of different algal species, with the best results obtained in the case of *Chlorella sorokiniana* and *Nannochloropsis oceanica*. Testing different ultrafiltrate concentration and light regimes it was possible obtain up to 133% increase in growth rate and biomass accumulation compared to optimal synthetic medium, recovering nearly all nitrogen and phosphate.
To close the rim of the circular economy, biomass obtained from algal growth was successfully used as a biostimulant on crops of interest. This sustainable approach can reduce upstream and downstream costs of algal production and valorize industrial waste into new bioproducts, reducing the need for synthetic fertilizers.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Microalgae, Production, Agriculture, Environmental solutions/ Circular Economy

# 11000 - INVESTIGATING CALVIN CYCLE REGULATION IN CHLAMYDOMONAS REINHARDTII THROUGH HETEROLOGOUS EXPRESSION OF CYANOBACTERIAL FBP/SBPASE

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**ABSTRACT**
Photosynthesis is the metabolic process that enables photosynthetic organisms to convert solar energy into biochemical energy, storing it as carbohydrates from water and $CO_2$. In recent decades, microalgae have gained attention for their potential in food, feed, energy, and raw material production. Moreover, their role as bio-factories for high-value metabolite synthesis is widely recognized. Despite their advantages over plants, the large-scale use of microalgae remains limited by high production costs and low productivity. Therefore, domestication strategies are essential to enhance biomass yield and improve their industrial viability. The Calvin-Benson cycle presents an attractive target for genetic manipulation due to multiple reported bottlenecks in plants and microalgae. One of the most promising findings is that overexpression of the cyanobacterial enzyme fructose-1,6-/sedoheptulose-1,7-bisphosphatase (FBP/SBPase) in tobacco significantly enhances growth rate and biomass accumulation. In this study, we engineered *Chlamydomonas reinhardtii* to overexpress the same enzyme, which catalyzes both the FBPase and SBPase reactions, to assess its impact on photosynthetic efficiency and biomass production. The enzymatic activity and kinetics of the chimeric FBP/SBPase were evaluated and compared to the endogenous FBPase. Additionally, growth performance was assessed under both atmospheric and $CO_2$-enriched conditions, exploring different light regimes in mixotrophic and autotrophic modes. The results revealed alterations in morphology and cell size, along with an increased accumulation of key metabolites such as proteins, lipids, and starch, particularly under $CO_2$-limiting conditions. These findings provide important insights into microalgal carbon metabolism and demonstrate promising potential for enhancing biomass accumulation, supporting future efforts in domestication and industrial applications.

**KEYWORDS**
Microalgae

# 10949 - FRESHWATER MICROALGAL STRAIN SELECTION FOR THE INDUSTRIAL PRODUCTION OF TRIACYLGLYCEROL USING A SCALE-DOWN APPROACH

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**ABSTRACT**
The production of triacylglycerols (TAGs) from microalgae has great potential and is a more sustainable alternative to traditional agricultural oil crops. TAG accumulation is typically induced under stress conditions, with nitrogen limitation/starvation being the most effective trigger. However, despite their potential, large-scale microalgal TAG production remains economically unfeasible due to high costs compared to vegetable oils. Process optimization and strain selection are critical to improving economic viability. This study aimed to identify the most promising microalgal species for large-scale TAG production using a scale-down approach. Four freshwater microalgal strains were selected based on literature reviews and evaluated under simulated outdoor conditions, including temperature and light fluctuations, as well as nitrogen-sufficient and deficient conditions. Selection criteria for promising strains included robustness, lipid and TAG content under nutrient-sufficient and deficient conditions, growth characteristics, and volumetric lipid and biomass productivity. Freshwater species were prioritized due to their potential for wastewater-based cultivation, reducing costs and enhancing environmental sustainability. Biomass and lipid productivity were analyzed in batch cultures for up to two weeks following nitrogen depletion. With this work, we move one step closer to selecting a suitable microalgal strain for large-scale TAG production.

**KEYWORDS**
Microalgae

# 11061 - IMPROVING THE NUTRITIONAL VALUE OF ACHETA DOMESTICUS DIETS WITH MICROALGAE TO MITIGATE INTESTINAL DYSBIOSIS

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## ABSTRACT
Intestinal dysbiosis is one of the major challenges faced by people with type 2 diabetes (T2D), a chronic disease directly related to insulin resistance resulting from a nutrient-deficient diet. Maintaining a balanced and nutrient-rich diet is essential to promote intestinal health and control glucose levels. A promising approach to enrich the diet and diversify the intestinal microbiota is the inclusion of insects as a sustainable and highly nutritious food source. *Acheta domesticus* (house cricket) has gained attention due to its high protein content and rich amino acid profile. However, their nutritional profile can be further improved. A possible strategy is using microalgae to supplement and enrich the insect diet to improve its nutritional value regarding antioxidant and polyunsaturated fatty acid contents. Microalgae are unicellular organisms with significant commercial potential due to their diverse composition of valuable compounds. In this context, the DiBaN project aims to improve the nutritional profile of *A. domesticus* by incorporating microalgae into the feed and using its extract to develop novel foods proposed to mitigate insulin resistance in patients with T2D. The project will employ strain improvement strategies, such as random mutagenesis (RM), to obtain improved microalgal strains with a nutritional profile rich in bioactive compounds. Specific metabolic inhibitors will be used after RM to increase the selective pressure and screen for cells that grow at sublethal or lethal concentrations for the wildtype. This selection process will also be conducted with fluorescence-activated cell sorting (FACS) and autofluorescent dyes, facilitating the isolation of mutated cells with increased antioxidant capacity. In addition, DiBaN will use a biorefinery process to generate several extracts/streams using high-pressure homogenization and enzymatic hydrolysis to determine which streams will be best for improving the nutritional value of the crickets. At a later stage, the impact of the enriched cricket flour on human health will also be assessed by the DiBaN consortium.

## KEYWORDS
Microalgae, Biorefinery, Food, Production, Feed

# 11062 - COMPARATIVE STUDY OF SEAWEED AND SEAGRASS LIQUID EXTRACTS: EFFECTS ON GERMINATION OF VICIA FABA

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## ABSTRACT
In modern agriculture, biostimulants have emerged as eco-friendly and sustainable alternatives, offering a rich source of bioactive compounds that not only stimulate plant growth and quality but also reduce environmental pollution. This study is focused on examining the effect of Extracts from the green seaweed *Chaetomorpha linum* (CLE and the dead leaves of the mediterranean seagrass *Posidonia oceanica* (PLE on germination of *Vicia Faba*. Experiments were conducted under laboratory conditions. Three extracts concentrations (1%,5% and 10% were tested. Our results demonstrate that both CLE and PLE are rich in biochemical compounds, antioxidants, macronutrients and micronutrients, but low in heavy metals. CLE is characterized by higher amounts of Cl and Fe, as well as N and K, while PLE exhibits high concentrations of P, Mg, and Na. V. Faba seeds Germination, precocity, mean germination time and seedling vigor index were stimulated at low concentration 1% for both CLE and PLE. Growth parameters demonstrate the stimulating effect of CLE on the length of the root and shoot, as well as the number of leaves. At the same time, PLE improved precocity, fresh and dry biomass. Our findings support the use of CLE and PLE as a sustainable substitute to minimize chemical inputs and to improve *Vicia faba* growth. However PLE with its balanced nutrient profile, may be more suitable and safer, especially in conditions where excess salinity is a concern.

## KEYWORDS
Macroalgae, Agriculture

# 11123 - HOLODETECT: AI-ENHANCED DETECTION OF CONTAMINANTS IN CULTURES OF CHLORELLA SOROKINIANA

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## ABSTRACT

The Holodetect HiRes+Fluor3 is an advanced volumetric microscope that integrates digital holographic microscopy with multi-wavelength fluorescence microscopy for automated sample analysis. The instrument integrates artificial intelligence to train deep neural network models for recognition, allowing for real-time contamination assessment. To evaluate the efficiency of Holodetect system, pure *C. sorokiniana* cultures were prepared at a laboratory scale. The initial step involved comparing cell counts obtained using the Neubauer chamber with those generated by the Holodetect system at different concentrations, demonstrating a strong correlation between both methods. The system's detection limit was then assessed, revealing that increasing the number of counted objects from 375 to 1500 reduced the measurement error from 2.3% to 1.5%.

The Holodetect HiRes+Fluor3 system includes an integrated training module and annotation tool, enabling the development of an extensive training database. The training process follows a staged approach, beginning with the manual labelling of a small subset of detected objects. A preliminary model was trained, and its results refined the database by correcting misclassifications. This iterative process gradually builds a large and accurate dataset. This approach was used to develop two classification models. The first model was developed to distinguish *C. sorokiniana* cells from other objects, such as debris, small particles, and potential contaminants. The second model was developed to identify both *C. sorokiniana* and a contaminant, *Haematococcus pluvialis,* as well as debris and small particles. Five different cultures of each microalga were used during the training process in order to capture variability in cell morphology. To validate the models, different mixtures of *C. sorokiniana* and *H. pluvialis* were prepared, ranging from 10% to 90% of *C. sorokiniana*. It was observed that the single-model approach misclassified some contaminants as *C. sorokiniana*, leading to deviations in contamination estimates. In contrast, the combined model, which recognised *H. pluvialis* as separated class, demonstrated a high correlation ($R^2$ = 0.98 between predicted and experimental values. This indicates a high level of accuracy in contamination detection.

These findings highlight the potential of Holodetect HiRes+Fluor3 as a precise and efficient tool for monitoring microalgae cultures in real-time. The incorporation of AI-based classification provides a robust method for the detection and reduction of contamination risk. Furthermore, it optimises quality control processes and supports large-scale industrial applications.

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## KEYWORDS

Microalgae, Production, Algae Market

# 11182 - VALORISING AGRICULTURAL DRAINWATER: MICROALGAL CULTIVATION FOR SUSTAINABLE NUTRIENT RECOVERY AND BIOMASS PRODUCTION

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## ABSTRACT
Agricultural advancements, such as hydroponic systems, have improved crop production but they also generate wastewater with high nutrients levels from fertilizers (drainwater), which represents an ecological challenge. Due to its composition, drainwater can be used for microalgae cultivation, allying nutrient removal and production of biomass which can be valorised for different applications, such as agriculture or aquaculture. In this sense, this study aims to use *Chlorella* sp., isolated from this agriculture byproduct, to evaluate this microalga potential for nitrogen and phosphorus uptake, using either fresh or recirculated drainwater under a daily semi-continuous regime.
In these experiments, 300-L raceway ponds were used to cultivate *Chlorella* sp. using drainwater from a soilless cultivation greenhouse as a nutrient source. Starting at a concentration of 0.6 $g \cdot L^{-1}$ (dry weight), one culture was grown in a semi-continuous cultivation mode, where the concentration was adjusted daily to maintain stable exponential growth. In contrast, the second culture, used as a control, was grown in batch mode. A comparison between batch and semi-continuous cultivation with and without recirculation of the spent drainwater was conducted, assessing biomass productivity, nutrient consumption rates, and the effect of abiotic factors on these parameters. A membrane system was used to harvest the culture in the semi-continuous regime. The permeate water was discharged if nutrient levels dropped below the legal limits of 10 mg/L of nitrogen and 0.7 mg/L of phosphorus. Above these values, drainwater was either mixed with the fresh-drainwater reservoir or fully recirculated into the raceway pond. Algal growth was measured through optical density (spectrophotometry), cell counting (microscopy) and dry weight measurements (gravimetry), and the cell's physiological state was attained through chlorophyll *a* fluorescence. Nitrogen and phosphorus concentrations were assessed by spectrophotometry and a multiparameter analyzer with a continuous segmented flux (San Plus, Skalar Analytical B.V., Netherlands). During these trials, a new sensor, developed by OnePlanet Research Center, was tested to analyse microalgal growth and nitrogen and phosphorus concentrations in real-time. Abiotic conditions parameters such as light, temperature and rain were also collected. The preliminary trial grown in batch mode, the culture achieved a productivity of 0.11±0.01 $g \cdot L^{-1} \cdot d^{-1}$, when the dry weight ranged from 0.7 to 1.1 $g \cdot L^{-1}$ – during the exponential growth phase. During this period, *Chlorella* sp. exhibited a nitrogen consumption rate of 20.7 mg N·g $biomass^{-1} \cdot d^{-1}$ and phosphorus consumption of 15.9 mg P·g $biomass^{-1} \cdot d^{-1}$. These data were then used to optimise conditions for the semi-continuous cultivation mode, in which the culture achieved a productivity of 0.32±0.19 $g \cdot L^{-1} \cdot d^{-1}$.

