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Optimization of green extraction of phenolic compounds from the brown seaweed *Fucus spiralis* using Natural Deep Eutectic Solvents

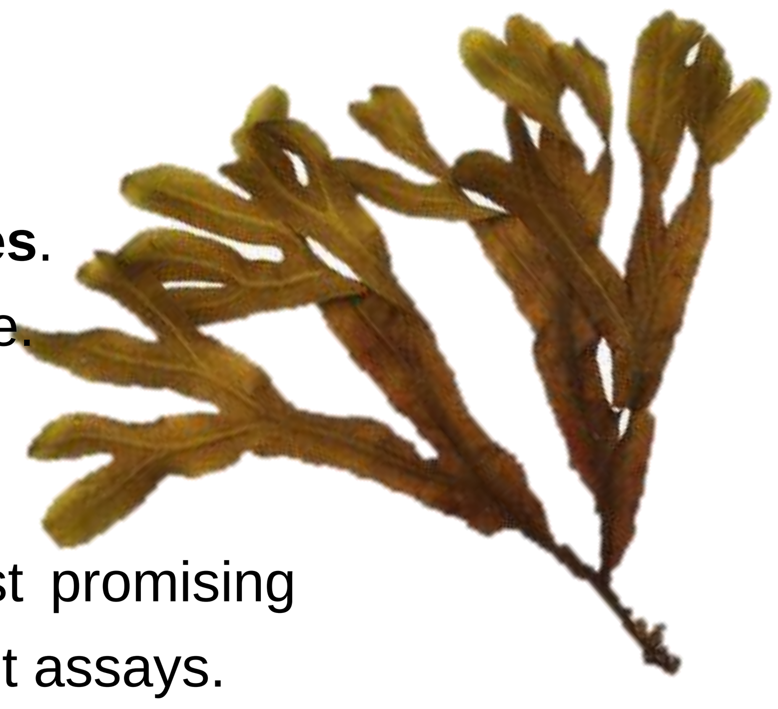
Semmouri Ilias[1], Mansinhos Inês[2], Rodríguez-Solana Raquel[2,3], Janssen Colin[1], Jana Asselman[1], Gonçalves Sandra[2], Romano Anabela[2]

[1]Blue Growth Research Lab, Ghent University, Ostend Science Park, Wetenschapspark 1, 8400 Ostend, Belgium

[2]MED-Mediterranean Institute for Agriculture, Environment and Development & CHANGE-Global Change and Sustainability Institute, Faculdade de Ciências e Tecnologia, Universidade do Algarve, Campus de Gambelas, 8005-139 Faro, Portugal

