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Sustainable Recovery and Valorisation of *Saccharina sp.* Polysaccharides Using Hydrothermal Processing Technologies

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Objectives

- Evaluate the effects of temperature, pressure, extraction time, and solid-to-liquid ratio on the extraction yields of alginate, fucoidan, and β-glucans from *Saccharina sp.*
- Optimize hydrothermal extraction conditions to maximize the simultaneous recovery of alginate, fucoidan, and β-glucans while minimizing polysaccharide degradation and process complexity.
- Perform LCA of the hydrothermal extraction process to identify environmental hotspots associated with energy consumption, water use, and downstream processing.
- Assess valorisation pathways for all process streams, including polysaccharide-rich fractions and residual biomass, to improve resource efficiency and reduce waste generation.

Blue-biorefinery of Macroalgae

Why to valorize macroalgae biomass in the Blue Bioeconomy ?

Environmental
- ✓ Fast CO_2 capture, no land/freshwater competition
- ✓ Nutrient recycling → reduces eutrophication

Economic
- ✓ Renewable alternative to fossil resources
- ✓ Source of high-value compounds (proteins, polysaccharides, pigments..)

Societal
- ✓ Nutritious & functional food
- ✓ Circular bioeconomy, minimal waste

Blue Economy
- ✓ Sustainable marine resource use & New bio-based industries
- ✓ Supports Sustainable Development goals SDGs

Greener Extraction → **Time-Saver** → **Higher Recovery** → **Scalable**

[1,2,3]

Materials & Methods

Saccharina sp.

Pretreatement
washing → air drying → milling (80 µm)

Design of Experiments Software: StatEase

Hydrothermal extraction
(temperature, pressure, mass: volume ratio, time)

Ultrafiltration (10 KDa)

- **Fucoidan** → **Anti-coagulant activity**
- **ß-glucans** → **Prebiotic activity**
  β-glucanase hydrolysis
  in vitro gastrointestinal stability
- **Residue** → **Alginate** → **Alginate-based biofilms**
  gel-forming ability
  Biodegradable
  non-toxic
- **Waste** → **Organic fertilizer**
  Mineral supply