The results of this work have the potential to reduce microalgal production costs in the scope of the REALM project.

## KEYWORDS
Agriculture, Environmental solutions/ Circular Economy, Microalgae

# 11183 - ENHANCING ANTIOXIDANT CAPACITY AND BIOMASS PRODUCTION IN PHAEODACTYLUM TRICORNUTUM THROUGH VITAMIN SUPPLEMENTATION

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## ABSTRACT

Microalgae are increasingly recognized as a sustainable and nutritious source of animal and aquaculture feed, offering a rich composition of proteins, omega-3 fatty acids, and antioxidants (Costa et al., 2022; Dineshbabu et al., 2019). These microorganisms contain bioactive compounds, including carotenoids, phenolic substances, and essential vitamins such as C and E, which significantly contribute to their antioxidant capacity (Goiris et al., 2012). The antioxidant activity of microalgae is species-specific and influenced by growth conditions and extraction methods (Goiris et al., 2012; Mavrommatis et al., 2023).

Among microalgae, *Phaeodactylum tricornutum*, a marine diatom, has gained attention for its high antioxidant content, particularly fucoxanthin, known for its strong antioxidant and antiproliferative properties (Smeriglio et al., 2023; Neumann et al., 2019). Vitamins C and E are key antioxidants in *P. tricornutum*, with vitamin C (ascorbic acid) scavenging reactive oxygen species (ROS) and vitamin E (α-tocopherol) preventing lipid peroxidation in cell membranes. Optimizing culture conditions to enhance the synthesis of these compounds is essential to maximize their potential for industrial applications.

This study explored the effects of vitamin supplementation on the growth and antioxidant properties of *P. tricornutum*. Cultures were obtained from Greencolab at the University of Algarve and grown in standard algal medium (control) and medium supplemented with either ascorbic acid (vitamin C) or α-tocopherol acetate (vitamin E) at varying concentrations. For vitamin C, concentrations ranged from 0.5 to 20 mg·L$^{-1}$, while for vitamin E, concentrations ranged from 2 to 10 mg·L$^{-1}$. Triplicate cultures (800 ml) for each concentration were incubated for 10 days at 25 ± 2°C under continuous illumination (2,500 lux) in sterile conditions, with vitamins sterilized using Millipore filtration.

The preliminary results showed that vitamin supplementation had a significant effect on the growth rates of *Phaeodactylum tricornutum*. The highest specific growth rate (SGR) for vitamin C was recorded at 0.5 mg·L$^{-1}$ (0.14 day$^{-1}$), while the optimal concentration for vitamin E was 8 mg·L$^{-1}$ (0.18 day$^{-1}$). These findings indicate a possible link between enhanced algal growth and increased antioxidant production. This suggests that strategic vitamin supplementation can effectively improve both biomass yield and antioxidant capacity in *P. tricornutum*, enhancing its potential applications in the nutraceutical, cosmeceutical, and animal feed industries.

This work highlights the value of *P. tricornutum* as a sustainable and nutrient-rich source, particularly due to its ability to produce bioactive compounds such as fucoxanthin, vitamins, and antioxidants. By optimizing culture conditions, it is possible to enhance the functional properties of microalgae, supporting sustainable animal production practices and advancing biotechnological innovations (Mavrommatis et al., 2023).

## KEYWORDS

Microalgae, Production, Feed, Food

# 11197 - ADAPTATION OF SPIRULINA SP. LEB 18 TO HETEROTROPHIC CULTIVATION

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## ABSTRACT

*Spirulina* is a microalga widely valued for its high protein content and the presence of high-value compounds such as phycobiliproteins, polyunsaturated fatty acids, and vitamins. Heterotrophic cultivation is a strategy employed to redirect cellular metabolism, promoting the accumulation of bioactive compound. As the cultivation of this microalga is commonly conducted under photoautotrophic conditions, the transition to heterotrophic cultivation requires adequate time and supplementation to prevent cellular stress and the sudden reduction of photosynthetic activity. In this context, the gradual reduction of light intensity, combined with the supplementation of nutrients such as glucose and nitrates, can optimize the adaptation process of *Spirulina* cells, enhancing metabolic efficiency and the quality of the biomass obtained. The objective of the present study was to gradually adapt *Spirulina* sp. LEB 18 to heterotrophic cultivation through the gradual reduction of light intensity combined with the supplementation of glucose and nitrates, in a fed-batch cultivation mode. The cultivation of *Spirulina* sp. LEB 18 was carried out in flasks with a working volume of 400 mL, aerated with sterile air injection, and maintained at 30 ± 2ºC for 100 days. The experiments were conducted in Zarrouk medium, replacing the inorganic carbon source with glucose, which was fed in batches every two days, with the added concentration adjusted weekly until 10 g $L^{-1}$. A control cultivation was performed using standard Zarrouk medium. The cultures were subjected to variations in light intensity, starting at a photon flux of 100 $\mu mol_{photons}$ $m^{-2}$ $s^{-1}$ for 14 days. Subsequently, the light intensity was reduced weekly until the cultures were kept in complete darkness. During light reduction, nitrate ($NaNO_3$) supplementation was provided every three days, starting at 1.0 g $L^{-1}$ and increasing to 2.5 g $L^{-1}$. The evaluated parameters included maximum growth ($X_{máx}$), maximum productivity ($P_{máx}$), maximum specific growth rate ($\mu_{máx}$), glucose and nitrate consumption, and phycocyanin concentration. All experiments were conducted in duplicate. Preliminary results, after 60 days, showed kinetic parameters for the control and supplemented experiments of, respectively: $X_{máx}$, 1.58 ± 0.64 g $L^{-1}$ and 2.99 ± 0.82 g $L^{-1}$; $P_{máx}$, 0.06 ± 0.01 g $L^{-1}$ $d^{-1}$ and 0.10 ± 0.02 g $L^{-1}$ $d^{-1}$; and $\mu_{máx}$, 0.05 ± 0.01 $d^{-1}$ and 0.07 ± 0.03 $d^{-1}$. As expected, light reduction contributed to glucose and nitrate consumption, cellular growth, and changes in culture color. The control cultures were affected by the absence of an organic carbon source for their development. With the gradual reduction of light, it is anticipated that the phycocyanin concentration will decrease compared to higher light conditions. In conclusion, the gradual reduction of light intensity, combined with glucose and nitrate supplementation, positively influenced the adaptation of *Spirulina* sp. LEB 18 to heterotrophic cultivation.

## KEYWORDS

Microalgae, Production, Environmental solutions/ Circular Economy

# 11212 - OPTIMIZATION OF CRYOPRESERVATION METHODS FOR HARMFUL BIOLOGICAL CONTAMINANTS OF ARTHROSPIRA PLATENSIS AND NANNOCHLOROPSIS OCEANICA

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## ABSTRACT
The microalgae production industry has grown significantly over the past decade due to its potential to address food shortages and environmental challenges. However, culture collapse in industrial microalgal cultures remains a major issue, leading to significant economic losses. One of the primary causes is contamination by harmful biological contaminants (HBCs), which can destroy cultures within days. Understanding the biology of these contaminants is crucial for developing early detection methods and implementing mitigation strategies. However, maintaining and preserving HBCs at a laboratory scale remains challenging, with limited information on optimal storage methods.
Cryopreservation for obligate pathogens has been practised for years, with preservation alongside their host. The first challenge is preparing cells for freezing, as ice crystal formation can damage cellular structures. Cryoprotectants such as dimethyl sulfoxide (DMSO) and glycerol are used, to maintain low toxicity. Factors such as sample volume, cell type and cryoprotectant concentration must be optimized for each target. Despite the importance of cryopreservation, finding a protocol that fits all cell organisms is not possible. Tailor-made protocols are necessary for specific taxa and cell types.
Industrial cultures of *Arthrospira platensis* and *Nannochloropsis oceanica* have recently suffered rapid collapse due to unknown parasitic fungi. To develop effective mitigation strategies, molecular and biological characterization of these HBCs is essential. To facilitate long-term study, a protocol to cryopreserve contaminated cultures at -80°C is being developed. This method will ensure the viability, storage, and purity of HBCs without the need for continuous subculturing.
Contaminated microalgal cultures were grown to optimal concentrations (highest contamination levels), and different glycerol concentrations (5–40%) were tested in a 1:1 ratio. Two control groups were included: one with contaminated cultures without glycerol and another with healthy microalgal cultures exposed to the same glycerol concentrations as the contaminated ones. Aliquots of 1 mL were cooled at a controlled rate (-1°C $min^{-1}$) until -80°C. After one week, samples were thawed in a dry bath at 20-25°C for five minutes. Cells were then transferred to a fresh medium, centrifuged to remove glycerol residues and incubated at 22°C under continuous light and agitation. Daily microscopic analysis was conducted to monitor HBC development.
Preliminary results suggest that glycerol concentration, freezing rate, and thawing conditions play crucial roles in maintaining HBC viability. By refining these methods, this research will contribute to a better understanding of HBC biology and facilitate the development of early detection and control strategies, ultimately improving the resilience of microalgae production systems.