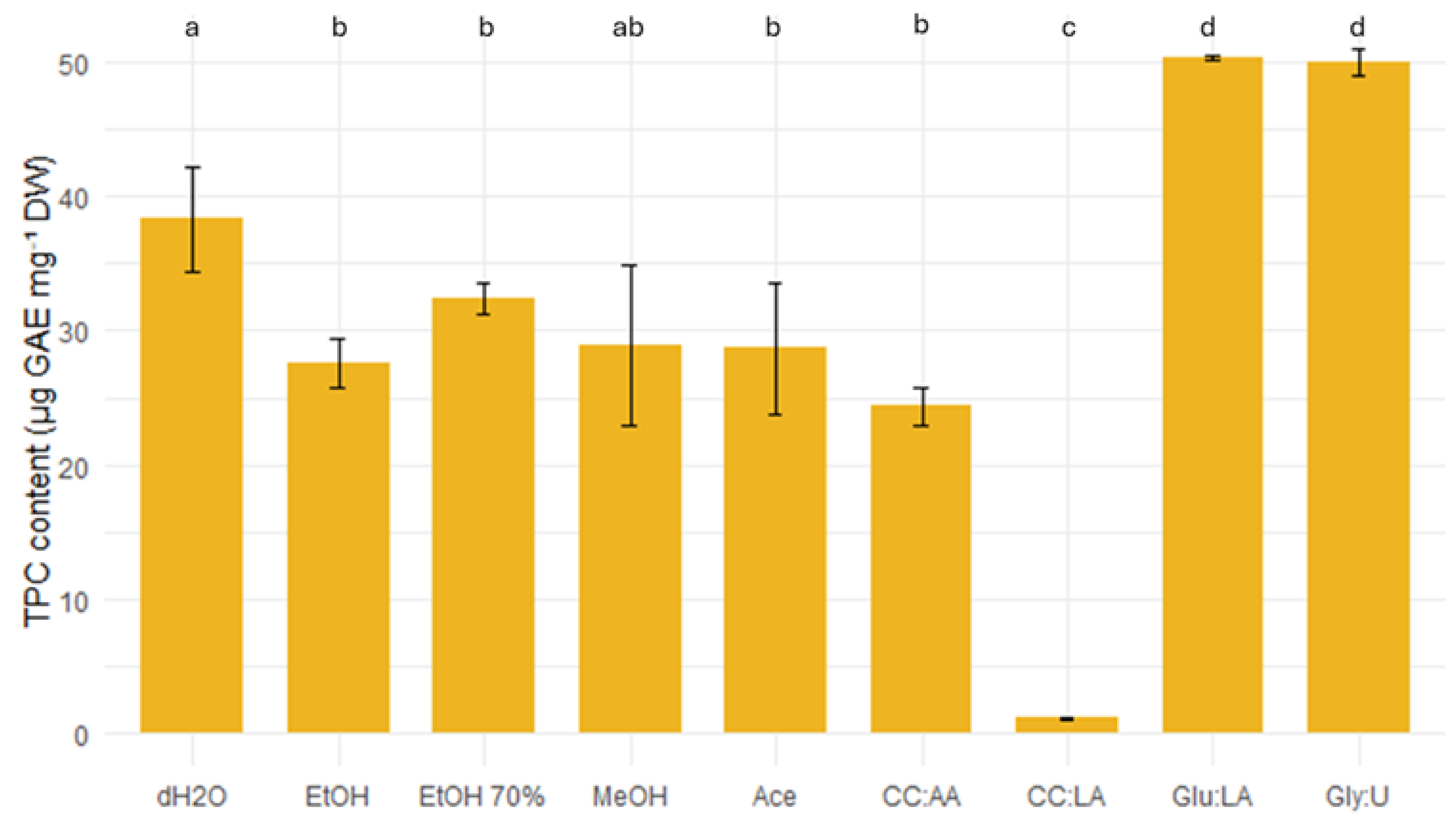
[3]Department of Agroindustry and Food Quality, Andalusian Institute of Agricultural and Fisheries Research and Training (IFAPA), Rancho de la Merced Center, Carretera Cañada de la Loba (CA-3102) Km 3.1., SN, 11471 Jerez de la Frontera, Cádiz, Spain

