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Editorial

Special Issue on "Extraction Optimization Processes of Antioxidants"

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Understanding the importance of extraction optimization processes of bioactive molecules in the food industry is fundamental in the choice of innovative extraction processes involving sustainable procedures and is essential in process design for the isolation of antioxidants, thus preserving their chemical integrity and biological properties. This Special Issue on "Extraction Optimization Processes of Antioxidants" showcases advances in the development, application, and optimization of bioactive isolation techniques. We believe that the progress described by the contributors has significantly helped accomplish this target. In addition to 2 reviews, the Special Issue features 17 research articles, covering a range of topics which highlight the versatility of the research area. The Special Issue is available online at: https://www.mdpi.com/journal/processes/special_issues/Extraction_Optimization_Antioxidants (accessed on 18 July 2023).

The use of the ultrasound-assisted extraction (UAE) method in various contexts and its convenience in food processes has demonstrated numerous benefits. Generally, UAE is applied for the isolation of bioactives from natural sources, for example, the extraction of phenol compounds from plants and agri-food waste. For instance, Soussi et al. [1] found the best solvent mixture for the extraction via UAE of phenols and flavonoids from *Pimpinella anisum* using an experimental design. They first carried out a screening of solvents (polar and nonpolar) to select those that facilitated the highest recovery of total phenol compounds, showing that water, ethanol, and methanol were the most effective. Cavalaro et al. [2] also optimized the extraction via UAE of antioxidants from a medicinal plant (*Baccharis dracunculifolia*) using a central composite rotatable design. They found that the best extraction was obtained with a 99% ethanol solution. A comparison with green propolis extract was also carried out. Their results confirmed that optimization is a key step in ensuring that efficient extraction processes are feasible on an industrial scale. In another paper, for the first time, phenol extracts of the stem of six *Ferocactus* species were obtained via UAE and methanol [3]. Then, their phenol profile was characterized via high-performance liquid chromatography coupled with diode-array detection (HPLC-DAD), and their antiproliferative, antimicrobial, and antifungal activities were evaluated. The authors affirmed that extracts of *Ferocactus* sp. stem are a novel potential source of antioxidants with antimicrobial and anticancer properties. In some cases, the UAE procedure was applied in the case of liquids to study if the content of biocompounds may be improved by the treatments applied. As an example, Brezan et al. [4] reported that black carrot and blueberry extracts could increase the antioxidant capacity of the cider, chiefly in case of ultrasound-treated products. Among green extraction techniques, microwave-assisted extraction (MAE) can be also cited. Saifullah et al. [5] maximized the extraction via MAE of phenols from lemon myrtle and their antioxidant properties by applying the response surface methodology (RSM). A comparison with UAE and shaking water bath (SWB) was also carried out, highlighting that MAE was much faster and required lesser solvent volume in respect to UAE and SWB.

Food processing consists of a series of operations based on mechanical or chemical processes to make raw foodstuffs suitable for consumption, even if a significant amount