## KEYWORDS
Microalgae, Production

# 11219 - INDUSTRIAL BIOTECHNOLOGY ALGAL BANK (IBAB): PROMOTING EFFICIENT AND FAST NOVEL SOLUTIONS FOR INDUSTRIAL PRODUCTION CULTIVATION

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## ABSTRACT
The field of biotechnology has witnessed a remarkable increase in the cultivation of both macro- and microalgae in the last decades. With the increase of new algal varieties as food and the uncovering of valuable traits in previously unexplored species, the sector is anticipated to continue expanding significantly. In response, GreenCoLab has spearheaded the innovation of microalgae culture collections, guaranteeing that collaborating firms can obtain strains prepared for large-scale production as fast as possible. We concentrate on delivering optimal environments and growth media for each species, encompassing growth enhancement and process optimization for innovative biomass strains. Using a pipeline going through the solid algal stocks to on-time maintenance of strains ready to scale up production, decreasing the time of a restart production from months to days. Our offerings comprise the prospection for novel strains, strain extraction, strain re-isolation, taxonomic classification, phylogenetic analysis, creation of new strains via adaptive laboratory evolution or random mutagenesis, biochemical assessment of yielded biomass, and topnotch optical imaging data gathering. To assure the survival and purity of all strains, we employ a dual-layered safeguarding approach, utilizing the Nagoya protocol as a framework for data monitoring and handling. Additionally, we ensure the security of sensitive information. Our facilities can accommodate over 100 independently operating 1L bioreactors, along with the capacity to scale up to 100L cultures for select strains. The operation system is constantly on improvement to facilitate information gathering as automatic control of abiotic factors and data collection. Currently, facilities are on the way to improvement on the better ideals as well as a new platform of information availability, through the participation in the national project Biobanco Azul Portugues, which will comprise and disponibilize necessary information for the partners as updated state of the cultures as well as genetic information and best production parameters for each strain.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Microalgae, Production

# 11225 - POLYSACCHARIDES FROM MARINE RESOURCES: VERSATILE COMPOUNDS FOR BIOMEDICAL AND FOOD APPLICATIONS

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## ABSTRACT
In recent years, polysaccharides from marine environments emerged as a new class of renewable and functional molecules. Particularly negatively charged ones have gained significant attention for their diverse biological properties. These compounds exhibit important bioactivities, including anticoagulant, antiviral, immunomodulatory, and anti-inflammatory effects. However, the structural characterization of these polysaccharides and their relationship to biological functions remains limited. Advancing this knowledge is crucial for their valorization.
This study focuses on the structural analysis of water-soluble polysaccharides extracted from various seaweed and microalgae. The immunostimulatory properties of purified polysaccharides were evaluated to assess their potential applications. Polysaccharides from brown seaweed (*Saccharina latissima*) and microalgae species (*Nannochloropsis oculata*, *Chlorella vulgaris*, and *Porphyridium purpureum*) were extracted using hot water and fractionated via ethanol precipitation and/or anion-exchange chromatography. Fucose-containing sulfated polysaccharides from *S. latissima* were rich in uronic acids, fucose, and galactose. Water-soluble polysaccharides from *N. oculata* consisted of mixed-linked (β1→3, β1→4)-glucans, (α1→3)- and (α1→4)-mannans, as well as anionic sulfated heterorhamnans. In *C. vulgaris*, aside from starch (the predominant polysaccharide), a sulfated galactan exopolysaccharide was identified. *P. purpureum* was found to be rich in floridean starch and capable of excreting sulfated polysaccharides, specifically glucuronoglucogalactoxylan. The sulfated polysaccharides from brown seaweed, and exopolysaccharides from *N. oculata*, *C. vulgaris*, and *P. purpureum* demonstrated the ability to stimulate murine B-lymphocytes *in vitro*, with sulfate esters playing a key role in this activity.
This highlights the great potential of using the marine environment as a source of sulfated polysaccharides that can be used as functional ingredients in food products and for biomedical applications.

## ACKNOWLEDGMENTS/FUNDING
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## KEYWORDS
Microalgae, Macroalgae, Biorefinery, Food

# 11240 - COLORIMETRIC ASSAY KIT FOR EARLY DETECTION OF EUKARYOTIC CONTAMINANTS. CLEAN CULTURE KIT FOR DETECTION OF PARAPHYSOMONAS SP.

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## ABSTRACT
The cultivation of microalgae holds great potential for producing high-value compounds, yet it faces significant challenges that impact efficiency and profitability. Culture collapse, often caused by biological contamination, leads to substantial biomass losses and reduced production quality, threatening the economic viability of large-scale algal cultivation. Grazers pose the greatest threat among contaminants, actively feeding on microalgae and forming resilient cysts that enable their persistence under unfavourable conditions. Identifying harmful contaminants capable of causing culture collapse within days is crucial for mitigating these risks.
Current detection methods rely heavily on microscopic observation by skilled personnel, while molecular techniques such as PCR and qPCR, though effective, remain costly and impractical for industrial-scale facilities. A combination of molecular and phylogenetic analyses, alongside persistent microscopic monitoring, provides a robust approach to identifying and understanding the life cycle of harmful contaminants under controlled conditions.
*Tisochrysis lutea* a seawater haptophyte with photo- and mixotrophic growth capabilities, is a valuable microalga widely used in aquaculture and cosmetics due to its rich composition of high-value biocompounds, including polyunsaturated fatty acids (PUFAs), fucoxanthin, and chlorophylls. Nevertheless, the "golden alga" Paraphysomonas (Chrysophyceae) can cause the culture collapse of *T. lutea* cultures in large-scale production facilities.

In this context, developing a rapid detection kit for *Paraphysomonas* sp. offers a practical solution to mitigate culture losses in industrial microalgae production when the contaminant is detected on time. Early detection techniques, such as colourimetric kits, provide user-friendly tools for routine monitoring, enhancing culture stability and improving overall productivity. These advancements are critical for ensuring the sustainable and profitable cultivation of microalgae at an industrial scale and reducing economic losses.

## KEYWORDS
Microalgae, Algae Market, Production

# 11241 - ALGAE AND PUBLIC PERCEPTION IN PORTUGAL: A SURVEY-BASED ANALYSIS

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## ABSTRACT

Between November 29, 2024, and January 6, 2025, a total of 3,018 interviews were conducted with Portuguese individuals aged between 18 and 65 years. The research employed a quantitative mixed-methods approach, integrating both online questionnaires (via the CAWI system - Computer Assisted Web Interviewing) and face-to-face interviews (through the CAPI system - Computer Assisted Personal Interviewing).

The primary goal of this study was to evaluate public awareness, consumption behaviors, and perceptions concerning algae and algae-derived products. The research aimed to determine the main sources of information on algae, identify consumer preferences, and explore perceived advantages of algae consumption, alongside assessing opinions on algae farming as an environmentally friendly practice.

The most common sources of information on the topic “algae” are the Internet and social media, particularly in relation to human nutrition, dietary supplementation, coastal environments, and sectors like cosmetics, pharmaceuticals, and health.

Most participants reported having consumed algae-based foods and being familiar with certain species, with Spirulina and Sea Lettuce as the most well-known. When purchasing algae-related products, buyers highlight characteristics such as quality, price, and product origin. Supermarkets, as well as specialized dietetic, herbalist, organic, and vegan stores, were recognized as the most accessible points of sale.

A significant proportion of respondents recognized the functional properties of algae consumption, particularly its benefits for immune system enhancement and digestive health. However, over 36% of those surveyed were unaware of any notable nutritional attributes associated with algae. Furthermore, 75% of participants considered algae farming to be a sustainable practice with environmental benefits, while nearly 90% recognized the importance of algae for maintaining aquatic ecosystem balance. Despite this level of awareness, the majority of respondents could not identify any specific brands of algae-based products or local algae producers in Portugal.

Given Portugal’s role within the European algae strategy, it is critical to enhance public knowledge regarding algae-related products, local businesses, and the broader research developments taking place in the country.

## ACKNOWLEDGMENTS

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## KEYWORDS

Algae Market, Microalgae, Macroalgae, Food

# 11261 - ENHANCING MICROALGAE FOR IMPROVED PRODUCTIVITY OF LIPOPHILIC COMPOUNDS

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## ABSTRACT
Microalgae are highly valuable renewable resources, known for their ability to produce a wide range of bioactive compounds with applications in the food, feed, and pharmaceutical industries. Their rich nutritional composition and environmental benefits, such as their role in agriculture and bioremediation, make them an essential component of sustainable biotechnology. However, large-scale microalgae cultivation is often hindered by challenges in maximizing biomass production and compound yield. A promising strategy to overcome these limitations involves random mutagenesis, which, when combined with selective screening and optimized growth conditions, enables the development of enhanced strains. This approach is cost-effective and efficient, allowing for genetic improvements without introducing foreign DNA. Moreover, random mutagenesis accelerates genetic variation, facilitating the discovery of beneficial traits and improving biochemical productivity. In this study, microalgal strain 61 from the Algae4IBD collection was cultivated under exponential growth conditions and subjected to ethyl methanesulfonate (EMS) mutagenesis at concentrations of 200 and 250 mM, resulting in survival rates of 8.9% and 7.3%, respectively. The resulting mutants were screened using two different inhibitors targeting lipid biosynthetic pathways, applying sublethal concentrations based on the wild-type strain's tolerance. Stable, inhibitor-resistant strains were subsequently cultured in liquid media to assess their lipid productivity in comparison to the wild-type. To identify and isolate strains with enhanced lipid accumulation, Bodipy 505/515 staining combined with flow cytometry was employed. Additionally, growth parameters were optimized to further enhance lipid productivity.
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## KEYWORDS
Microalgae, Algae Market, Supplements and cosmetics

# 11262 - DEVELOPMENT OF A PORTABLE OPTICAL DENSITY SENSOR FOR MICROALGAE BIOMASS MONITORING

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## ABSTRACT
Microalgae are promising resources for many applications, such as food and feed ingredients, cosmetics, and pharmaceuticals due to their excellent biochemical composition, including pigments, lipids, and omega-3 fatty acids. Microalgae cultivation requires precise monitoring of biomass concentration to optimize growth conditions and improve production efficiency. Traditional biomass estimation methods, such as dry weight measurements, are labour-intensive, time-consuming, and often disruptive to the culture. To address this, an optical density (OD) sensor has been developed for continuous in situ monitoring of microalgae growth. Currently in its final phase of development, undergoing testing and validation, this sensor establishes a robust correlation between OD values and dry weight for a list of tested microalgal strains, allowing for non-invasive and quick biomass assessment.
The system features a tailored OD sensor capable of real-time OD measurements up to 6 g $L^{-1}$ for Nannochloropsis oceanica and Phaeodactylum tricornutum. As the final validation steps are completed, the sensor is being refined to ensure reliability and accuracy across different cultivation conditions. One of the key advantages of this device is its portability, which makes it highly versatile and suitable for a wide range of applications, from small-scale laboratory experiments to large-scale outdoor photobioreactor cultivation setups. This device allows researchers and producers to monitor biomass growth in real-time across different cultivation environments, significantly reducing manual labor and simplifying culture monitoring control.

## KEYWORDS
Microalgae, Culture Monitoring, Optical-Density Sensor, Dry-Weight, Culture Concentration Monitoring, Production

## ACKNOWLEDGEMENTS
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# 11267 - ERGEVA: A CIRCULAR ECONOMY MODEL INTEGRATING AGRI-VOLTAICS, MICROALGAE PRODUCTION, AND AGRO-INDUSTRIAL SYNERGIES

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## ABSTRACT

The global algae market is valued at $3.5 billion, with an annual growth rate of 6% (1) ) global market insight 12/2022. Despite this promising expansion, several challenges impede its full potential. In Italy, where domestic production meets only 13% of the national biomass demand (2) agronotizie 08/2022, various barriers—including complex regulations, lengthy certification processes, limited funding opportunities, and low consumer awareness—continue to hinder industry development (3) EU commission : Towards a Strong and Sustainable EU Algae Sector 11/2022

One of the primary obstacles in algae biotechnology is the underdeveloped supply chain, which limits scalability and commercialization. Ergeva aims to bridge this gap by fostering an integrated framework that connects microalgae production with sustainable value chains. This approach ensures consistent quality, enhances scalability, and facilitates broader market accessibility by strengthening collaboration among stakeholders.