Introduction & methodology

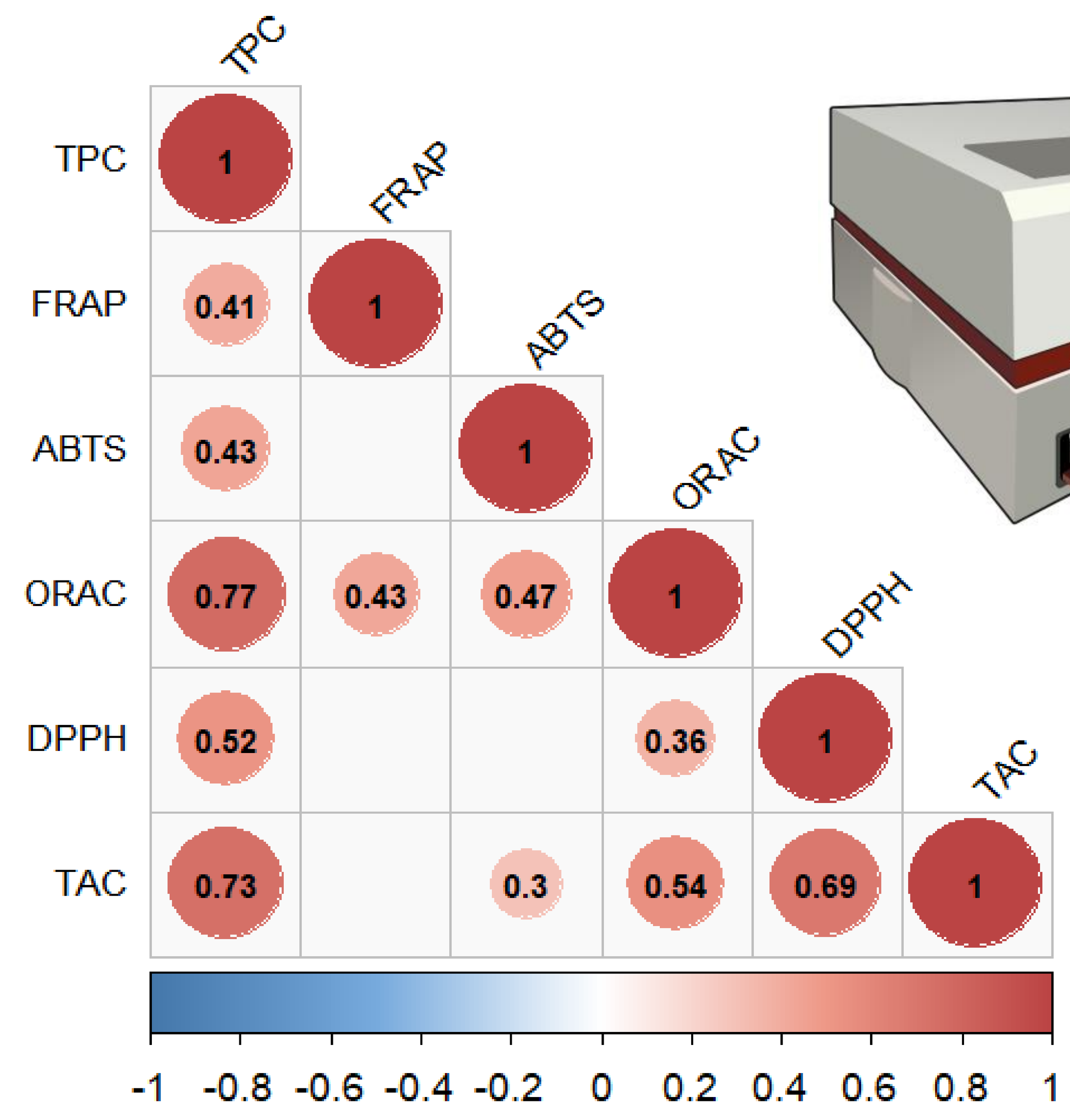


- Seaweeds have garnered significant attention in recent years due to their chemical and **bioactive properties**.
- **Phenolic compounds** stand out for their diversity and high abundance in seaweeds, especially brown algae.
- Using ultrasound-assisted extraction (UAE), we first compared **extraction capacity of different natural deep eutectic solvents (NADES)** with those of conventional solvents.
- Second, we aimed to **optimize UAE** of phenolic compounds using a Box-Behnken design for the most promising solvent (via the Folin-Ciocalteu method) and we assessed antioxidant capacity of extracts through 5 different assays.
- The optimization process was conducted with three key factors in mind: extraction **temperature** (ranging from 20 to 50 °C), extraction **time** (ranging from 30 to 120 minutes), and **liquid-to-solid ratio** (ranging from 5 to 55 mg mL^{-1}).
- Finally, we aimed to **identify** the phenolic compounds through **HPLC** analysis (not shown here).

