Comparative evaluation of techniques for extracting bioactive compounds from brown seaweed

Garcia Peran Roberto, Minardi Carlotta, Sweygers Nick, Appels Lise and Dewil Raf

Chemical and Biochemical Reactor Engineering and Safety (CREaS) and Process and Environmental Technology Lab, KU Leuven, , 2860 Sint- Katelijne-Waver, Belgium
E-mail: roberto.garciaperan@kuleuven.be

For centuries, marine seaweed has been a vital food source, valued for its abundant bioactive compounds that exhibit antitumor, antiviral and antioxidant properties [1]. Seaweeds stand out as a sustainable resource for these compounds, thriving without the need for land or fertilizer and outperforming terrestrial plants in productivity [2].This study focused on brown seaweed, particularly the species *Ascophylum nodosum.* This species was chosen due to its high polysaccharide content (approximately 50 wt%), especially the sulfonated polysaccharide fucoidan, which is more prevalent in this species compared to others. Three extraction techniques, i.e., ultrasound-assisted (US), microwave-assisted (MW) and conventional (CV) techniques, are evaluated in this study for their efficiency in cell wall disruption and the yield of desired components (i.e., alginate, fucoidan, laminarin, polyphenols and proteins).

Traditionally, research in this field has focused on extracting single compounds, predominantly alginate. However, this study introduces a novel cascaded extraction process designed to selectively extract and separate multiple products, including polysaccharides (alginate, fucoidan and laminarin), proteins and polyphenols. To recover polysaccharides, food-grade chemicals are employed, such as ethanol, sodium bicarbonate and citric acid, avoiding the use of harsher, toxic substances such as HCl and formaldehyde. This approach opens the door for potential applications in food and feed products.

A novel biphasic system is evaluated in this study, combining ethyl acetate and an aqueous citric acid solution. This system works in combination with the extraction techniques previously mentioned (i.e., US, MW, and CV), which enables the simultaneous solubilization and separation of polyphenols and pigments into the organic phase, while retaining the polysaccharides and proteins in the aqueous and solid phases for further separation. This innovative approach reduces the number of steps involved in the extraction process. Traditionally, a pretreatment step using organic solvents is necessary to remove polyphenols and pigments, which are then discarded [3]–[5].

The process involves centrifugation to separate the solid and liquid phases and decantation to separate the organic and aqueous phases. As a result, the initial extraction step yields three distinct phases: organic, aqueous and solid. Following this, sodium bicarbonate is added to the solid phase to derive (soluble) sodium alginate. in the final step, ethanol is introduced to the aqueous phase and the sodium alginate solution to precipitate the individual polysaccharides.

Results indicate that the use of microwave and ultrasound assisted extraction increase the yield of alginate by 37.72% and 47.70% respectively when compared to conventional extraction. It was observed that after the initial extraction step instead of three phases: organic, aqueous, and solid; a fourth gel-like phase appeared. This gel-like phase contained a higher nitrogen content than all other products, indicating a high concentration of proteins in this phase.

References

- S. L. Holdt and S. Kraan, “Bioactive compounds in seaweed: functional food applications and legislation,” *J. Appl. Phycol.*, vol. 23, no. 3, Art. no. 3, Jun. 2011, doi: 10.1007/s10811-010-9632-5.
- G. Ó. Hreggviðsson *et al.*, “Chapter 16 - Biocatalytic refining of polysaccharides from brown seaweeds,” in *Sustainable Seaweed Technologies*, M. D. Torres, S. Kraan, and H. Dominguez, Eds., in Advances in Green and Sustainable Chemistry. , Elsevier, 2020, pp. 447–504. doi: 10.1016/B978-0-12-817943-7.00016-0.
- N. Flórez-Fernández, H. Domínguez, and M. D. Torres, “A green approach for alginate extraction from Sargassum muticum brown seaweed using ultrasound-assisted technique,” *Int. J. Biol. Macromol.*, vol. 124, pp. 451–459, Mar. 2019, doi: 10.1016/j.ijbiomac. 2018.11.232.
- N. González-López, A. Moure, and H. Domínguez, “Hydrothermal fractionation of Sargassum muticum biomass,” *J. Appl. Phycol.*, vol. 24, no. 6, Art. no. 6, Dec. 2012, doi: 10.1007/s10811-012-9817-1.
- P. Digala *et al.*, “Optimized extraction of sulfated polysaccharide from brown seaweed Sargassum polycystum and its evaluation for anti-cancer and wound healing potential,” *South Afr. J. Bot.*, vol. 151, pp. 345–359, Dec. 2022, doi: 10.1016/j.sajb.2022.03.015.

Keywords
Seaweed; Extraction; Ultrasounds; Microwaves; Cascade; Alginate ; Fucoidan; Laminarin; Polyphenols; Proteins