To support innovation, Ergeva provides a dedicated space for developing and testing novel technologies, addressing the common hurdles of inadequate infrastructure, technical expertise, and financial resources. Serving as a hub for start-ups, researchers, and industry professionals, Ergeva accelerates technological advancements and provides a robust environment for practical implementation. The involvement of an experienced engineering company further ensures that these innovations progress efficiently from concept to market-ready solutions.

Additionally, Ergeva takes a comprehensive approach to overcoming financial challenges. By fostering strong connections among corporations, investment funds, and individual investors, the initiative bridges the funding gap that often limits new ventures. This collaborative model ensures that promising algae-based technologies receive the necessary support to scale effectively, fostering a sustainable and resilient innovation ecosystem.

Microalgae production is central to Ergeva's mission. The project includes a pilot facility dedicated to cultivating and processing microalgae for high-value bioactive compounds. This initiative aligns with the growing demand for sustainable bioproducts in sectors such as nutraceuticals, cosmetics, and biofuels. Additionally, the integration of microalgae cultivation within the broader agro-industrial system maximizes resource efficiency, utilizing CO2 from fermentation processes and recycling nutrients from agricultural byproducts.

Beyond microalgae production, Ergeva encompasses several interconnected projects:

- Development of an agri-voltaic park to achieve energy self-sufficiency while optimizing land use.
- Creation of a supply chain for beer production, leveraging locally cultivated raw materials.
- Implementation of a test field for underground pipeline protection systems, focusing on cathodic protection and advanced coatings.

## KEYWORDS

Microalgae, Environmental solutions/ Circular Economy, Production, Agriculture

# 11281 - SEAWEED-DERIVED BIOPLASTICS: HOW AGAR EXTRACTION AFFECTS PERFORMANCE

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**ABSTRACT**

Plastic pollution is one of today's most pressing environmental challenges (Herberz et al., 2020). Biodegradable bioplastics have emerged as a sustainable alternative, with seaweed-based materials standing out due to the abundance of seaweed biomass and its non-competition with land-based crops. However, one of the biggest obstacles to large-scale market adoption of this class of material is cost, which is mostly influenced by the high price of highly refined polysaccharide fractions currently available in the market that are used for the bioplastic production (Döhler et al., 2022).

This study explores bioplastic production using different types of agar, a polysaccharide extracted from *Gracilaria*. The agar was firstly extracted and then used to make bioplastic films: its mechanical properties were evaluated and compared to those obtained using commercial agar (highly refined agar). Two types of extraction methods were explored, native (without further purification, low refined agar) and alkali (refined agar) extraction, using both a conventional water bath and an autoclave. Results showed that performing a native autoclave extraction reduces processing time by fourfold compared to conventional alkali pre-treated water bath extraction. On the other hand, having an alkali pre-treatment decreased the yield from 20-25% to 5-10%. The mechanical properties of the commercial agar were generally higher than the low-refined agar, which in turn showed higher elongation at break. Finally the combination of commercial and low-refined agar was tested as an interesting approach for reducing production costs while achieving the best tradeoff in terms of mechanical properties.

# 11276 - PURIFAE – MODULAR BIOREACTOR FOR MICROALGAE CULTIVATION FABRICATED WITH ADDITIVE MANUFACTURING TECHNIQUES

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## ABSTRACT
The increasing demand for eco-friendly raw materials in industries like biofuels, biogas, cosmetics, and pharmaceuticals has heightened interest in microalgae [1,2]. However, existing bioreactors face issues such as low efficiency, high operational costs, and maintenance difficulties. Key challenges include optimizing light exposure, $CO_2$ and nutrient delivery, biomass harvesting, and system cleanliness [3,4,5].

The Purifae project tackles these issues by developing a modular photobioreactor in flat and tube-in-tube designs. Created using CAD software (Fusion 360, Autodesk, USA) and 3D-printed with biodegradable polylactic acid, this system allows scalability, efficient biomass and gas circulation, and improved microalgae cultivation.

Future work will optimize growth conditions, focusing on nutrient and $CO_2$ levels, light intensity, and the effects of different growth media on biomass yield. Tests will use Chlorella vulgaris, a widely used microalgae species for biomass production.

This research contributes to more efficient and sustainable microalgae biomass production, addressing key challenges in modern biotechnology.

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## KEYWORDS
Microalgae, bioreactor, 3D Printing

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# 11287 - BIOSYNTHESIS OF ORGANIC MATTERS AND EXTRACELLULAR POLYSACCHARIDES IN SPIRULINA PLATENSIS AND THEIR INTRINSIC METABOLIC REGULATORY MECHANISMS

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## ABSTRACT
Extracellular polysaccharides (EPS) produced by *Spirulina platensis (S. platensis)* are highly valued in industrial applications due to their diverse biological activities, yet their accumulation in the culture medium can inhibit algal growth through metabolic imbalances. Semicontinuous culture systems, which involve reusing the culture medium for sustainable cultivation, could minimize freshwater and nutrient, thus reducing production costs significantly. Recycling the culture medium enhances EPS yield but concurrently reduces biomass production, with high pH and salt stress conditions promoting EPS secretion while suppressing growth. The impact of nitrogen and phosphate concentrations is also critical: excessive or insufficient levels hinder biomass production, whereas optimal concentrations support elevated EPS yields. Mechanistically, the accumulation of EPS and organic matters (OMs) in the reused medium induces oxidative stress, disrupting key metabolic pathways such as protein synthesis and photosynthetic efficiency. However, EPS and OMs act as adaptive stress responses, increasing polyphenol production, enhancing chlorophyll content, and improving cellular viability by mitigating oxidative damage. These findings suggest that, while EPS accumulation under certain conditions inhibits growth, careful regulation of medium components can optimize EPS production without compromising biomass yield, providing a pathway for cost-effective and high-efficiency EPS production through controlled recycling and nutrient management. Future research should focus on mitigating the inhibitory effects of residual organic matters, and further optimizing culture conditions to balance EPS yield with biomass production. Additionally, exploring genetic and metabolic engineering strategies could enhance the adaptive response of *S. platensis*, unlocking new potentials for large-scale, sustainable EPS production.

## ACKNOWLEDGMENTS/FUNDING
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## KEYWORDS
Abiotic stress; Resource allocation; Extracellular polysaccharides; Growth inhibition; Semicontinuous culture systems

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1st INTERNATIONAL CONGRESS ON ALGAE BIOTECHNOLOGY

## POSTER SESSION

# SPECIAL SESSION: ALGAE VERTICAL PROJECT

# 10909 - UNVEILING SEASONAL SHIFTS OF LIPID CONTENT AND FATTY ACIDS PROFILE OF OUTDOOR CULTIVATED SPIRULINA (LIMNOSPIRA PLATENSIS) AND MICROCHLOROPSIS GADITANA

Authors
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## ABSTRACT
Microalgae are increasingly valued as sustainable bioresources for food, feed, cosmetics, and pharmaceuticals due to their nutrient-rich biomass and bioactive compounds. *Spirulina (Limnospira platensis*) and *Microchloropsis gaditana* stand out for their biochemical profiles, particularly their lipid and fatty acid (FA) composition, with application in functional foods and nutraceuticals. Spirulina is notable for its essential FA content, such as linoleic acid (FA 18:2 *n*-6), while *M. gaditana* is a rich source of omega-3 polyunsaturated fatty acids (PUFA), including eicosapentaenoic acid (EPA, FA 20:5 *n*-3).
These microalgae could be cultivated in open raceways ponds (RP) and close photobioreactors (PBR). However, the cultivation systems face challenges, particularly with seasonal variations of temperature and light. These environmental changes affect biomass production and lipid biosynthesis, but the extent and implications of the biochemical variations remain underexplored. This study monitored the lipid content and FA profiles of Spirulina (ALLMICROALGAE - Natural Products, SA, Pataias, Portugal) cultivated in RP, and *M. gaditana* (Necton SA, Faro, Portugal) cultivated in PBR under uncontrolled environmental conditions during spring, summer, autumn, and winter.
Spirulina's lipid content showed minor seasonal variations (4.6%–9.5%), with the highest in spring (9.5%) and lowest in winter (4.6%). The FA profile was dominated by FA 16:0, FA 18:2*n*-6, and FA 18:3*n*-6. Saturated fatty acids (SFA), such as FA 16:0, peaked in autumn (13.9 ± 0.2 mg FA $g^{-1}$ biomass) and declined in winter (4.6 ± 0.5 mg FA $g^{-1}$ biomass). PUFA levels were lowest in winter (2.5± 0.4 mg FA $g^{-1}$ biomass for FA 18:2*n*-6) and higher in other seasons.
*M. gaditana* exhibited a peak lipid content in autumn (21.7%), followed by a decline in winter (18.9%) and stabilization in spring and summer (15.9%). The FA profile was dominated by FA 16:0, FA 16:1*n*-7, and FA 20:5*n*-3. Seasonal trends showed MUFA and PUFA, such as FA 16:1*n*-7 and FA 20:5*n*-3, peaking in autumn and winter, with levels declining in spring and summer. For instance, FA 20:5*n*-3 reached 33.5 ± 7.5 mg FA $g^{-1}$ biomass in autumn and 31.6 ± 3.7 mg FA $g^{-1}$ biomass in winter, compared to 20.5 ± 2.5 mg FA $g^{-1}$ biomass in spring and 11.4 ± 1.2 mg FA $g^{-1}$ biomass in summer.
These results underscore the impact of seasonal variations on the lipid content and FA profiles of *Spirulina* and *M. gaditana*, highlighting their metabolic plasticity and the impact of seasonal fluctuations for selective harvesting during peak production periods for desired compounds, thereby maximizing productivity and economic efficiency.

## KEYWORDS
Microalgae, Food, Feed, Algae Market

# 10933 - UNRAVELING THE CULTIVABLE MICROBIOME OF MACROALGAE: SEASONAL INSIGHTS FROM INTEGRATED MULTI-TROPHIC AQUACULTURE SYSTEMS AND NATURAL HABITATS

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## ABSTRACT
Seaweed-associated microbial communities play an important role in host growth, development, and health. These symbiotic interactions are primarily shaped by host species and geography, while environmental factors such as seasonality and the life cycle of the host organism can further influence the composition of the associated bacterial communities. To fully harness the potential of these microbes, their function and capacity need to be identified. Moreover, in order to experimentally test their relationship with the seaweed host and to industrially apply them, we need to be able to cultivate them first. The present study aims to isolate and characterize the cultivable microbiome of the macroalgal genera *Ulva*, *Codium*, *Gelidium*, and *Laminaria* in Portugal. We assessed the diversity and composition dynamics of their cultivable associated microbial communities from natural habitats and Integrated Multi-Trophic Aquaculture (IMTA) systems across different seasons. To achieve this, microbes associated with wild and cultivated seaweeds from the IMTA systems at the seaweed producer ALGAplus and the Ramalhete Marine Station of CCMAR were seasonally isolated using different culture media. Environmental reference control samples were collected from natural and tank seawater, inlet water, and sediment, while physical parameters were measured *in situ*. Regarding fungi, the isolates were obtained either by directly plating the macroalgal tissue on selective media amended with antibiotics, or indirectly using leaf baits. Subsequently, the culturable microbial strains were identified to the lowest taxonomic level through full 16S rRNA / ITS gene amplicon Sanger sequencing, and the total community was analysed through Illumina MiSeq technology. Through this process, a cutting-edge biobank of more than 500 isolated bacteria and 68 fungi from all macroalgal species was created. The collection includes various strains with potential growth-promoting capacity and high-value metabolites. Our findings indicate a diverse range of bacterial communities associated with seaweed across cultivated and wild habitats, as well as in distinct culture media. Beneficial microbes such as *Cobetia*, *Pseudoalteromonas*, *Pseudomonas*, *Sulfitobacter*, *Ruegeria*, and *Roseovarius* were identified among others. High throughput sequencing will elucidate us about the non-culturable part of the microbiome and unveil the biotechnological potential of the whole community. The outcomes of this study are promising for advancing seaweed research and further biotechnological applications of seaweeds in various fields.