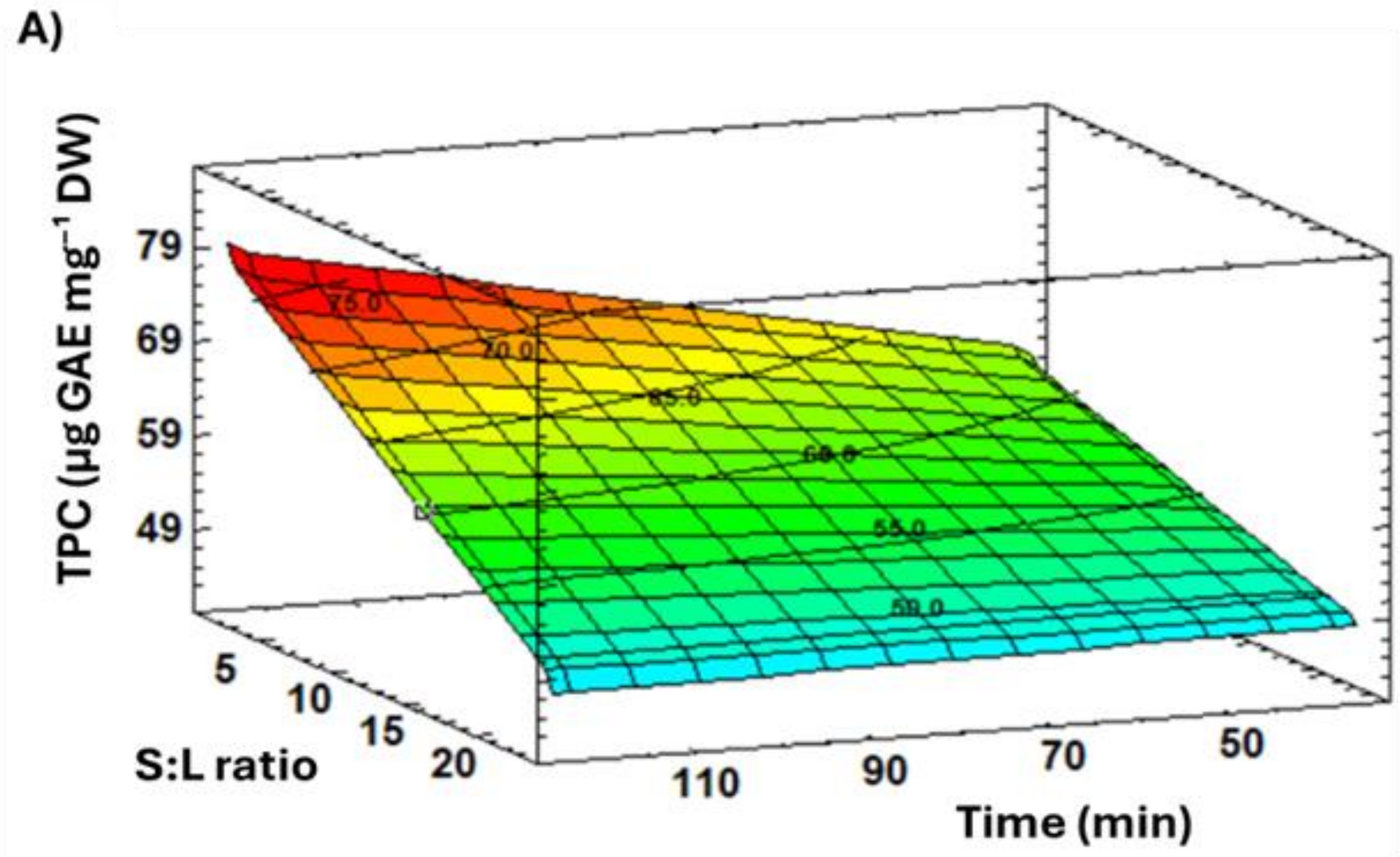
Results

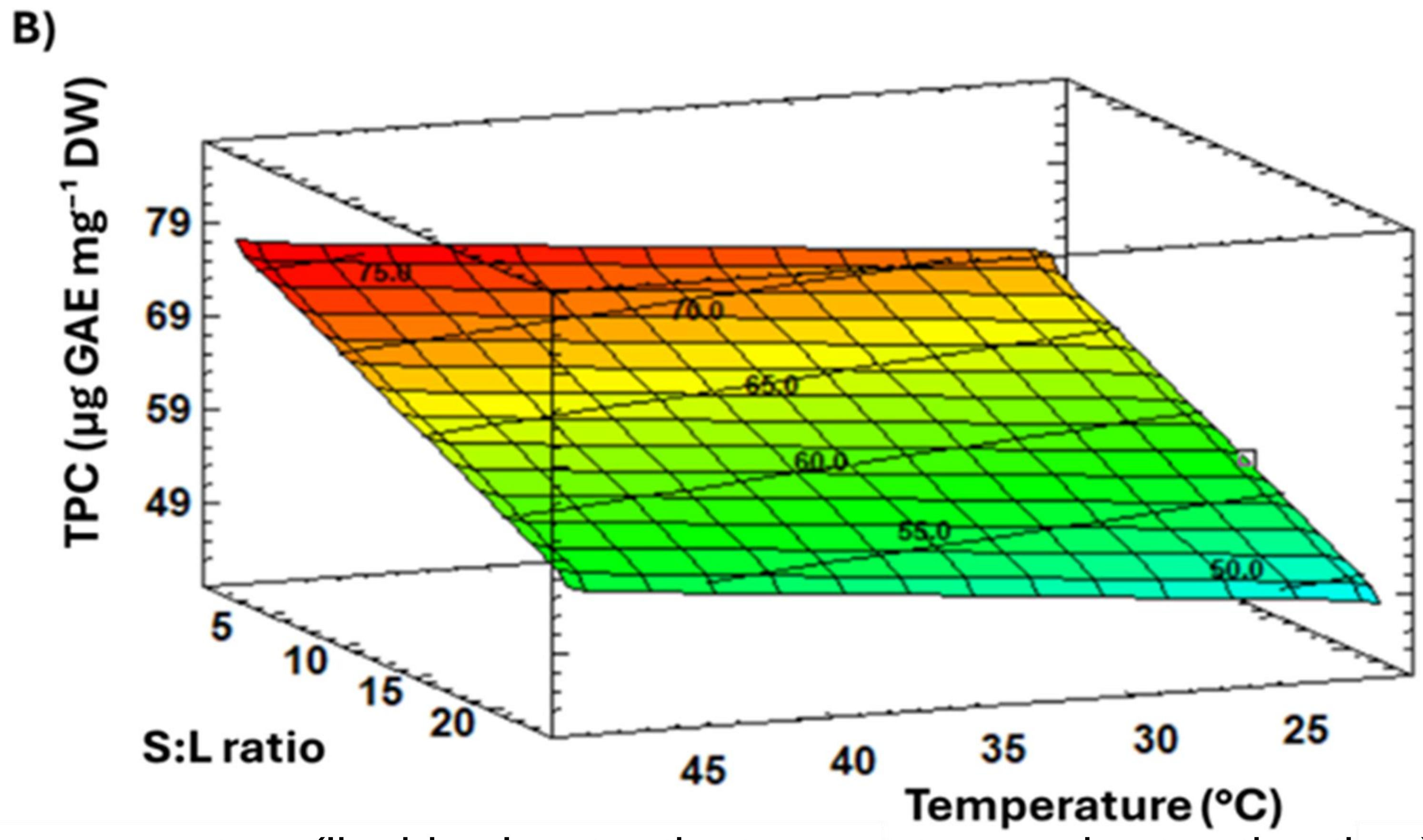


Above: Bar plot illustrating variation in total phenolic content (TPC) of *F. spiralis* extracts obtained with 4 different NADES (1:2 CC:AA, 1:2 CC:LA, 1:5 Glu:LA, 1:1 Gly:U), and conventional solvents. Results were expressed as mean ± standard deviation (SD). Different letters represent statistically significant differences (Tukey HSD, adjusted $p < 0.05$). Acronyms used: CC= choline chloride, AA = acetic acid, LA = lactic acid, Gly = glycerol, Glu = glucose.



Above: Correlation plot (Spearman) between TPC obtained from optimization experiment and antioxidant activity, using five different assays: the ABTS, FRAP, DPPH, ORAC and TAC assay. Color and numbers represent correlation strength. Only significant correlations are reported (p<0.05).





Above: 3D response surface plot illustrating the combined effects of extraction parameters (liquid:solvent ratio, temperature and extraction time) on total phenolic content (TPC).

CONCLUSION

- One **NADES (Gly:U) is promising** to replace conventional solvents to extract phenolics in terms of TPC and antioxidant activity.
- Extraction temperature, time and solid:liquid ratio proved significant parameters to optimize TPC.
- Higher temperatures and longer extraction time improved TPC, while increasing S:L ratio had opposite effect.
- We **observed significant correlations between antioxidant activity and TPC** for all assays, but not all antioxidant assays correlated significantly with each other, suggesting different sensitivities of the evaluated assays.

GHENT UNIVERSITY
UAlg FCT UNIVERSIDADE DO ALGARVE FACULDADE DE CIÊNCIAS E TECNOLOGIA
Blue Growth Research Lab
fwo

Ilias.semmouri@ugent.be
https://www.linkedin.com/in/ilias-semmouri-03605210b/
https://bluegrowthlab.ugent.be/