Optimization of Pulsed Electric Fields-Assisted Extraction of phenolic compounds from sweet cherry press cake using Response Surface Methodology

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Sweet cherry (Prunus avium L.), which belongs to the Rosaceae family, is widely cultivated in many countries (Hu et al., 2019). Due to their early ripening, attractive appearance, organoleptic quality, and richness of nutrients, sweet cherries are one of the most appreciated fruits by customers (Blando & Oomah, 2019). Italy is the fourth cherry producer worldwide after Turkey, USA, and Iran, with the Apulia region being the leading sweet cherry producer (*Prunus avium* L.) on a national level with 17,800 hectares producing almost 40,800 tons, mainly of the "Ferrovia" cultivar (Tricase et al., 2017). Sweet cherries are predominantly consumed as fresh fruits, other parts are also used to produce food products. Though tonnes of sweet cherries are produced annually, tonnes of stems, pits/kernels, and non-marketable fruits are also wasted, and pits represent about 14.6% of the total mass of cherries (Yılmaz et al., 2019).

Agricultural and food by-products constitute an interesting source of bioactive compounds with great potential for the development of functional foods, new natural food additives, or food active packaging according to consumer concerns about life quality and healthy food and demands for natural, organic, biological, and/or less process food products (Soares Mateus et al., 2022). To this purpose, cherry by-products can be valued in order to generate environmental, economic, and social benefits, particularly through the recovery of bioactive compounds with significant commercial potential for their potential applications, and extraction is the key step in recovering bioactive compounds from agricultural and food wastes (Frontuto et al., 2019).

Choosing the appropriate extraction solvent, as well as optimizing the sample-to-solvent ratio, extraction temperature, and time is of paramount importance as they greatly affect the yield and extract composition as well as the economics of the whole process. This is crucial to improve the efficiency of the conventional extraction process, which otherwise typically require a high amount of energy, solvent, and long diffusion time, (Devi et al., 2020). To overcome the above limitations while pursuing the "zero waste" concept, present research focuses on promoting greener, sustainable, and viable extraction processes of valuable compounds from cherry by-products. The first and most crucial step in the recovery process of valuable compounds, is the cell disintegration pre-treatment of plant tissues, through which damages to the cell wall/membrane system are induced, thus reducing the mass transfer resistance of intracellular compounds, while maintaining the high-quality and purity of the extracts, as well as to prevent the reduction of the product value (Carullo et al., 2022; Luengo et al., 2013; Pataro et al., 2017). To this purpose, pulsed electric fields (PEF) as a promising and innovative technology was chosen for establishing the sustainability of the novel approach for developing a green extraction method. However, so far, only a few works demonstrated the feasibility of PEF technology to intensify the recovery yield of phenolic compounds from cherry by-products (Pataro et al., 2017) and studied the effect of different field strengths (E) at constant total specific energy input (W_T) on the subsequent extraction yield of bioactive compound from sweet cherry by-products. Furthermore, in order to maximize the benefits and advantages of PEF-assisted extraction over conventional SLE, the entire PEF-assisted extraction process should be optimized. To the best of our knowledge, response surface methodology (RSM) has not been used as a tool for optimizing the main variables involved in the traditional SLE process in order to maximize the extractability of bioactive compounds from cherry by-products.

Therefore, the objective of the research was to intensify the extractability of valuable compounds with high antioxidant activity from sweet cherry press cake by using the optimal pulsed electric field-assisted extraction conditions found in previous research (Pataro et al., 2017) in terms of field strength (E = 3 kV/cm) and energy input (W_T = 10 kJ/kg). SLE for both untreated and PEF-treated samples was optimized to determine the most effective combination of extraction temperature (20-50 °C), extraction time (30-360 min), solvent concentration (0–50% ethanol in water and solid-liquid ratio 1/5 (w/v). Total phenolic content (TPC), flavonoid content (FC), anthocyanin content (AC), and antioxidant activity (FRAP) of the obtained extracts from sweet cherry press cake were determined. The extracted compounds from untreated and PEF-treated samples at optimal conditions were analyzed via HPLC-PDA analysis.

The results showed that at a fixed extraction temperature (50 °C), the application of PEF at optimal processing conditions (E=3 kV/cm, W_T=10 kJ/kg, for cherry press cake extracts) and prior to SLE process has the potential to reduce, the solid/liquid ration (25%) and shorten the extraction time (3%) to achieve the same recovery yield of phenolic compounds, as compared to control extraction. Under optimized conditions, the extracts obtained from PEF-treated cherry press cake can either enhance the extractability of high-added value molecules, respectively increasing the release of TPC (+22.9%), FC (+15.4 %), AC (+46.8 %), and improving the antioxidant power of the extracts, FRAP (+22.6%), as compared with control extraction. HPLC analyses revealed that epicatechin, p-coumaric acid, and quercetin were among the main phenolic compounds extracted, and no degradation phenomena occurred due to PEF application. Moreover, it was also shown that the application of PEF pre-treatment did not affect the composition of the anthocyanin extracts while greatly intensified the recovery yield of neochlorogenic acid, chlorogenic acid, and cyanidin 3-rutinoside rutin.

Overall, these promising results confirm the potential of an optimized PEF-assisted extraction process to boost the valorization of cherry processing by-products through sustainable recovery with a higher yield of valuable compounds with antioxidant proprieties, resulting in a greater variety of products.

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