Microwave-Assisted vs. Traditional Extraction of Polyphenols from Olive Pomace: A Comparative Study

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Introduction

Olive pomace, a byproduct of olive oil production, is rich in antioxidant polyphenols, but poses environmental risks due to its phytotoxicity. Efficient extraction is essential for both waste management and the development of high-value bioactive compounds for industrial applications. Given the growing interest in green and sustainable technologies, optimizing extraction techniques for polyphenol recovery has become increasingly important. This study compares traditional solvent extraction (TSE) and microwave-assisted extraction (MWAE) to identify the most effective method for maximizing polyphenol yield while minimizing environmental impact.

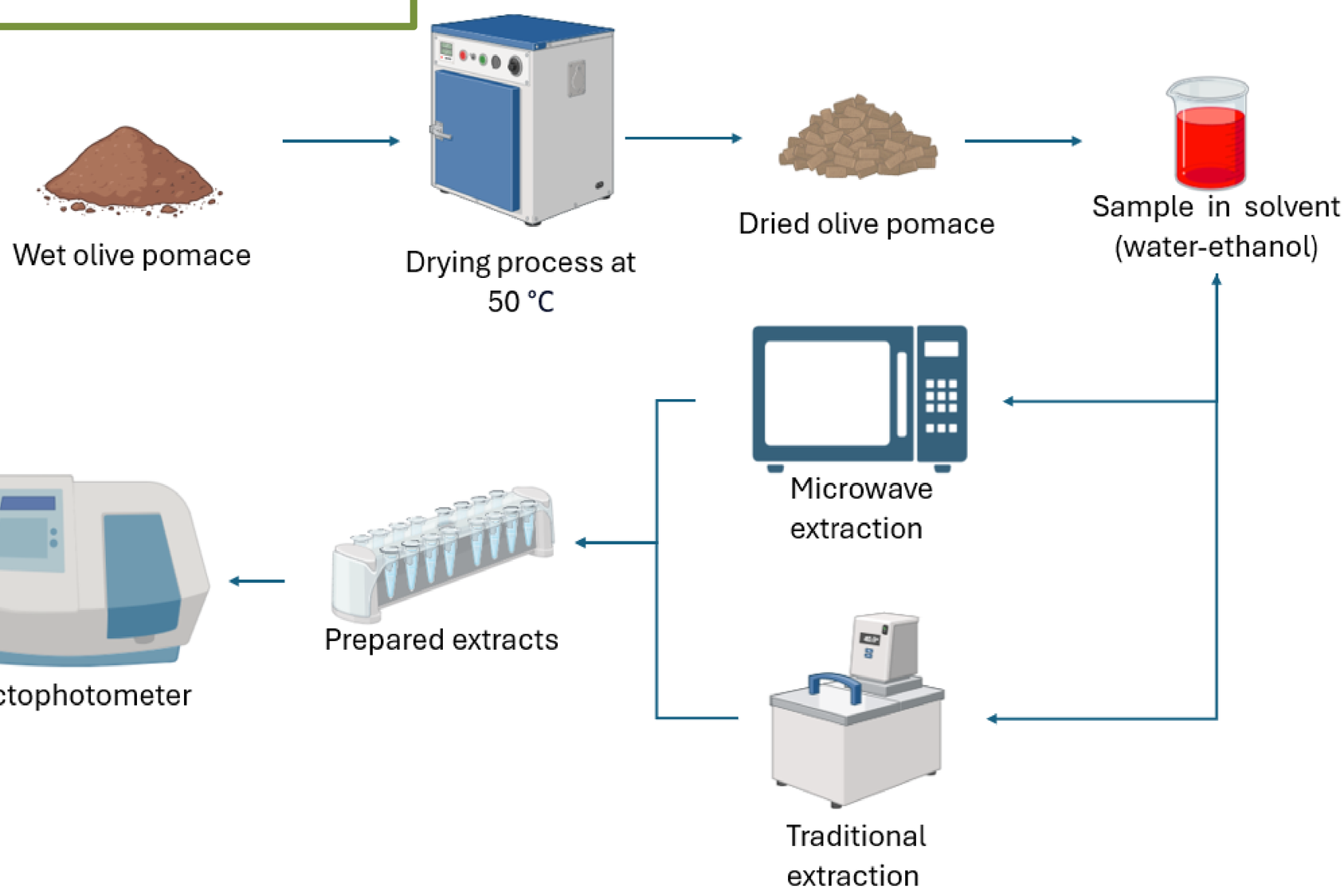
Aim

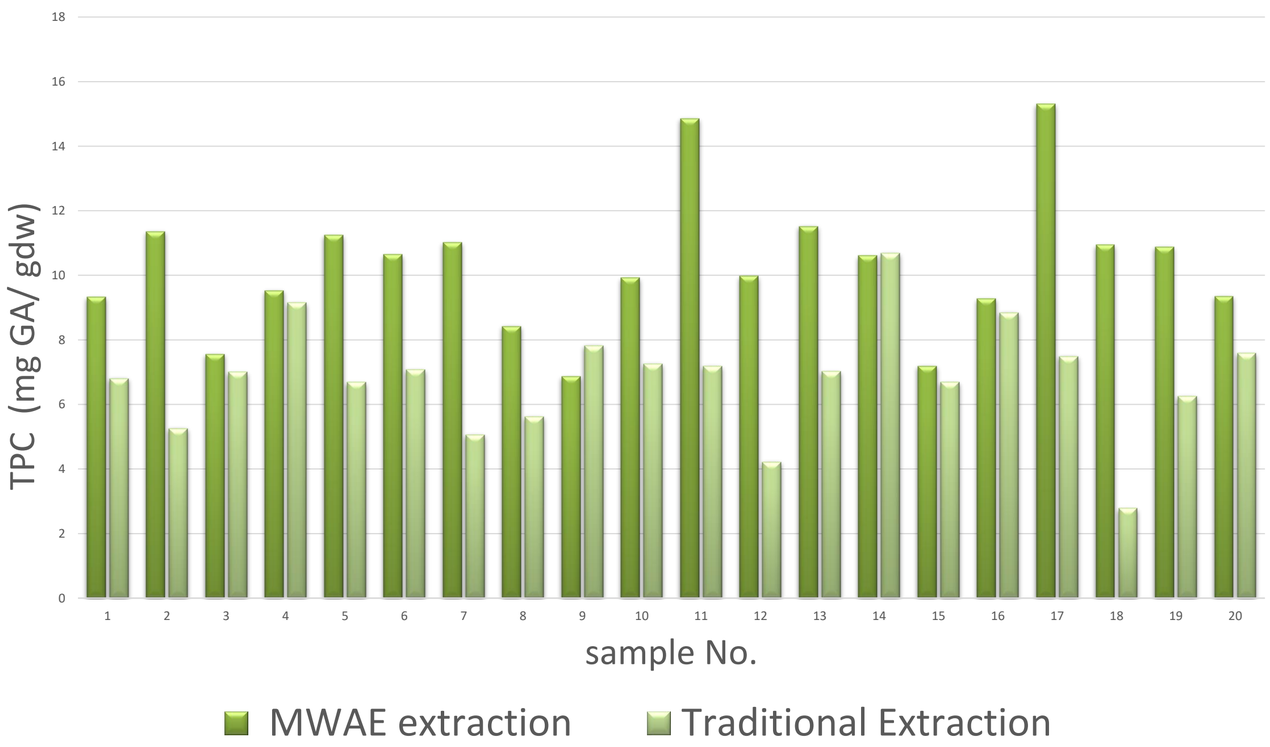
The aim of this study is to compare the efficiency of microwave-assisted and traditional extraction methods in recovering polyphenols from olive pomace, focusing on total polyphenol content (TPC) and antioxidant activity (AA).

Methodology

Total polyphenol content and antioxidant activity of both microwave-assisted and traditionally extracted olive pomace samples were evaluated using the Folin–Ciocalteu (gallic acid standard, $R^2 = 0.97$) and FRAP (ascorbic acid standard, $R^2 = 0.99$) assays, with absorbance measured at 760 nm and 593 nm, respectively.

The experimental design varied three key variables: for MWAE, extraction time (30–180 s), solid-to-solvent ratio (2–12 g/100 mL), and power (100–800 W); for TSE, extraction temperatures (40–80°C), solid-to-solvent ratio (2–12 g/100 mL), and solvent concentrations (10–90% v/v) were tested. Total polyphenol content (TPC) was measured using the Folin–Ciocalteu method, and antioxidant activity (AA) was assessed via the FRAP assay.