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of waste products is produced. Tremendous research interest has emerged in the isolation of bioactives from vegetable foods and, more recently, from agro-food waste, which necessitates new paradigms for understanding how to optimize their extraction. In this regard, the review of Lizárraga-Velázquez et al., 2020 [6] focused on the extraction processes and biological activities (i.e., antihypertensive, antidiabetic, antibacterial, and anticancer properties) of antioxidants (i.e., phenols, sterols, and peptides) from plant waste. The authors reviewed traditional (maceration and hydrodistillation) and innovative (pressurized liquid extraction, supercritical fluid extraction, and enzyme-aided extraction, UAE, and MAE) extraction methods, highlighting advantages and disadvantages. The main goal of the research of Ianni et al., 2020 [7] was the development of the most suitable conditions of the extraction-alkaline hydrolysis protocol, aiming to recover low-molecular-weight phenols (i.e., (*E*)-coniferyl alcohol) from *Quercus* spp. waste, with the aim of potentially extending it to a large scale for lignin degradation processes. Squillaci et al. [8] described a procedure to valorize underutilized olive oil dregs for the preparation of an active antioxidant ingredient, rich in hydroxytyrosol (HT). Their results provided a preparation with high HT recovery and high radical scavenging power, using a weakly polar resin (Amberlite XAD7HP) and a safe solvent (25% ethanol). The same authors [9] investigated the protective property of their HT-enriched extracts against sunflower oil oxidation during storage (4 weeks at 65 °C). The same type of oil, in combination with the essential oil of *Angelica dahurica* cv. Yubaizhi, showed improved antioxidant activity and sensory properties during high-temperature storage (24 days at 65 °C) [10]. Interestingly, an overview of natural extracts rich in carotenoids or phenols toward increasing the oxidative stability and shelf life of vegetable oils, among which are soybean, sunflower, and olive oils, was also published in this Special Issue [11]. An attractive application of supercritical carbon dioxide extraction for the recovery of bioactive compounds (lycopene, *cis*-isomers of lycopene, and β-carotene) from freeze-dried tomatoes was reported by Urbonavičienė et al. [12]. These authors also studied the cytotoxic effect of lycopene extract rich in *cis*-isomers on rat glioblastoma C6 cells. Phenols from *Ruta graveolens* L. and *Artemisia abrotanum* leaves were isolated via UAE and methanol, and they exhibited antibacterial and antifungal activities [13]. The first property was mainly due to quercitrin, isochlorogenic acid, and *p*-coumaric acid, while the second was essentially attributed to isochlorogenic acid and quercetin. Interestingly, methanol extract of *Scabiosa columbaria* leaves could be potentially applied in the treatment of skin hyperpigmentation; in fact, the extract adequately decreased melanin content in B16F10 (mouse melanoma) cells with moderate inhibition of tyrosinase enzyme in a dose-dependent manner [14].

Three research papers studied the effect of storage [15], drying and steeping temperatures [16], and heat treatment and light exposure [17] on phenol content and antioxidant activity. Phenol extracts of whole wheat flour from four cultivars, stored under different conditions at different times, were studied. All determined parameters decreased at the end of the storage period with respect to the initial storage time [15]. Furthermore, Silva-Ramírez et al. [16] studied the volatile composition and sensory properties of *Cunila polyantha* infusions (leaves and flowers), in addition to phenol content and composition and also antioxidant activity. The authors demonstrated the differences in consumer acceptability of the infusions, prepared at different drying and steeping temperatures, highlighting the importance of linking sensory and chemical data to obtain the best sensorial quality and the optimal nutraceutical properties of the infusions. Differently from the other studies, Ioannou et al. [17] investigated six model solutions of flavonoids (i.e., rutin, naringin, eriodictyol, mesquitol, luteolin, and luteolin 7-O-glucoside) after heat treatment and exposure to visible light. The authors affirmed that the aforementioned processing could be an interesting avenue for further study as it induces an increase in the in vitro and in vivo antioxidant activity of the flavonoids, without causing cytotoxicity due to the degradation products obtained.

Optimization via RSM was reported by Quesada-Salas et al. [18] to evaluate the efficiency of three promising technologies of cell disruption (bead milling, microwaves, and

ultrasound) aiming to increase the lipids extraction yield from microalgae (*Nannochloropsis oceanica*, *N. gaditana*, and *Tetraselmis suecica*). They concluded that the best process varied according to the microalga species and the operating conditions applied, taking into consideration also the fatty acid profile. In another paper, the authors optimized the extraction of polysaccharides from *Bletilla ochracea* (BOP) schltr. via RSM, and then they evaluated their antioxidant activity. As little information is available regarding this topic, the author's results highlighted that BOP could be considered a promising antioxidant ingredient for food, medical, and cosmetic applications [19].

In conclusion, all the contributions to this Special Issue of *Processes* establish a solid basis for future investigations aimed at the individuation of optimized conditions for food and waste valorization, addressed at the sustainable recovery of precious bioactives with the perspective of their real application in various industrial fields (i.e., the pharmaceutical, cosmetic, and food industries). We thank all the authors for their important scientific contributions to this Special Issue, as well as the editorial staff of *Processes*, for their kind and active collaboration, without whose efforts this project could not have been a success.

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