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Editorial

Potential Health Benefits of Fruits and Vegetables III

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Over the past few decades, there has been a marked increase in public awareness about the connection between nutrition and the prevention of chronic diseases [1,2]. Plant-based foods, particularly fruits and vegetables, have become essential components of a healthy diet due to their rich content of bioactive phytochemicals [3,4]. These natural compounds have been widely recognized for their role in supporting health and reducing the risk of disease [5]. A broad spectrum of scientific research has focused on profiling the phytochemical constituents of various fruits and vegetables [6,7], as well as exploring the biological mechanisms through which they exert beneficial effects [8,9]. This Special Issue aims to present cutting-edge findings on the chemical composition of these foods and to explore their health-enhancing properties, drawing from evidence gathered through a range of experimental approaches, including in vitro studies, animal models, and clinical trials.

This Special Issue features 12 original papers, including nine research articles and three review papers. A common starting point in this field of research is the assessment of antioxidant properties and the profile of bioactive compounds in fruits and vegetables. This is typically achieved by examining their composition under various conditions, such as genotype, environmental factors, farming practices, and post-harvest handling.

In line with this focus, almost half of the research articles (four out of nine) explore the phytochemical content of plant-based foods—specifically, one study on vegetables and three on fruits. Starting from the manuscript that explores the quality of a vegetable matrix, the article examines how cryogenic grinding—a process in which materials are ground at extremely low temperatures using liquid nitrogen—affects the nutritional and antinutritional components of rapeseed cake, a by-product of oil extraction (Contribution 1). Traditionally, rapeseed cake has been used in animal feed; however, its potential for broader applications is limited by the presence of antinutritional factors, such as glucosinolates, tannins, and phytic acid. These compounds can interfere with digestion and the absorption of nutrients. The study finds that cryogenic grinding significantly reduces these unwanted substances, improving the nutritional profile of the final product. Additionally, because cryogenic grinding prevents the heat buildup typical of conventional grinding methods, it helps preserve sensitive nutrients, such as proteins, amino acids, and lipids. This means the ground rapeseed cake retains more of its original nutritional value. The resulting powder also has a finer and more uniform particle size, which improves bioavailability and enhances its functional properties, making it more suitable not only for animal feed but also as a possible ingredient in human food products. In conclusion, the article highlights cryogenic grinding as an effective technique to enhance both the nutritional quality and functional potential of rapeseed cake, opening new opportunities for its use in the food and feed industries. The other three studies on the topic of nutritional quality have highlighted

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the promising role of fruit pomaces and medicinal plant materials as natural sources of enriching nutritional and bioactive compounds. One noteworthy example is the use of black chokeberry (*Aronia melanocarpa* L.) pomace in wheat bread, which has shown significant potential to enhance both the nutritional value and antioxidant capacity of bakery products (Contribution 2). Specifically, the addition of chokeberry pomace at a level of 3% relative to flour content resulted in a marked increase in dietary fiber and total phenolic content, leading to improved antioxidant activity in the final product. However, higher concentrations negatively affected dough rheology and bread volume, as well as intensified the dark coloration of the crumb, factors that can influence consumer acceptability. These results suggest that low-level incorporation strikes a balance between nutritional enhancement and sensory quality. In a similar context, the application of fruit pomaces (including chokeberry, cherry, and blackcurrant) in the production of gluten-free extruded snacks has demonstrated substantial improvements in both nutritional and functional attributes (Contribution 3). For example, the incorporation of 20% chokeberry pomace into corn-based formulations significantly boosted the total phenolic and anthocyanin content, with increases up to tenfold compared to controls, without compromising essential technological parameters such as expansion ratio and texture. These findings reinforce the potential of fruit-derived by-products as effective natural enhancers of antioxidant activity and dietary quality in gluten-free processed foods. Extending beyond processed food systems, a comparative study on milk thistle (*Silybum marianum*) fruits from organic and conventional farming revealed nuanced differences in phytochemical composition and microbiological quality (Contribution 4). While the overall silymarin and oil content were comparable across both cultivation systems, organic samples were notably richer in silydianin and silychristin compounds known for their hepatoprotective properties. Interestingly, despite showing higher microbial counts (including mesophilic bacteria and molds), the organic fruits remained within acceptable safety limits. Moreover, extracts derived from organic milk thistle exhibited greater antimicrobial activity, particularly against *Staphylococcus aureus*, suggesting additional therapeutic potential associated with cultivation practices. Taken together, these studies illustrate the multi-faceted benefits of integrating fruit pomaces and phytochemical-rich plant materials into food systems. Beyond enhancing nutritional density and antioxidant capacity, such ingredients contribute to the functional, sensory, and microbial profile of food products, offering sustainable strategies for waste valorization and health-oriented product innovation.

