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Editorial

Phenolic Compounds and Functional Beverages

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The rise in the prevalence of non-communicable diseases (NCDs) over the last few years has promoted the need to afford consumers with accurate health data on food and beverage products as part of their right to health. Indeed, it has been observed that consumers are increasingly aware of healthy and natural diets [1]. As a consequence, nowadays, the food and beverages industry faces new challenges to design functional foods. There are different types of functional foods, such as functional beverages, dairy products, snacks and baked products, meat products and spreads. Among them, beverages are the most acceptable functional foods due to facilities in the logistics and their distribution as well as the easiness of incorporating bioactive compounds as functional ingredients [2]. Furthermore, the demand for functional beverages with health benefits has grown rapidly. However, the design and formulation of new products to fulfil consumer requirements is still a challenge for the beverages industry. Based on the aforementioned, broad research must be performed to respond to the challenges derived from this increasing demand [3]. Wide scientific data regarding bioactive compounds' chemistry, occurrence, nature, extraction technologies and health-related effects must be gathered. Likewise, the effect of technological processing and matrix effects must be evaluated to properly formulate a functional beverage.

In this context, this Special Issue compiles new findings in the field to develop well-designed functional ingre dients and beverages and explore new products. Among the wide range of bioactive compounds, phenolic compounds arise as appealing ingredients in the formulation of functional beverages based on their higher bioactivities and widespread nature. A growing build-up of research has described the use of several fruits and vegetables in the formulation of functional beverages. Likewise, more recently, the use of phenolic compounds from food by-products and agri-food wastes in the fortification of beverages in a circular economy approach has gained a lot of attention. Hence, this Special Issue focuses on the use of phenolic compounds as new ingredients in the design of functional beverages. A wide perspective is herein endorsed, from the different extraction methods of phenolic compounds to their characterization, effects on beverage processing and health-related effects.

Phenolic compounds are secondary metabolites from the plant kingdom. Chemically, the phenolic compounds possess an aromatic ring bearing one or more hydroxyl substituents, including functional derivatives (esters, methyl ethers, glycosides, etc.). Different structural classifications have been proposed, but the most widely used one divides phenolic compounds into flavonoids and non-flavonoids. Flavonoids are subsequently divided into anthocyanins, flavanols, flavonols, isoflavones, flavanones and flavones and non-flavonoids are grouped into phenolic acids, lignans and stilbenes. Phenolic compounds appear in nature glycosylated, acylated and polymerized, which confer high structural variability. Indeed, to date, more than 8000 different structures of phenolic compounds with different bioactivities have been identified [4]. This structural diversity of phenolic compounds joined with the difficulties associated with the chemistry that discloses their bioactivities, open an exciting field of research. Extraction technologies play a pivotal role in the achievement of desired phenolic compounds with a proper preservation of their structure and reactivity [5]. Hence, a research paper by Lakka et al., 2020 [6], included in

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this Special Issue, evaluates the use of cyclodextrins as green food-grade cosolvents in the aqueous extraction of phenolic compounds from waste orange peels. An efficient green method was validated, obtaining an extraction selectivity depending on the cyclodextrins used. Likewise, Adjé et al., 2019 [7], have used a combined technique in a multistep process including ultrasound-assisted extraction (UAE), cross-flow microfiltration (CFM) and reverse osmosis (RO) to extract phenolic compounds from the red aqueous beverages of Carapa procera (D.C.) leaf extracts. Furthermore, the phenolic compounds were characterized using HPLC-DAD, HPLC-ESI-MS and semipreparative HPLC.

Phenolic compounds have been described as highly reactive antioxidants with anti-inflammatory properties, which renders them useful tools in the prevention and treatment of several NCDs, such as cardiovascular diseases, metabolic disorders, neurodegenerative and aging diseases or several types of cancer [8]. In this context, Quader et al., 2020 [9], summarized the ability of phenolic compounds from juices, coffee, cocoa and wines to modulate Nrf2 activity in cellular systems. This review, embedded in this Special Issue, contains results from in vitro and in vivo studies. The proposed mechanisms deal with the antioxidant capacity of phenolic compounds, which are able modulate transcription factors through their ability to quench reactive oxygen and nitrogen species (RONS) or reactive free radicals and further protect against reactive oxygen species (ROS)-mediated oxidative damage.

Besides the health-related effects, phenolic compounds are closely associated with the organoleptic properties of fresh and processed plant foods [10]. Some phenolic compounds have been described as directly related to the astringency and bitter taste sensation, which plays a pivotal role in certain beverages such as coffee, beer or wine. Indeed, the sensory attributes of beverages containing phenolic compounds can be correlated with the composition. However, processing can directly affect the phenolic compound's profile. Hence, Nguyen et al., 2020 [11], analyzed the influence of drying temperature on the total phenolic content and antioxidant capacity of dried Roselle, and the effects of brewing conditions, including water temperature, liquid–solid ratio and brewing time, on the total soluble solid content, total phenolic content and the antioxidant capacity of Roselle tea. Results derived from this study showed how the combination, with drying at 80 °C and the brewing of dried Roselle for 30 min using 90 °C hot water (1:10 *w/v*), are recommended to produce Roselle tea with the highest content of phenolic compounds.

Leaving aside the above considerations, Pinto et al., 2021 [12], reviewed the literature regarding consumer preferences in a broad approach. Phenolic compounds are bioactive compounds that naturally occur in fruits and vegetables, being considered as "natural" or even endogenous sources of bioactive compounds, which clearly affect consumer preferences. Besides used as antimicrobial and antioxidant agents, phenolic compounds, namely anthocyanins, have been described as food colorants. Anthocyanins are a ubiquitous group of phenolic compounds with a particular interest in the beverage industry given their ability to be used as colorants. Moreover, phenolic acids and tannins have been mainly related to taste. Furthermore, information about phenolic compounds' bioaccessibility, bioavailability and bioactivities were also gathered to summarize the potential use of phenolic compounds as ingredients with pleasant and functional properties.

Phenolic compounds have additional technological impacts and can also be used as preservative agents [10]. Indeed, phenolic compounds have been described as antimicrobial agents. Zokaityte et al., 2020 [13], studied the antimicrobial properties of milk permeate fermented with probiotic strains and berry/vegetable (B/V) pomace (gooseberries, chokeberries, cranberries, sea buckthorn, rhubarb).

Moving from the fundamental research to the real application of phenolic compounds as ingredients in the formulation of functional beverages, Adadi et al., 2020 [14], evaluated the use of Tetrapleura tetraptera (TT) and Hibiscus sabdariffa (HS) as cheap and readily available materials in designing functional flavored pito, a sorghum beer from northern Ghana and parts of other West African countries.

Overall, the research findings compiled within this Special Issue will help to validate the use of phenolic compounds as a powerful tool in the design of functional beverages. Multidisciplinary scientific data were herein embedded from the combined fields of natural products, food technology, analytical chemistry, biochemistry and molecular biology.

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