## ACKNOWLEDGEMENTS
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## KEYWORDS
Macroalgae, Production, Environmental solutions/ Circular Economy, Algae Market

# 10945 - EVALUATING THE STABILITY OF LIPIDS AND CARBOHYDRATES DURING THE SHELF LIFE OF ULVA SP., FUCUS VESICULOSUS, AND PORPHYRA DIOCA

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## ABSTRACT

Seaweed consumption in Europe has been increasing due to growing awareness of its nutritional value and potential health benefits. They are a rich source of bioactive compounds, driving their applications in food, nutraceuticals, cosmetics and pharmaceuticals. However, the biochemical composition of seaweed can be affected during storage by influence of factors as temperature, moisture, and light exposure.

The aim of this study was to evaluate the shelf life, after package opening, of three seaweed species - *Ulva* sp., *Fucus vesiculosus* and *Porphyra dioca*. For each species, dried biomass was analysed for the lipid content (determined by gravimetry of the Folch extract), the profile of esterified fatty acids (FA) (by GC-MS) and sugar composition (by GC-FID of neutral sugars and determination of uronic acids by colorimetry). Samples were taken from a single package on the production date and after 1, 3 and 6 months of storage at room temperature, protected from light. Lipids accounted for 1.3-2.4% in *Ulva* sp. biomass, 0.8-2.5% in F. *vesiculosus* and 1.0-1.4% *P. dioca*. For the three species, a slight decrease in the content of esterified FA was observed over the storage time. This decrease was mainly observed after 6 months of storage in the content of polyunsaturated fatty acids (PUFA), namely FA 18:4*n*-3 in *Ulva* sp., FA 20:4*n*-6 in F. *vesiculosus* and FA 20:5*n*-3 in *P. dioca*. Probably, there was a release of FA from the complex lipids and formation of free FA. The biomass of *Ulva* sp. presented 25.3-26.8% of total sugars, primarily consisting of uronic acids and glucose. In *F. vesiculosus*, total sugars ranged from 25.5-28.4%, with uronic acids and fucose as the main components. *P. dioca* exhibited a total sugar content of 27.9-29.2%, predominantly composed of galactose and 3,6-anydrogalactose. No significant differences were found in the carbohydrate composition during storage.

In a package opened and stored at room temperature, the sugar composition of the three seaweed species remained stable during six months and the PUFA only registered a slight decrease. These preliminary results highlight the importance of monitoring specific nutrient variations during shelf life to ensure the quality and nutritional value of seaweed biomass during storage, and, in this case, validating the stability of the processing methods used.

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## KEYWORDS

Macroalgae, Food, Supplements and cosmetics

# 10957 - INFLUENCE OF SEASONAL PRODUCTION OF LIMNOSPIRA PLATENSIS (SPIRULINA) AND MICROCHLOROPSIS GADITANA ON CARBOHYDRATE COMPOSITION

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## ABSTRACT
Carbohydrates play a key role in microalgae as energy sources, structural components, and metabolic intermediates. Under stress conditions, many microalgae adjust their metabolic pathways, often leading to an increase in sugar production. Large-scale microalgae cultivation encounters seasonal challenges, particularly related to fluctuations in temperature and light, which influence their biochemical composition and, consequently, their value for end-use applications. Nonetheless, the variations in carbohydrate composition under the seasonal changes is not fully elucidated. Bridging these knowledge gap could lead to more effective optimization of microalgae cultivation. In this context, the sugar profile of *M. gaditana* and *Limnospira platensis* (Spirulina) cultivated across different seasons—autumn, winter, spring, and summer—was analyzed to assess the impact of seasonal variations on carbohydrate composition.
Spirulina shows significant variation in total sugar content throughout the year, peaking in winter (52.6 %w/w), five times higher than in spring (10.3 %w/w), indicating a tendency to accumulate carbohydrates under stress. Glucose residues are the predominant constituent (5–48 %w/w), which is associated with the presence of glycogen and 1,3/1,6-linked β-glucans [1] the later known to present bioactive properties. In *M. gaditana*, total carbohydrates varied from 8.7 to 11.6% of dry weight biomass throughout the year, with lower content in winter and higher in summer. Glucose residues were the predominant constituent (5.3–7.9 %w/w), also related to 1,3/1,4-β-glucans [2]. Mannitol, an osmoregulatory compound, was detected, significantly decreasing in summer (0.2 %w/w) compared to spring and autumn (3 %w/w).
These findings highlight the seasonal variability of the polysaccharide's composition of microalgal biomass and underline the need for targeted harvesting to optimize the biomass for value-added applications.

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## KEYWORDS
Microalgae, Production

# 10959 - BIOSURFACTANT AND LIPID PRODUCTION CAPACITY OF YEASTS ASSOCIATED WITH INDUSTRIAL CULTURES OF THE OLEAGINOUS MICROALGAE MICROCHLOROPSIS GADITANA

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## ABSTRACT
The marine oleaginous microalga *Microchloropsis gaditana* is predominantly utilized as feed in aquaculture due to its nutritional value. Moreover, this species exhibits rapid growth and high capacity to thrive in a broad range of environmental conditions. Microbial contamination of microalgae has the potential to decrease the production of biomass and added value bioproducts and, in the worst cases, leads to the collapse of the microalgal culture. However, the mechanisms of algae-microbe interactions are poorly understood and in the case of positive symbiotic interactions, co-cultures can promote algal growth and the synthesis of relevant bioproducts. This study was dedicated to uncovering culturable yeast diversity present during a three-month industrial scale-up cultivation of *M. gaditana* cultivation at Necton S.A. facilities, from 5-L flasks until tubular photobioreactors (max. 27000 L). The 146 yeast isolates obtained were molecularly identified, based on D1/D2 and ITS rDNA regions. Ninety-nine percent of the isolates belong to six species of the phylum Basidiomycota, including four *Rhodotorula* species *(R. diobovata, R. mucilaginosa*, *R. taiwanensis* and *R. sphaerocarpa), Vishniacozyma carnescens* and *Moesziomyces aphidis*. In the phylum Ascomycota, only *Meyerozyma guilliermondii* was identified. The abundance of microalgal culture-associated yeast isolates was found to increase throughout upscaling stages. The yeast populations isolated from microalgal cultures and from the water used to fill the bioreactors share yeast species of phylogenetically close isolates indicating a possible common source. The impressively high percentage of red yeasts isolated (90%) is consistent with the recognized role in yeast photoprotection of carotenoid pigments of high economic value. The screening of 60 yeast isolates for lipid and biosurfactant production revealed that these capacities are common features among the isolated yeast population. Besides the biotechnological potential of the corresponding microbial oils and biosurfactants, that can be produced from renewable and economically viable substrates and residues given the capacity of these yeasts species to catabolize a very wide range of carbon sources, they can also fulfill various physiological roles and provide advantages in natural environments. The roles of biosurfactants include antimicrobial activity, the capacity to regulate microbial attachment/detachment to the surfaces and to increase the bioavailability of hydrophobic nutrients promoting their uptake. These reported roles can contribute, in many ways, to the promising use of yeasts as probiotics in industrial microalgae production.

## KEYWORDS
Microalgae, Environmental solutions/ Circular Economy, Production, Feed

# 10960 - CULTURABLE YEASTS ASSOCIATED WITH INDUSTRIAL CULTURES OF MICROALGAE FOR AQUACULTURE

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**ABSTRACT**
The marine microalgae species *Nannochloropsis oceanica, Tisochrysis lutea* and *Microchloropsis gaditana* are well appreciated in aquaculture due to their nutritional value. Although microbial contamination is one of the main causes of biomass loss, there is a lack of comprehensive knowledge on the mechanisms of algae-microbial interactions and an increasing interest in the use of co-cultures to tackle contamination issues and increase microalgae productivity and product diversity. The diversity of culturable yeast populations associated with the scale-up production of *N. oceanica, T. lutea* and *M. gaditana* at Necton S.A. facilities (Olhão, Portugal) was molecularly characterized in this study, based on D1/D2 and ITS rDNA regions. Microalgae cultures were followed, with the collection of samples since the beginning of the scale-up process, in 5 L flasks, until the end of the bioprocesses, in 18000 and 27000 L photobioreactors (*T. lutea* and *M. gaditana*) or 1000 L flat panels (*N. oceanica*). Most of the yeast isolates obtained from one month cultivation of *N. oceanica* (44) belong to the phylum Ascomycota and to the flavinogenic species (overproduce riboflavin-vitamin B2) *Meyerozyma guilliermondii* (59%). Representing the Basidiomycota phylum, the red yeasts (carotenoid pigments producers) *Rhodotorula mucilaginosa* (14%) and *R. diobovata* (27%) were also isolated. From the two months-*T. lutea* cultivation, 53 isolates were obtained belonging to the phylum Basidiomycota, including three species of the oleaginous genus *Rhodotorula (R. sphaerocarpa* (26%), *R. mucilaginosa* (19%) and *R. diobovata* (8%) ) together with *Vishniacozyma carnescens* (42%)*, Naganishia diffluens* (2%)*, Moesziomyces aphidis* (2%) and *Cystobasidium slooffiae* (2%). As detailed in the abstract by Matos *et al*., the 146 isolates gathered during the 3-months cultivation of *M. gaditana* belong to the species *R. diobovata* (41%)*, R. mucilaginosa* (30%)*, R. taiwanensis* (6%) *and R. sphaerocarpa* (13%) and to *V. carnescens* (3%), *M. aphidis* (6%) and *M. guilliermondii* (1%).The yeast genera isolated in this work from microalgae cultures have also been isolated from marine and estuarine environments. The *Rhodotorula* species were present across the three microalgal cultures examined, especially *R. mucilaginosa* and *R. diobovata,* and other species were common to at least two microalgal cultures. Results suggest that the cultured yeast populations retain some similarity to those found in wild environments, such as the Ria Formosa, where Necton facilities are located and where the water for the bioreactors is collected. Differences registered could be related to the microalgae nature and the climatic conditions of the time of year in which microalgae cultivation occurred. In addition to the promising capabilities described of the isolated yeasts to produce bioproducts of interest, in particular biosurfactants and oils, selected isolates have potential as probiotics in industrial microalgae production.