Results & Discussion

The results clearly demonstrate that MWAE significantly outperformed TSE in both total polyphenol content (TPC) and antioxidant activity (AA). The highest TPC achieved with MWAE was 15.3 mg GAE/g dw, compared to 10.8 mg GAE/g dw in TSE. This represents an increase of approximately 41.7%, emphasizing the efficiency of microwave heating in enhancing mass transfer and cell wall disruption. Similarly, antioxidant activity (AA) measured by the FRAP assay peaked at 10.48 mg AAE/g dw with MWAE, whereas TSE yielded a maximum of 10.00 mg AAE/g dw. Although the difference in AA is modest, it suggests that MWAE better preserves or enhances antioxidant capacity, possibly by reducing thermal degradation due to shorter extraction times.

Importantly, MWAE achieved these results at lower extraction temperatures (50–60°C) and within shorter times (30–90 s) compared to the longer durations (up to 180 min) and higher temperatures (up to 80°C) required for TSE. This highlights MWAE's energy efficiency, making it a more sustainable approach for polyphenol recovery from olive pomace.

These findings support the growing body of evidence that MWAE is a fast, efficient, and eco-friendly technology suitable for the valorization of agri-food residues like olive pomace. Its implementation in industrial settings could contribute to circular economy practices, turning waste into value-added products for food, cosmetic, or pharmaceutical use.

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