Process optimization for functional compounds extraction from *Sargassum thunbergii* using subcritical water: towards zero-waste biorefinery

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This study explores the application of eco-friendly technology, specifically subcritical water, for extracting functional compounds from underutilized marine biomass with the aim of achieving complete valorization in a sustainable biorefinery process with zero waste. Using response surface methodology, we determined the optimal conditions for extracting the maximum yield of total phenolic content from *S. thunbergii* biomass to be a temperature of 195.43°C, an extraction time of 18.82 min, and a solid/liquid ratio of 0.032 g/mL. Chemical analyses were conducted to investigate the structural characteristics of the optimized *S. thunbergii* extract (OSE), including total phenol content, total flavonoid content, total sugar, reducing sugar, monosaccharide composition, and molecular weight determination. The OSE's unknown compounds were profiled using UPLC-QTOF-MS/MS, GC-MS, FT-IR and NMR techniques.

For OSE extracted under optimal conditions, the total phenolic content and total flavonoid content values were 29.01 ± 0.28 mg Phloroglucinol Equivalent/g and 10.33 ± 0.48 mg Quercetin Equivalent/g, respectively. Additionally, the total and reducing sugar contents of OSE were analyzed and found to be (35.54±0.58 and 24.25±1.40) mg glucose/g, respectively. The main monosaccharides of OSE were Fucose at 35.29%, Galactose at 24.04%, Xylose at 17.71%, and Glucose at 16.65%. The number average molecular weight (Mn), weight average molecular weight (Mw), and polydispersity index (PDI, Mw/Mn) were 2190, 2499, and 1.14 at peak 1, 1700, 780, and 1.11 at peak 2, and 196, 213, and 1.09 at peak 3, respectively. The main compounds identified using GC-MS were D-glucitol 39.51%, L-5-oxoproline 7.64%, and various functional components. A total of 64 phenolic compounds were tentatively identified in OSE, including 27 phenolic acids, 16 flavonoids, and 21 other polyphenols (5 hydroxycoumarins, 3 tyrosols, 2 phlorotannins, etc.). FT-IR was also used to predict comprehensive information about the chemical structure of OSE. NMR analysis confirmed the presence of characteristic peaks of polysaccharides and phenolic compounds in OSE.

This study lays theoretical foundations and provides technical guidelines for optimizing the extraction and processing of phenolic compounds from *S. thunbergii*. Our results confirm the feasibility of employing subcritical water not only to utilize valuable substances like phenolic compounds contained in the extract but also to convert the remaining residue into biofuel, thereby achieving a truly zero-waste biorefinery.

References


DOI: https://doi.org/10.1016/j.jenvman.2023.119497


DOI: https://doi.org/10.1016/j.supflu.2022.105535