Extraction of phenolic compounds by high hydrostatic pressure from eight edible algae species from the North-West coast of Spain: Process modelling and optimization

C.P. Lamela [1]*, C. Jiménez López [1], A.G. Pereira [1], C.S.P.L. Lopes [1], Lillian Barros [2], M.A. Prieto [1], Isabel C.F.R. Ferreira [2], J. Simal-Gandara [1]

[1] *Nutrition and Bromatology Group, Faculty of Food Science and Technology, University of Vigo, Ourense Campus, E32004 Ourense, Spain.*
[2] *Centro de Investigação de Montanha (CIMO), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.*

Keywords: Algae, high pressure, phenolic compounds, extraction, optimization.

*e-mail: cconchipl@uvigo.es

Two thirds of the word are covered by oceans and a vast majority of that upper layer are inhabited by photoautotrophic organisms such as algae.

Algae are not only of high ecological, but also of great economic importance. The industrial exploitation of algae has suffered a boom in the last two decades, revealing a source of compounds relevant to a diverse range of sectors (agriculture, energy, food science, cosmeceutical, pharmacology, etc). In consequence, many possible applications have emerged, such as production of biofuels for energy production, as nutraceutical ingredients in fish meals, as fertilizer in landfill applications, anti-biofilm activity in food science, incorporation in cosmeceutical and pharmacological products due to the rich content in bioactive compounds, among others [1].

In this work, high hydrostatic pressure (HHP) was applied to the extraction of phenolic compounds from eight edible algae species (**Table 1**).

Table1. Edible algae species used for this study.

Local common name	Scientific name
Kombu	*Laminaria spp.*
Kombu real	*Saccharina latissima*
Espagueti de mar	*Himanthalia elongata*
Wakame	*Undaria pinnatifida*
Nori	*Porphyra spp.*
Dulse	*Palmaria palmata*
Alga percebe	*Codium spp.*
Lechuga de mar	*Ulva spp.*

The process was optimized by response surface methodology using a five-level central composite design combining the independent variables of processing time (*t*, 5-90 min), pressure (*P*, 10-600 MPa) and solvent (*S*, 0-100 % of ethanol, v/v) [2]. The individual and grouped phenolic compounds were analyzed, and the extraction yield were used as response variables. The theoretical models were fitted to the experimental data, statistically validated, and used in the prediction and optimization steps. In general, the optimum extraction conditions for phenolic acids for all eight species analyzed were found at shorter values of *t*, high values of *P* and high values of *S*. The identified phenolic compounds were also clustered according to the conditions that maximize their extraction. HHP was highlighted as a promising emerging technology to extract phenolic compounds from edible algae species using a green solvent and reduced extraction times.

The analysis presented provides important data that allows the comparison between different extraction conditions, in terms of efficiency, and consequent related decision making. In an industrial level, these methodologies reduce costs related to energy, solvent consumption, equipment investment, etc. Achieving the optimal conditions and maximizing the responses is an important step to guide the choice of a suitable and sustainable process. The study concludes that several conditions of extraction, reduce both economic and ecological impacts of the process, in the extraction of phenolic compounds. In conclusion, the present study contributes in the valorization of edible algae species, common in the North-West region of Spain, by the obtainment of rich extracts in phenolic compounds that potentially can be applied as ingredients in different industrial fields.

Acknowledgments: To AlgaMar for the algae material provided (www.algamar.com). To MICINN for the financial support for the Ramón&Cajal researcher of M.A. Prieto. To University of Vigo for the financial support for the pre-doctoral researchers of A.G. Pereira and C. Jiménez López. The authors are also grateful to the Interreg España-Portugal for financial support through the project 0377_Iberphenol_6_E.

1. Zakaria, S.M.; Kamal, S.M.M. Subcritical Water. *Food Eng. Rev.* 2016, *8*, 23–34.
2. Pinela, J.; Prieto, M.A.; Barros, L.; Carvalho, A.M.; Oliveira, M.B.P.P.; Saraiva, J.A.; Ferreira, I.C.F.R.. *Sep. Purif. Technol.* **2018**, *192*, 501–512.