Optimization of ultrasonic and microwave assisted extraction of antioxidant compounds from cherry stems using NADES

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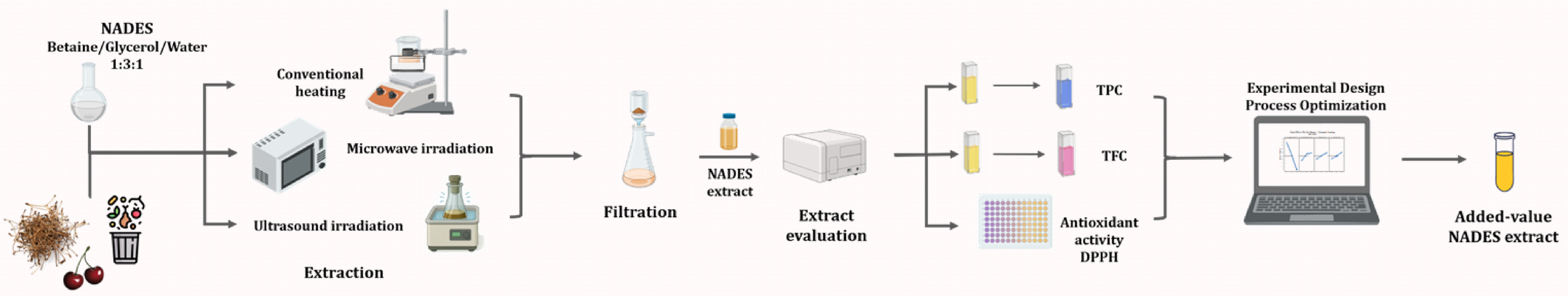
Introduction

Aim of this work is the **development** and **optimization** of an **environmentally friendly** and economically sustainable **extraction process** of bioactive compounds from dried **cherry stems** using green solvents of natural origin. The **green approach** involves the use of **Natural Deep Eutectic Solvents (NADES)** which are considered as the green solvents of the 21st century. NADES derive from natural sources, that in specific molar ratios, show a high reduction on their melting point. Among their several advantages, they can be **tailored** for specific applications through the appropriate selection of their constituents, allowing them to exhibit desired physicochemical properties and, in many cases, to be directly incorporated into end-use products without further processing.

Cherry stems, a by-product generated during food processing, has been used in traditional medicine, commonly as decoctions, for the treatment of a broad variety of conditions, due to their antioxidant and anti-inflammatory properties. In this context, three different extraction techniques (**microwave assisted extraction** (MAE), **ultrasound assisted extraction** (UAE) and **conventional heating**) combined with two solvents were employed and were assessed for the optimization of the extraction process by a 4-factor 3-level Taguchi Experimental Design to study the effect of temperature, extraction time, solid-to-liquid ratio (S/L) and the %water content in the NADES-water system on the total phenolic (TPC) and flavonoid content (TFC) of the extract.