**KEYWORDS**
Microalgae, Production, Feed

# 10979 - MICROCHLOROPSIS-ASSOCIATED MICROBIOME ALONG A TEMPORAL AND SPATIAL CULTIVATION SCALE

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## ABSTRACT
*Microchloropsis gaditana* is an oleaginous marine microalga, often used in marine biotechnology due to its high lipid contents and high resiliency. However, low-growth rates and collapse of cultures due to biological contamination are some of the constrains faced by their industrial cultivation. The role of the associated microbiome, including potential beneficial interactions, such as vitamin and co-factors exchanges, and inhibition of growth of pathogenic strains, has yet to be elucidated. In this study, with the main goal of identifying growth-promoting or culture collapse-inducing biological drivers, the microbiome-associated with *Microchloropsis gaditana*, along a temporal and spatial cultivation scale, was analyzed. The microbiome (shotgun metagenomics sequencing) was studied for a total of 23 samples, from the initial inoculum of 5 L of microalgae culture (28 days in production) up to a 19-$m^3$ photobioreactor (112 days). A total of 402 high and medium quality bacterial metagenome-assembled genomes (MAGs), dereplicated into 92, were recovered. The MAGs were mostly distributed across Pseudomonadota (*n*=45), Bacteroidota *(n*=26) and Verrucomicrobiota (*n*=9) phyla, including well described marine genera, such as *Marinobacter* and *Muricauda*. Functional annotation of the retrieved MAGs revealed complete biosynthetic pathways for the production of several vitamins and co-factors, including biotin and the growth-limiting cobalamin. Furthermore, the presence of genes encoding for phytohormones, such as auxins and cytokinins, was also inspected. In this study, we provide an overview of the microbiome-associated with the cultivation of the microalgae *Microchloropsis gaditana*, from their taxonomic distribution to their primary and secondary metabolism.
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## KEYWORDS
Microalgae, Production, Biorefinery

# 10984 - UNVEILING THE DIVERSITY AND AUXIN BIOSYNTHESIS CAPACITY OF CULTIVABLE BACTERIA FROM PORPHYRA UMBILICALIS ACROSS ITS AQUACULTURE PRODUCTION CYCLE

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## ABSTRACT
Macroalgae aquaculture has been expanding rapidly due to growing demand for seaweed biomass from a wide range of applications, especially as a food source. However, the industry faces challenges related to productivity, resilience to environmental stresses and sustainability. Bacterial communities coexisting in these systems, often seen as threats, emerge as valuable biological resources that can be manipulated to improve algal farming, owing to their potential to enhance macroalgal growth and resilience to pathogens and other environmental stresses. This study focuses on characterizing culturable, heterotrophic bacteria associated with aquacultured *Porphyra umbilicalis* and assessing their potential to support algal growth. Bacteria were cultivated and isolated from five algal production stages, encompassing the whole life cycle of *P. umbilicalis*. Isolates were identified through 16S rRNA gene sequencing and screened for their capacity to produce auxin, a growth-promoting phytohormone. Clear differences were identified in the cultivable microbiome between the algal developmental stages. The number of Colony Forming Units estimated for *P. umbilicalis* samples from early indoor nursery stages was two to five times higher than that of samples farmed outdoors, representing mature life stages. This suggests a greater abundance of cultivable bacterial cells in early algal development, where production occurs in controlled conditions and with lower sources of bacterial colonisers. Conversely, outdoor production stages exhibited greater diversity of culturable bacteria, likely reflecting a more competitive environment, which may contribute to the verified lower bacterial abundance. A total of 122 bacterial isolates were identified, mostly from the *Pseudomonadota* and *Bacteroidota* phyla, spanning 18 taxonomical families. A microbial shift was observed at the family level, with *Alteromonadaceae*, the most dominant family in early stages, being gradually overtaken in later stages by *Flavobacteraceae*. *Roseobacteraceae* was also highly represented in the collection throughout most of the life cycle. The isolates were classified into over 30 bacterial genera. Some genera, such as *Paraglaciecola*, were present through the whole algal life cycle, while many others appeared to be stage-specific, suggesting a degree of bacterial selection throughout the host's life cycle. Notably, some of these genera, such as *Sulfitobacter* and *Roseovarius*, have been reported to benefit algal growth, health and morphogenesis. In fact, phenotypic screening revealed that over 37% of the preserved isolates in this collection, from all algal life stages, produce auxin, the most prolific producers belonging to the genera *Alteromonas*, *Aliivibrio* and *Yoonia-Loktanella*. Overall, this study uncovers diverse bacterial candidates for improved *P. umbilicalis* farming, offering insights for future co-cultivation experiments and potential application in aquaculture systems.

## KEYWORDS
Macroalgae, Production, Environmental solutions/ Circular Economy, Food

# 10988 - FROM DIVERSITY TO AUXIN BIOSYNTHESIS: HARNESSING CULTIVATABLE BACTERIAL SYMBIONTS OF ATLANTIC NORI (PORPHYRA DIOICA) ACROSS ITS LIFE CYCLE

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**ABSTRACT**
Porphyra is a highly valuable edible red seaweed. However, little is known about the symbiotic relationships in which it participates with different bacteria. These interactions are fundamental for the normal development of the host organism and its ability to defend itself against environmental stresses. In this study, heterotrophic aerobic bacteria associated with the species Porphyra dioica, cultivated at ALGAplus, were isolated and characterised over five stages of development. A collection of 114 isolates was created, including isolates from 19 families and 37 genera. Most of the isolates belonged to the classes Alphaproteobacteria, Gammaproteobacteria and Flavobacteriia, represented by orders such as Rhodobacterales, Alteromonadales and Flavobacteriales. The algae were grown in their first stages indoors in autoclaved seawater. It was therefore important to identify the genera exclusive to these stages. These were dominated by Alteromonas and Paraglaciecola. Bacillus, Maribacter and Roseovarius, previously reported as key agents in morphogenesis in other algae, were also observed. The collection presents a high biodiversity and great potential for discovering new species, especially in the Roseobacteraceae family. In addition, colorimetric assays for auxin (a phytohormone also produced by bacteria biosynthesis were carried out to examine the possible use of the isolates as algal growth promoters in an aquaculture context. The genus with the highest number of auxin producers was Alteromonas, with an average auxin concentration of 50 µg per mL culture broth. Other genera of the Roseobacteraceae and Alteromonadaceae families, and the genus Leucothrix, were also notable auxin producers, with values ranging from 5 µg/mL to 50 µg/mL. This work sheds light on the culturable bacterial community of Porphyra along its life cycle and provides the basis for future co-cultivation experiments that will investigate the growth-promoting effects of selected bacterial isolates on Porphyra.

**KEYWORDS**
Macroalgae, Environmental solutions/ Circular Economy, Food

# 11003 - ENHANCING RICE GROWTH WITH ALGAE-BASED BIOSTIMULANTS: A PATH TO SUSTAINABLE AGRICULTURE

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## ABSTRACT
As the global population is projected to reach nearly 10 billion by 2050, agricultural demand will continue to rise, exacerbating pressures on the sector. Concurrently, climate change and the increasing need for nutritionally balanced products are further intensifying these challenges. Innovative solutions to protect and enhance natural resources are critical, and the use of biostimulants, particularly algae-based ones, is gaining attention for their potential to boost crop production sustainably.
Biostimulants can enhance key processes like nutrient uptake, root development, and tillering. This study aimed to evaluate the biostimulant properties of over 30 microalgae and macroalgae species in rice (*Oryza sativa* var. Caravela) cultivation, focusing on their effects during early seedling development. Marked by active tillering, the vegetative stage is critical for biomass accumulation, which directly influences the plant's potential to produce a high yield during the reproductive phase. Therefore, understanding the effects of algae-based biostimulants at this critical stage helps in fine-tuning cultivation practices for higher and more sustainable rice production.
Results showed that microalgae, particularly NG6.1, NG7.1, N14.1 and N15.1 species, were particularly effective in promoting shoot growth and biomass accumulation in rice during the early vegetative stage. The findings suggest that these algae species hold significant potential for enhancing crop development, providing a foundation for ongoing research into their effects at the reproductive stage and imposed abiotic stress conditions (salinity and drought). These results highlight the potential of algae-based biostimulants as a sustainable solution to enhance rice productivity, paving the way for more resilient agricultural practices in the face of climate change and rising global demand of this staple crop.

## KEYWORDS
Microalgae, Macroalgae, Agriculture, Environmental solutions/ Circular Economy, Algae Market

# 11010 - BIOSTIMULANT EFFECTS OF ALGAE EXTRACTS ON THE GERMINATION OF RICE AND TOMATO SEEDS

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## ABSTRACT
Algae extracts are natural biostimulants rich in bioactive compounds that have been shown to enhance plant growth, seed germination, and stress tolerance while reducing dependency on synthetic agrochemicals. Although traditional agricultural practices along the Portuguese coast have long recognized the benefits of algae in farming, a systematic scientific validation is crucial to optimize their application in agriculture and ensure reproducible outcomes.
Seed germination is a critical developmental stage influencing seedling vigor and overall crop performance. This study evaluates the biostimulant effects of algae-based extracts on the germination of rice (*Oryza sativa* var. Caravela and tomato (*Solanum lycopersicum* var. Heinz. Aqueous extracts were prepared through sequential centrifugation and filtration steps and tested at three concentrations (0.1, 0.5, and 1.5 g/L. Germination assays were conducted under controlled conditions using 105 seeds per treatment, with three independent replicates. Germination rate and speed were assessed at 48, 72, and 96 hours, while early-stage development was evaluated based on root elongation and the Germination Index (GI.
Among 29 algae extracts tested on rice, 12 significantly enhanced germination rate and were further analyzed for their effects on GI. The most effective extracts increased GI by up to 40% at optimal concentrations, with N13.2 (0.1 g/L exhibiting the highest induction. In tomato, 36 extracts were evaluated, with N32.1 (0.1 g/L demonstrating the highest GI increase (32%. The optimal concentrations varied between species, with lower concentrations (0.1–0.5 g/L generally better for promoting germination, whereas higher concentrations, particularly in tomato, exhibited inhibitory effects on root growth.
These findings highlight the species-specific responses of rice and tomato to algae-based biostimulants, identifying extracts with strong potential for enhancing seed germination and early seedling development. While the results provide valuable insights into the potential agricultural applications of algae extracts, further research is needed to determine the mechanisms underlying their biostimulant effects and standardize application protocols to ensure consistency and efficacy in agriculture.

## KEYWORDS
Biostimulants, Germination Index, Seedling Development, Crop Productivity, Microalgae, Macroalgae, Agriculture

## ACKNOWLEDGMENTS/FUNDING
This work was financially supported by “Pacto da Bioeconomia azul” (Project No. C644915664-00000026) within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR), under the scope of the incentive line “Agendas for Business Innovation” through the funding scheme C5 - Capitalization and Business Innovation. We also thank COTArroz (Ing. Lourenço Palha) for providing the ‘Caravela’ rice seeds.

# 11016 - THE MARINE MICROALGAE BIOBANK AT THE UNIVERSITY OF LISBON (ALISU)

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**ABSTRACT**
Founded in 1997, the Microalgae Biobank of the University of Lisbon (ALISU) is a collection of microphytoplankton and microphytobenthos species (≥20 µm) isolated from estuaries, coastal areas, and oceanic regions of mainland Portugal, the Azores, and Madeira. Its main objective is the *ex-situ* conservation of biodiversity, focusing on ecologically relevant species, species producing bioactive compounds with potential impacts on public health or with interest in biotechnology, and species relevant for aquaculture development.

