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Pulsed Electric Field (PEF) and Ultrasound (US) Assisted Extraction of Bioactive Compounds from Brewers' Spent Grain (BSG)

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Abstract

Brewer’s spent grain (BSG), the primary by-product of the brewing industry, is generated in large quantities and represents up to 85% of total brewing residues. Despite being rich in valuable components such as dietary fiber, proteins, and phenolic compounds, its high moisture content and susceptibility to microbial spoilage limit its industrial reuse. Phenolic compounds are of particular interest due to their well-documented antioxidant and bioactive properties, which can contribute to the development of functional food ingredients and nutraceuticals. However, their extraction from lignocellulosic matrices such as BSG is often limited by cell wall complexity. In this context, emerging non-thermal technologies such as pulsed electric field (PEF) and ultrasound (US) have attracted attention for their ability to enhance mass transfer and facilitate the release of intracellular compounds. The aim of this study was to evaluate and compare the efficiency of PEF and ultrasound-assisted extraction in recovering phenolic compounds from BSG using water as a green solvent. A 2k with two central points and two repetitions experimental design was applied to optimize PEF and Ultrasound treatment parameters. For PEF, the electric field strength (1.5–5 kV/cm), pulse width (10–30 µs), and number of pulses (50–150) were tested. Ultrasound-assisted extraction was conducted by varying sonication time (5–15 min), temperature (5–50 °C), and amplitude (20–60%). After treatment, extraction was performed under constant stirring, followed by centrifugation and filtration. The obtained extracts were characterized for total phenolic content (TPC) using the Folin–Ciocalteu method and total flavonoid content (TFC) via the aluminum chloride assay. Antioxidant activity was assessed using DPPH and ABTS radical scavenging assays. Furthermore, individual phenolic compounds were identified and quantified by reverse-phase high-performance liquid chromatography (HPLC). Results indicated that both PEF and ultrasound treatments enhanced the extraction of phenolic compounds compared to untreated controls. Optimal extraction yields depended on the specific combination of processing parameters, highlighting the importance of process optimization. Overall, this study demonstrates the potential of integrating green and non-thermal technologies for the valorization of BSG, contributing to sustainable waste management and supporting circular economy strategies within the food industry.

Keywords: brewers spent grain, phenolic compounds, pef, ultrasound

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