Methods



Results

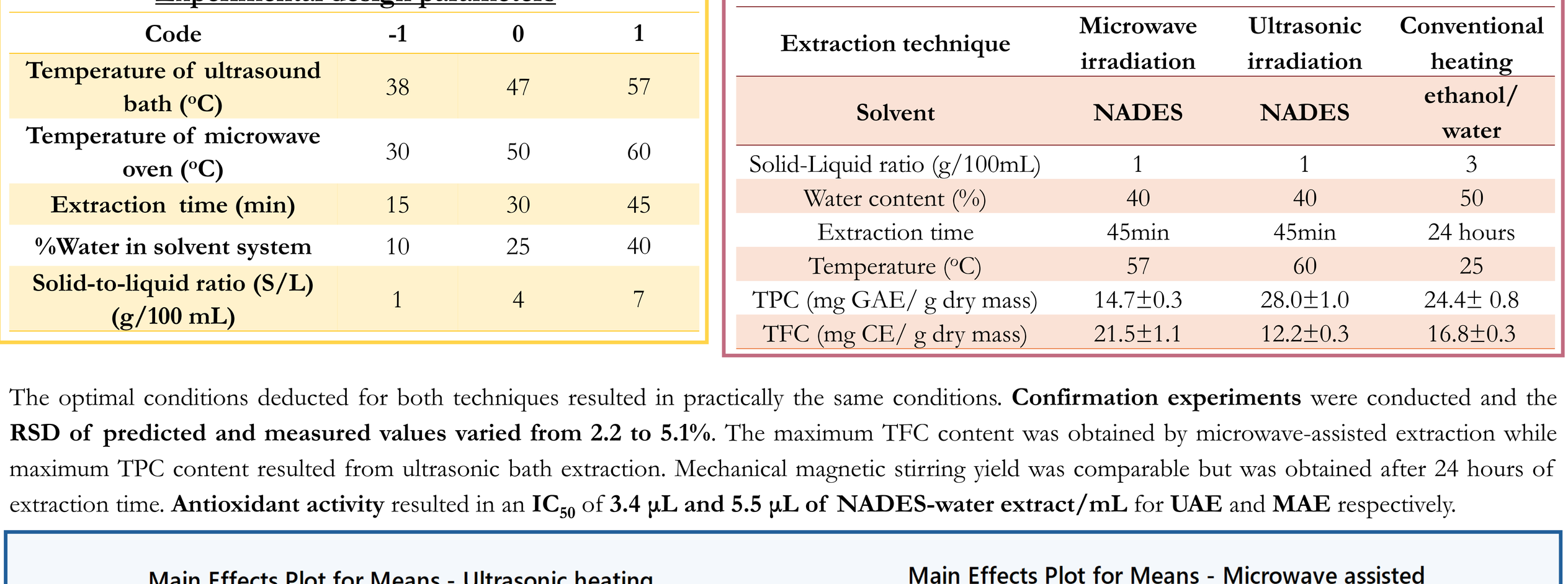
Experimental design parameters

Code	-1	0	1
Temperature of ultrasound bath (°C)	38	47	57
Temperature of microwave oven (°C)	30	50	60
Extraction time (min)	15	30	45
%Water in solvent system	10	25	40
Solid-to-liquid ratio (S/L) (g/100 mL)	1	4	7

TPC and TFC for the optimum conditions

Extraction technique	Microwave irradiation	Ultrasonic irradiation	Conventional heating
Solvent	**NADES**	**NADES**	**ethanol/ water**
Solid-Liquid ratio (g/100mL)	1	1	3
Water content (%)	40	40	50
Extraction time	45min	45min	24 hours
Temperature (°C)	57	60	25
TPC (mg GAE/ g dry mass)	14.7±0.3	28.0±1.0	24.4± 0.8
TFC (mg CE/ g dry mass)	21.5±1.1	12.2±0.3	16.8±0.3

The optimal conditions deducted for both techniques resulted in practically the same conditions. **Confirmation experiments** were conducted and the **RSD of predicted and measured values varied from 2.2 to 5.1%**. The maximum TFC content was obtained by microwave-assisted extraction while maximum TPC content resulted from ultrasonic bath extraction. Mechanical magnetic stirring yield was comparable but was obtained after 24 hours of extraction time. **Antioxidant activity** resulted in an IC_{50} of **3.4 μL and 5.5 μL of NADES-water extract/mL** for **UAE** and **MAE** respectively.



Statistical analysis performed on MAE and UAE showed that all parameters had a positive impact on total content with the most significant one being the solid to liquid ratio.

Conclusions

- ✓ NADES Betaine/Glycerol/Water 1:3:1 was selected as a green extraction solvent, while EtOH/water system was also studied as indicative conventional solvent
- ✓ The optimal conditions of extraction for both MAE and UAE are: 45 min extraction time, 60 °C extraction temperature, 1 g/100 mL Solid-to-Liquid ratio, 40% water as a co-solvent
- ✓ The use of NADES in combination with green extraction techniques enhances the extraction of bioactive compounds achieving high contents in bioactive compounds in short extraction time.

Acknowledgement

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