The taxonomic groups represented in the ALISU collection, in decreasing order of diversity, include dinoflagellates, diatoms, haptophytes, chlorophytes, eustigmatophytes, and raphidophytes. Each species is represented by multiple strains. Most species have been identified based on morphology, photosynthetic pigments, and rDNA sequencing (LSU and ITS regions).
The collection is widely used for research and teaching at the University of Lisbon, as well as at other national and international institutions. Over the years, funding has been secured through various scientific projects supported by FCT (Fundação para a Ciência e Tecnologia), particularly via MARE and ARNET (UIDB/04292/2020, UIDP/04292/2020, LA/P/0069/2020).
Currently, ALISU is a partner in the "Blue Bioeconomy Pact" project (C644915664-00000026), WP5 Algae Vertical, where it is involved in the bioprospection of new microalgae strains and the maintenance of a microalgal biobank available for all partners. This initiative has contributed to an increase in the number of isolates and the overall collection diversity.

**KEYWORDS**
Microalgae

# 11018 - CULTIVABLE EPIPHYTIC DIATOMS FROM PORPHYRA UMBILICALIS AND PORPHYRA DIOICA PRODUCED IN AQUACULTURE

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## ABSTRACT
Diatoms are a ubiquitous group in aquatic ecosystems, thriving in both benthic and pelagic habitats. In macroalgae aquaculture systems, epiphytic diatom assemblages growing on thalli may directly compete for light and nutrients, potentially affecting biomass production and the quality of the product. Under this assumption, in the framework of the Algae Vertical project, the present study investigated epiphytic diatom assemblages on *Porphyra umbilicalis* and *Porphyra dioica* blades produced in an aquaculture facility in late winter, spring, summer and fall of 2024. Epiphytic diatoms were isolated and cultured under laboratory conditions, with the objective of further characterizing their impact on *Porphyra* spp. production. In each sampling event, *Porphyra* blades were selected and separated into two groups based on macroscopic evaluation of color and morphology: (1 thalli with uniform color and morphology and (2 thalli with patchy discoloration or altered surface. A total of 85 samples were collected. Various isolation methods were used, including single-cell isolation directly from the detached epiphytic community, enrichment experiments in liquid and solid f/2+Si culture media, followed by single-cell isolation, and blade scrubbing directly onto solid culture medium.
The use of liquid medium stimulated a higher microalgae diversity, with groups other than diatoms quickly taking over. Solid medium was more effective in selecting diatoms and reducing the bacterial load in the samples. However, diatom diversity also showed a reduction with small species being selected.
A total of 73 diatom cultures have already been established. Results so far do not show clear differences between *Porphyra* species, thalli color and morphology. Most common cultivable diatoms include *Cylindrotheca closterium*, and species of the genera *Nitzchia*, *Navicula*, *Amphora*, *Odontella* and *Licmophora*. Ongoing molecular analyses will provide further insights into the taxonomic composition. Other species with planktonic affinities, of the genus *Skeletonema*, *S. dohrnii* and *S. pseudocostatum*, were isolated from the *Porphyra* surrounding water and represent the first reference for Portuguese coastal waters. All cultures are maintained at the microalgae culture collection of Lisbon University (ALISU and are available for other project partners and tasks.

## KEYWORDS
Microalgae, Macroalgae, Production

# 11044 - ENHANCING LARVAL ROBUSTNESS WITH ALGAL PRODUCTS: INSIGHTS INTO GROWTH AND REDOX STATUS

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## ABSTRACT
Marine fish larvae face significant challenges during their early development, particularly during the critical benthic transition. At this stage, rapid growth, and intense metabolic activity make fish larvae highly vulnerable to oxidative stress. This work explores how dietary inclusion of micro- and macroalgae may support larval robustness and resilience through a positive modulation of oxidative stress response and growth performance indicators in *Solea senegalensis* postlarvae. In this experiment, sole were fed one of four experimental diets: a commercial-like diet (COM or three experimental diets supplemented with different combinations of algal products. These combinations used the macroalgae *Ulva* sp. and the microalgae *Tetraselmis* sp., Phaeodactylum *tricornutum*, and *Tetradesmus* sp. The experiment lasted 24 days, from 25 days after hatching (DAH to 49DAH. After 49DAH, sole previously fed with the experimental diets (UTS, UPD, UTD were fed with a new diet (Boost for 5 days, until the end of the experiment. For a period of 30 days, postlarvae (initial dry weight 1.24 mg were reared in triplicate tanks in a recirculating aquaculture system (RAS. Throughout the nutritional trial, dissolved oxygen was maintained above 99.5%, temperature at 20.7°C, and pH at 8.1. Growth performance was assessed at 49DAH. Key markers for oxidative stress, catalase (CAT, total glutathione (GSH and macromolecules damage, lipid peroxidation (LPO were evaluated at 49DAH and 54DAH. Superoxide dismutase activity (SOD and total antioxidant status (TAS, as well as antioxidant-related gene expression, are currently being analysed. At 49DAH, the dietary treatments had no significant effects on growth, with larvae presenting a dry weight of 31.31 mg, a total length of 26.01 mm, and a condition factor of 0.88. The relative growth rate was 14.36 % day$^{-1}$, and the survival rate was 67.83 %. Additionally, the inclusion of micro- and macroalgae were unable to modify CAT, TG and LPO ($p$ > 0.05, neither at 49 nor 54 DAH. Supplementing microdiets with algae products rich in antioxidants and other bioactive molecules can have both positive and negative effects. The findings of this study highlight that understanding the consequences and implications of early nutrition remains a critical challenge for improving juveniles fish quality.
This work was financially supported by “Pacto da Bioeconomia Azul” (Project N C644915664-00000026 within the WP5 Algae Vertical, funded by Next Generation EU European Fund and the Portuguese Recovery and Resilience Plan (PRR, under the scope of the incentive line “Agendas for Business and Innovation” through the funding scheme C5–Capitalization and Business Innovation; and by FCT – Foundation for Science and Technology through projects UIDB/04326/2020 (DOI:10.54499/UIDB/04326/2020, UIDP/04326/2020 (DOI:10.54499/UIDP/04326/2020, LA/P/0101/2020 (DOI:10.54499/LA/P/0101/2020 to CCMAR. The authors thank Necton SA for supplying the microalgae.

## KEYWORDS
Microalgae, Macroalgae, Feed

# 11122 - ADVANCES IN PORPHYRIDIUM PURPUREUM STRAIN IMPROVEMENT: CREATION OF MUTANTS WITH ENHANCED STRESS TOLERANCE TO ENVIRONMENTAL STRESSORS

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**ABSTRACT**
The red microalga *Porphyridium purpureum*, a mesophilic species, produces high-value biocompounds, including sulphated-exopolysaccharides (EPS), phycobiliproteins, and long-chain polyunsaturated fatty acids (PUFAs), with applications in the cosmetics, pharmaceutical, and food industries. However, its response to elevated temperatures and $CO_2$ levels—crucial for industrial cultivation under global warming—remains poorly understood. This PhD research investigates how these abiotic stressors affect the growth and metabolism while establishing a foundation for understanding the impact of introducing mutations into *P. purpureum* through transcriptome analysis. The work involved adapting a pre-validated random mutagenesis and FACS-based screening pipeline to *P. purpureum* for the first time, pioneering the creation of a mutant library with enhanced abiotic stress tolerance. Physiological responses were assessed under selective pressures (high temperature, high carbon dioxide levels, low pH, high salinity), isolating three promising strains: a thermotolerant strain, a thermosensitive strain (with higher $CO_2$ absorption potential), and a halotolerant strain. The thermotolerant mutant exhibited the most stable and robust phenotype, justifying its validation for pre-pilot cultivation in comparison to the wild-type strain, for more advanced growth and biocompound production. Similar biomass and polysaccharide composition were found in both strains, while the mutant achieved higher cell concentration at elevated temperatures (28°C, control conditions set at 20-25°C). Additionally, an RNA-Seq-based transcriptomic analysis workflow is under development to enable comparative studies between mutant strains and the wild-type in future projects. This study advances the current understanding of *P. purpureum*'s potential for climate-resilient biotechnological applications and fundamental carbohydrate metabolism research, extending down to the transcriptomic level.

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**KEYWORDS**
Microalgae, Environmental solutions/ Circular Economy, Production

# 11158 - FIRST STEPS TOWARDS THE DEVELOPMENT OF COMMERCIAL OFFSHORE SEAWEED CULTIVATION IN PORTUGAL'S SOUTH COAST

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## ABSTRACT
Considering the wide range of seaweed applications and its low carbon footprint, seaweed cultivation is key for EU sustainable aquaculture development. Particularly when seaweed is cultivated in integrated multi-trophic aquaculture (IMTA, as seaweed can remove excess dissolved nutrients from fed fish production, such as N and P, effectively providing a bioremediation service while building its biomass. Currently, commercial seaweed cultivation in Portugal is limited to land-based, but to answer the need to scale up production, offshore cultivation needs to be taken into consideration. While at sea the dilution of waste nutrients from fish farms can occur quickly, some studies have shown an increase in dissolved nutrients close to fish cages, hence integrating seaweed cultivation with fish farms could potentially benefit seaweed growth, as well as the sustainability of fish farming.
Thus, a project was developed to investigate the cultivation of several seaweed species in association with a seabream and seabass fish farm (Seaculture, Vila Real de Santo António in the Algarve coast. The sea structure is based on a simple mooring frame system with long lines suspended under the sea surface, supporting the perpendicular substrate lines.
For the first growing season, nursery protocols were established for *Saccharina latissima*, *Laminaria ochroleuca*, *Saccorhiza polyschides* and *Codium* sp.. Seaweed deployments took place between November 2023 and March 2024, and kelp biomass harvesting was carried out in June and July 2024, when seaweed subsamples were measured and weighed. Biofouled and clean samples were frozen, freeze dried and ground for C, N and P analysis. In July samples were taken for identification of the main biofouling organisms. Together with biomass productivity, N and P content are now being used to calculate nitrogen and phosphorus removal from the production area.
Several bottlenecks were identified, namely sea structure maintenance issues, condition of seedling transport from nursery, biological contamination/biofouling, and herbivorism at sea. Nonetheless, the first results show potential for these species' cultivation, particularly *L. ochroleuca*, and *S. polyschides*. For *S. latissima*, more work is needed to understand if the biomass disappearance between June and July was a result of herbivory, or due to rising temperatures. While *Codium* sp. time at nursery and deployment time require further research. Overall, these first results support the protocol optimization for nursery and offshore cultivation of seaweed in Portugal´s south coast.

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## KEYWORDS
Macroalgae, Production, Environmental solutions/ Circular Economy

# 11188 - DESIGN AND VALIDATION OF A CHILLER-REFRIGERATED PILOT SYSTEM FOR INDUSTRIAL TUBULAR PHOTOBIOREACTOR COOLING

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## ABSTRACT

Temperature control is one of the key factors when it comes to industrial production of microalgae cultures. In an open raceway pond, evaporation acts as a natural cooling mechanism avoiding excessive culture temperatures, whereas in a closed cultivation system like a tubular photobioreactor (TPBR this is not possible. This leads to the need of having forced cooling solutions, especially in locations with not only high outside temperatures, but also with high values of sun irradiance – as this has a huge contribution to the reactor's temperature raise due to radiation energy transfer.

