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Editorial: Boosting the potential of algae for biomass production, valorisation, and bioremediation

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Editorial on the Research Topic
Boosting the potential of algae for biomass production, valorisation, and bioremediation

Algae are on the rise. There has never been a better time for exploring the potential of algae for biomass production, valorisation, and bioremediation. Research into new species, bioactive compounds, production and processing of biomass, bioremediation performance and development of cost- and energy-efficient large-scale cultivation are all in full bloom. The eight articles consisting of seven original research articles and one review article published in this Research Topic cover advancements in the research and development of macro- and micro-algae to boost their potential for use in society through improvement in biomass production, valorisation, and bioremediation.

Our eight Articles are highly relevant to current global and European sustainability goals and fit well with circular bioeconomy principles. Algae fit with European policies such as the European Green Deal (COM/2019/640 final) and the Farm to Fork Strategy (COM/2020/381 final) which underline the potential of farmed algae and other seafood as a low-carbon footprint source of proteins for food and feed. The Sustainable Carbon Cycles Communication (COM/2021/800 final) also recognises the potential of algae for the blue carbon economy. In January 2021, the Aquaculture Advisory Council issued a General Recommendation to the Commission on cultivation in Europe; this contained first advice related to regulatory, research and market position aspects of seaweeds (macroalgae) (AAC, 2021). The policies have culminated in a communication in November 2022 from the Commission to the European Parliament entitled "Towards a Strong and Sustainable EU Algae Sector" (COM/2022/592 final) in which the potential of algae in the EU is evaluated and a coherent approach is laid out to support the upscaling of algae cultivation and production throughout the EU and to develop and mainstream the markets for food and non-food algae applications.

Four of our Articles relate to the development of the macroalgal (seaweed) economy, covering species diversification together with strain and product optimisation working

towards a biorefinery approach. A related article addresses using both macro- and microalgae to improve the quality of fish for food. Three further articles cover macro- and microalgal biomass cultivation on waste streams to make production more economical.

To strengthen the macroalgal sector for a range of industrial applications within the blue economy, a diversification of cultivation of species is required. Guillén et al., in their review paper, compare the chemical characteristics and potential applications in aquaculture of two red algal genera: the commonly grown *Kappaphycus* and the undervalued, however abundant, genus *Acanthophora*.

Strain optimisation is key challenge in developing macroalgae. Eléouët et al. developed new genetic tools for the economically important agar-producing red macroalgal species *Gracilariopsis lemaneiformis*. Their findings open the doors to more genetic applications and discoveries in this important red macroalgal species.

Optimising conditions for the extraction of target products is another crucial challenge in macroalgal biotechnology. Castro-Valero et al. optimised the conditions for extracting R-phycoerythrin from a red macroalgal species, *Sarcopeltis skottsbergii*, endemic to South America. They highlight the power of modelling using central composite design and response surface methodology to optimise the extraction conditions to achieve maximum yields with minimum time and resources.

The opportunities offered by downstream processes targeting the complete valorization of the algal biomass *via* a biorefinery model is covered by Barragán et al. aims at maximizing the spectrum of final products. Specifically, downstream green-processing of seaweeds was evaluated by means of bioprocess simulation software. The contribution of the biorefinery approach to the economic valorisation of the biomass constituents was discussed, with a special focus on enzyme-assisted processes prioritizing laminarin and fucoidan as main products.

In the animal feed sector, most of the research on the use of algae in finfish aquaculture feeds focuses on their effects on fish biomass production. Less attention has been paid to the potential effect of algae in the feeds on the quality of fish fillets. Sáez et al. present results of a trial where turbots were fed for a short time with micro- and macroalgae containing diets, followed by an additional feeding period with a control diet. Their key finding was that a short pulse with algae feeds prolonged the shelf life of fillets and improved their nutritional quality and organoleptic properties.

On using waste streams: Firstly, Massocato et al. studied the potential of using seaweed in the bioremediation of fishpond wastewater with the aim of developing an efficient integrated system of fish and marine algae biomass production. Specifically, *Ulva pseudorotundata* and *U. rigida* were grown in outdoor ponds using nutrients available in the aquaculture wastewater. The photosynthetic performance and seaweed physiology as well as the biofiltration efficiency were found to be satisfactory. The biomass quality was verified by identifying potential valorisation alternatives for the development of industrial products.

Secondly, Zittelli et al. tested the growth of the freshwater microalga *Chlamydopodium fusiforme* MACC-430 in diluted piggery wastewater for biomass production, which was found to have higher yields than in BG-11 (control) mineral medium. Diluting the wastewater and cultivating in open ponds resulted in improved nitrogen and phosphorus removal rates and higher protein content. Results also showed antimicrobial activity and weak biostimulant activity for biomass produced. Overall, *C. fusiforme* proved to be a suitable strain for growth in diluted PWW outdoors with increased nutrient removal rates.

Finally, Blažina et al. evaluated the use of the marine eukaryotic microalgae *Pseudochloris wilhelmii* as a potential way to remove nitrogen and phosphorus nutrients from oil refinery wastewater. Various growth experiments were conducted to see how temperature, light, and nutrient concentration could affect the removal rate and biomass production. *P. wilhelmii* showed great potential for large-scale oil refinery wastewater remediation and valuable biomass cogeneration.

In conclusion, we can say that the papers presented in this volume cover a variety of topics in micro- and macroalgae biomass production, processing, and applications, demonstrating the versatility of this biomass resource. We thank all the contributors for their excellent contributions.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

Author Maja Berden Zrimec was employed by company AlgEn, Algal Technology Centre, LLC.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Reference

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