Results

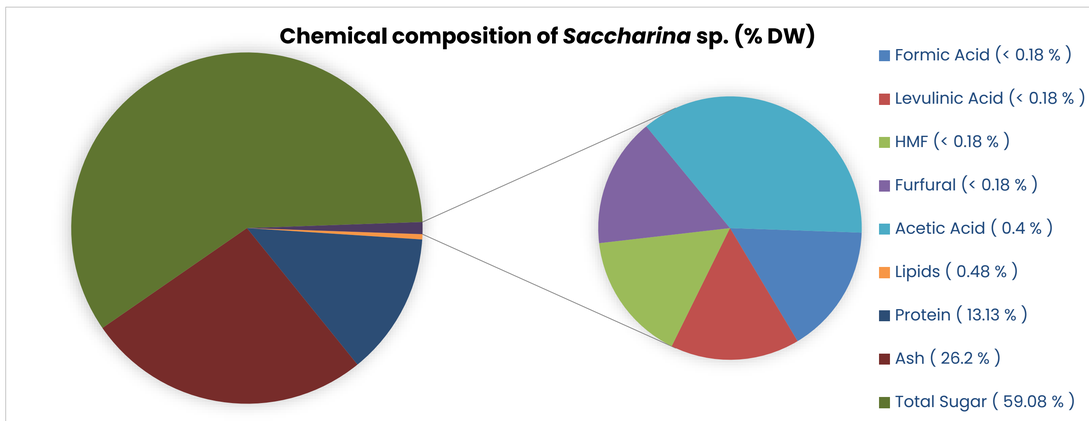


Fig. 1: Chemical Composition of *Saccharina sp.*

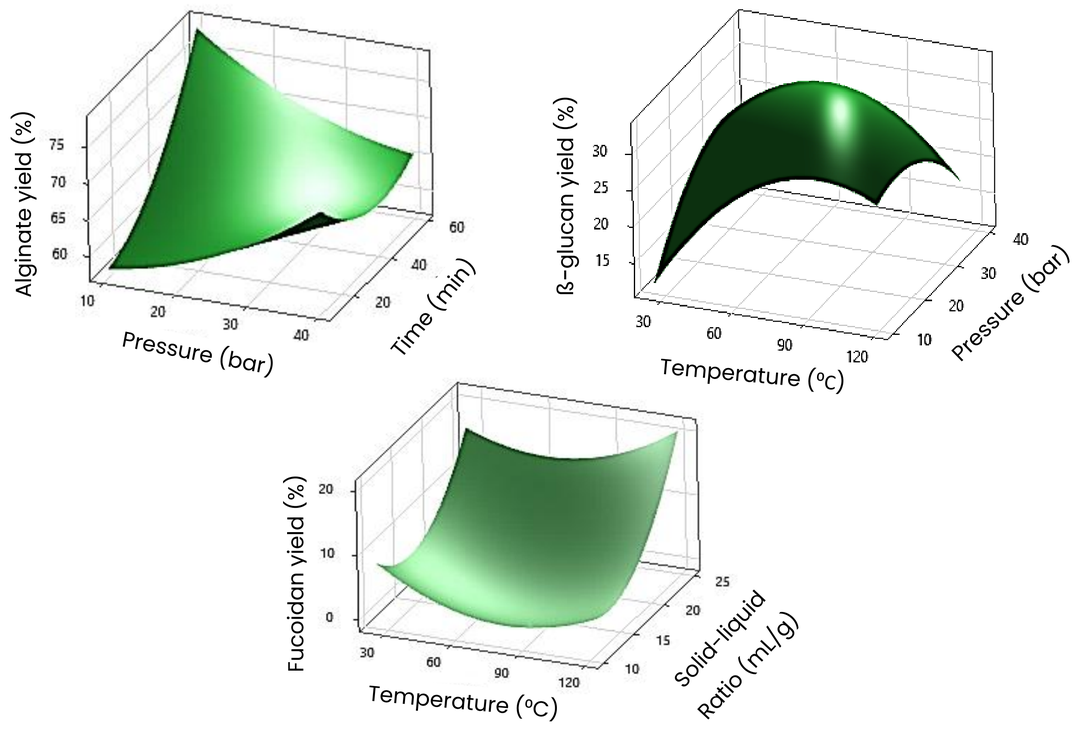


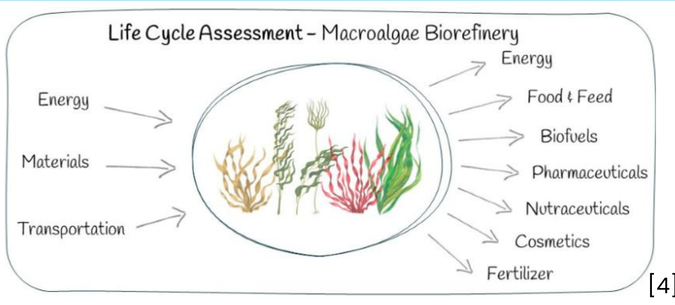
Fig. 2: Alginate, ß-glucan & fucoidan yield after hydrothermal extraction (Reaction conditions :Temperature 112.3°C, Pression: 10 bar, m:v 15.5 g/mL, Time :50.9 min)

Summary & Outlook

- Four-factor Box-Behnken Design (BBD) was applied to pressurized hot-water extraction of Saccharina sp., varying temperature, pressure, solid-to-liquid ratio and extraction time to simultaneously optimize three fraction yields, confirming Run M2 (112.3° C, 10 bar, 15.5 mL/g, 50.9 min; D = 0.573) as the optimum, yielding alginate 79.8%, fucoidan 18.7% and ß-glucan 19.3% dry biomass basis.
- A significant Pressure × Time interaction (p=0.022) governed alginate yield via thermomechanical chain depolymerisation, while solid-liquid ratio dominated retentate yield through a dilution-volume membrane retention mechanism.
- Multi-assay biochemical characterization and FTIR-ATR structural confirmation of the three recovered fractions.
- Bioactivity evaluation of laminarin fractions and alginate-based biofilm development for Food and nutraceutical applications.

Life Cycle Assessment of a Macroalgae-based Blue Biorefinery

CAMPUSLAB CIRCULAR ECONOMY



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[4]Pantis et al.(2024) https://doi.org/10.3390/chemengineering8040074

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