A common cooling method for TPBR is water spraying. This is a relatively cheap and practical solution to implement, but it has associated some drawbacks. It might become an expensive system to operate in more temperature-control demanding areas, or if underground reservoirs are used as water source, they may not provide enough to satisfy the cooling needs. This also affects the sustainability of the facilities and encourages the search for more sustainable cooling methods.

At Necton's facilities, we have developed an automatically controlled chiller-fed refrigeration pilot system. This has been implemented as a proof of concept to oppose temperature raises, limiting the maximum temperature reached in a 27 $m^3$ vertically stacked TPBR. The pilot unit consists of four inline interconnected shell-and-tube heat exchangers with a total heat transfer capacity of 130 kW, where a glycol mixture is used as cooling fluid, fed from a buffer tank for thermal inertia purposes. The glycol circuit is then a loop consisted by the thermal inertia tank being fed with cold fluid, which provides the heat transfer power for the heat exchangers, and finally returning again to the tank. Data collected during the summer season show that, during high temperature peaks, the pilot unit has not only kept the culture temperature lower than with the water spraying method, but also suppressed the water need for cooling on the test reactor, which represents a 26% reduction of the total water use for cooling in the plant's industrial scale production.

Due to the system's high electrical power demand, a photovoltaic (PV production unit for self-consumption was also installed in order to provide electrical power to the refrigeration system. The PV production unit has a maximum capacity of producing 350 kW/peak and was designed taking into account the total electrical demand for the refrigeration of two industrial scale TPBRs, making all the chiller-refrigerated units self-sustainable.

Proven the concept, it is expected to have installed another chiller-fed refrigeration system in a Necton's industrial scale TPBR, which will strongly contribute to the sustainability of our facilities when it comes to cooling at industrial scale.

## KEYWORDS

Microalgae, Production, Environmental solutions/ Circular Economy

# 11202 - EXPLORING THE BACTERIA ASSOCIATED WITH MICROALGAE CULTIVATION: ISOLATION, MOLECULAR CHARACTERIZATION, AND BIOTECHNOLOGICAL POTENTIAL

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Pursuing more sustainable microalgae cultivation methods with enhanced yields and resilience remains a trending topic in biotechnology. As part of the Algae *Vertical* project, an innovative approach involves characterizing bacteria capable of stimulating growth and bioproduct accumulation or causing damage to the algae. To this end, samples were collected at various stages of production, ranging from laboratory-scale flasks (5 L) to industrial photobioreactors (19 $m^3$), involving multiple microalgae species during scale-up processes at Necton facilities (Olhão, Portugal).
Fresh samples (50 mL) were collected in sterile tubes and subjected to serial dilutions from $10^{-1}$ to $10^{-6}$, which were then plated on marine agar to isolate heterotrophic bacteria. Plates were incubated at 30°C in the dark for up to 14 days and monitored for growth. Morphologically distinct bacterial colonies were selected and streaked to obtain pure cultures. Molecular identification was conducted using bacterial DNA extracted with a commercial kit (DNeasy PowerSoil Pro Kit – QIAGEN), followed by PCR amplification targeting the 16S rRNA region with primers F27 (5'–AGA GTT TGA TCG TGG CTC AG–3') and R1492 (5'–TAC GGY TAC CTT GTT ACG ACT–3') using an Applied Biosystems 3130XL DNA sequencer. The resulting sequences were analysed using BLASTn from the National Center for Biotechnology Information (NCBI), applying identification thresholds of ≥94.5% for genus-level and ≥97% for species-level similarity.
Over 350 bacterial isolation plates were analysed from 60 fresh samples, and more than 70 microorganisms were isolated and processed for molecular identification to assess their potential for biotechnological applications or as part of contaminant mitigation strategies. Such studies contribute to characterising biodiversity and the intrinsic bacteria communities associated with microalgae in industrial environments, fostering innovation in new strategies to optimize microalgae cultivation.

**KEYWORDS**
Algal Biotechnology; Heterotrophic microorganisms; 16S rRNA sequencing, Microalgae, Production

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# 11220 - AMINO ACIDS IN MICROALGAE: A SUPERIOR PLANT-BASED SOURCE?

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**ABSTRACT**
Microalgae have been consumed for centuries in Asian cultures, mainly due to their nutritional value, offering relevant amounts of proteins, polysaccharides, fatty acids, dietary fibers, vitamins, minerals, and bioactive compounds. However, there is a lack of literature regarding bioaccessibility and bioactivity of microalgae dietary compounds. Focusing on protein, it is important to highlight that protein content can vary nutritionally depending on its origin, amino acid composition, and bioavailability. According to FAO (2013, direct measures of protein quality are considered the gold standard because they assess how protein sources support normal growth and other functions that depend on an adequate protein diet in target populations. Indirect approaches such as Digestible Indispensable Amino Acid Score (DIAAS and/or Protein Digestibility Corrected Amino Acid Score (PDCAAS, which involve in vitro and animal or human metabolic studies, can be used routinely and safely to predict protein and amino acid utilization in humans. Therefore, this study aimed to assess the dietary protein quality of Allmicroalgae's Chlorella (Chlorella sp. using PDCAA, comparing them to commonly consumed food, namely flours (rice, green pea, soybean, corn, and wheat, considering whole egg as reference. White Chlorella and organic Spirulina displayed higher protein contents (42.50% and 55.00%, respectively compared to the other food ingredients. Honey Chlorella and Smooth Chlorella contained 32.50% and 35.00% of protein, respectively, with only soybean flour (38.60% showing a higher amount. The protein content of whole egg fresh is 13% and in powder is 48%. The differences in essential amino acid limitations between microalgae and plant-based flours (e.g., pea, rice stem from their distinct biosynthetic pathways, nitrogen assimilation, and protein storage mechanisms. Microalgae can utilize inorganic nitrogen sources, leading to a varied amino acid profile. In contrast, plant-based flours have amino acid compositions shaped by seed development, often resulting in deficiencies like low lysine in cereals or low methionine in legumes, with processing methods further influencing amino acid availability. The percentage of amino acids absorption of microalgae, soybean flour, and whole egg fresh based on PDCAA results were very similar, varying from 6.4 to 9.3%, whereas in the other ingredients it varied from 1.0 (rice flour to 2.7% (green pea flour. Although DIAAS provides a more accurate measurement, PDCAAS was used in this study due to the lack of literature on the true ileal digestibility of essential amino acids in microalgae, which is necessary for calculating DIAAS. Based on this study, it can be concluded that microalgae are a superior source of essential amino acids compared to rice, corn, and wheat flours, yielding results similar to those of whole egg and soybean flour. Further studies are needed for a more accurated response.

**KEYWORDS**
essential amino acids; dietary protein quality; PDCAA; DIAAS; Chlorella sp.; Limnospira platensis, Food, Microalgae, Production, Algae Market

# 11228 - THE POTENTIAL OF LIMNOSPIRA PLATENSIS AND L. MAXIMAAS BIOREMEDIATION AGENTS FOR AGRICULTURAL DRAINWATER

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## ABSTRACT

Known for its nutritional benefits and significant potential as a bioremediation agent, Spirulina has been reported has having mitigation effects of organic pollutants, including nitrates and phosphates, by utilizing them as nutrient sources during growth [1]. Since freshwater management is becoming a critical global challenge, all measures to efficiently use it, reduce its consumption and mitigate its pollution are of utmost importance. Alongside, microalgae industry is seeking for more sustainable and cost-effective practices [2]. Therefore, the use of algae to depurate wastewater has a high potential to reduce water pollution by uptaking excess nutrients and pollutants while simultaneously producing valuable biomass [3].

Within the Algae Vertical project, new strategies to promote the sustainability of microalgae production inputs are under development, including the reuse of effluents from soilless agriculture (i.e., hydroponics), commonly referred to as drainwater. Following previous lab-scale trials, two spirulina strains, *Limnospira platensis* and L. maxima, were tested for their capacity to use the nitrates and phosphates present in drainwater from hydroponics to grow in pilot raceways. The drainwater used to culture these strains had an initial concentration of 30 and 2.3 mM of nitrates and phosphates, respectively. The cultivation lasted for 29 days and both strains were able to consume part of the nutrients present in the drainwater, where L. maxima reached 2.9 g/L, while L. platensis reached 1.7 g/L of dry weight. In accordance, the nitrate concentration had a higher decrease in L. maxima culture compared to L. platensis culture (9.8 and 18.0 mM, respectively). The phosphates were consumed similarly by both strains, final concentration of approximately 1.5 mM. Visually, at the end of the trial, L. maxima presented a more green-blueish colour, characteristic from spirulina, while *L. platensis* was more green-yellowish. Overall, these results demonstrated that *L. platensis* and L. maxima are resilient cyanobacteria, able to grow in agricultural drainwater, while L. maxima presented better growth and appearance.

These results highlight the potential of microalgae-based wastewater treatment, by integrating microalgae cultivation with agriculture. This represents a sustainable solution to reduce water pollution, lower costs, and promote circular bioeconomy practices.

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## KEYWORDS

Microalgae, Environmental solutions/ Circular Economy, Agriculture

# 11230 - MAGNESIUM-ENRICHED CHLORELLA VULGARIS AND TETRASELMIS CHUI CULTIVATION: EVALUATING ITS EFFECTS ON BIOMASS PERFORMANCE FOR HIGH-VALUE

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## ABSTRACT

Microalgae are a promising source of bioactive compounds for the nutraceutical and cosmeceutical industries due to their high content of essential fatty acids, carotenoids, proteins, and antioxidants [1]. However, the economic viability of algal-based products remains a challenge due to high production costs, highlighting the need for more efficient strategies. The Algae Vertical project aims to address this challenge by promoting sustainable and circular development while creating innovative and high-value products. Magnesium (Mg) is an essential mineral for numerous physiological processes [2]. Microalgae biomass enriched in Mg could improve its nutritional and functional quality [3]. In this context, this study evaluates the effect of Mg addition on the growth of *Chlorella vulgaris* and *Tetraselmis chui* under pilot-scale conditions. Both microalgae were cultivated in 80L flat panel photobioreactors, with two replicates per treatment: one with Mg addition in the form of magnesium chloride and one without (Control). Preliminary lab-scale trials determined the optimal Mg concentration for each species (*C. vulgaris* 0.1M; *T. chui* 1M). Growth was evaluated via optical density (OD) over 7 days of culture. The results showed different responses to Mg supplementation. For *C. vulgaris*, the Mg addition did not influence the OD throughout the cultivation period (day0: Control 0.40±0.03, Mg 0.38±0.05; day3: Control 2.56±0.06, Mg 2.32±0.16), suggesting that it can tolerate the mineral, at the concentration tested, without affecting growth. In contrast, *T. chui* exhibited reduced OD values in Mg treatment compared to the Control, particularly after day three (day1: Control 0.61±0.00, Mg 0.50±0.01; day3: Control 0.99±0.00, Mg 0.73±0.14; day7: Control 1.88±0.07, Mg 1.37±0.41), indicating potential sensitivity to high Mg concentrations. Our findings emphasize the importance of better understanding Mg impacts on microalgae cultivation at pilot-scale, for future industrial-scale production. Beyond growth performance, further evaluation of the nutritional profile after Mg supplementation will be crucial in assessing its full potential for high-value applications. This study represents an important step in optimizing microalgae cultivation for the production of value-added biomass for the nutraceutical and cosmetic industries.

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## KEYWORDS

Microalgae, Production, Supplements and cosmetic


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