Beyond compositional studies, a further step in assessing the health benefits of bioactive compounds in fruits and vegetables involves investigating additional biological activities, such as antimicrobial, bactericidal, and anticancer properties. In this Special Issue, three of the research articles specifically address these functional aspects, further supporting recent investigations that have underscored the biomedical and nutraceutical relevance of fruit-derived phytochemicals and their role in modulating cellular and microbial processes. The hydroethanolic (50%) extract of *Plinia cauliflora* fruit has demonstrated dual bioactivity of significant interest (Contribution 5). In vitro assays revealed a potent inhibitory effect against the single-stranded DNA-binding protein (SSB) of *Klebsiella pneumoniae*, a key factor in bacterial DNA replication and repair, with an IC_{50} of 73 ± 8 μg/mL, suggesting potential antibacterial applications through interference with the replication machinery. Simultaneously, the same extract exerted pronounced cytotoxic effects on B16F10 murine melanoma cells, as evidenced by a dose-dependent reduction in cell viability, decreased migratory capacity, and activation of apoptotic pathways, indicating its promise as a multifunctional antitumor agent that acts through mechanisms involving redox imbalance and pro-apoptotic signaling. In the context of nutrient bioavailability, a comparative analysis of L-citrulline uptake from watermelon flesh, rind, and peel using the Caco-2 human intestinal

epithelial cell monolayer model revealed differential permeability profiles (Contribution 6). While the flesh possessed the highest intrinsic citrulline concentration, peel extracts exhibited superior intestinal transport rates, potentially due to interactions with dietary fiber or coexisting polyphenolic compounds that influence paracellular transport and active uptake mechanisms. These findings highlight the potential of underutilized anatomical fractions of watermelon as functional ingredients with improved bioaccessibility profiles, thereby supporting sustainable valorization strategies. Further supporting the health-protective properties of fruit-derived compounds, ethanolic extracts of strawberry (*Fragaria* × *ananassa*) and kiwifruit (*Actinidia deliciosa*) were evaluated for their radioprotective capacity in vitro (Contribution 7). Both extracts significantly mitigated DNA damage and oxidative stress in irradiated models, correlating strongly with their high total phenolic content, antioxidant activity (as measured by DPPH and FRAP assays), and ascorbic acid levels. These effects were attributed to synergistic interactions between flavonoids, phenolic acids, and vitamin C, which collectively scavenge free radicals and stabilize cellular redox balance. Together, these studies highlight the multifaceted bioactivity of fruit-derived extracts, ranging from antibacterial and anticancer mechanisms to enhanced nutrient bioavailability and radioprotection, underscoring their potential applications in the development of functional foods, dietary supplements, and adjunct therapeutic formulations.

The final stage in assessing the potential health benefits of fruits and vegetables involves in vivo testing, encompassing studies on both animal models and human participants; in this Special Issue, two research articles contribute to this phase by reporting findings from in vivo experiments conducted on mice, investigating the protective effects of plant-derived extracts in two distinct models of inflammation and tissue injury. In a DSS-induced rat model of inflammatory bowel disease (IBD), supplementation with fermented onion notably improved intestinal health compared to fresh onion or probiotic controls (Contribution 8). Specifically, high-dose fermented onion (20 g/kg) significantly preserved colonic crypt architecture, increased goblet cell density, and augmented mucosal thickness, while also restoring short-chain fatty acid (SCFA) levels—particularly butyrate, acetate, and propionate—and reducing systemic IgA/IgG titers and pro-inflammatory cytokines (IL-6, TNF-α, IL-1β). These results suggest that fermentation enhances the conversion of FODMAPs and enriches bioactive compounds, such as quercetin, thereby mitigating inflammatory damage more effectively than fresh onion. In a parallel study utilizing a mouse model of particulate matter ($PM_{2.5}$)-induced pulmonary injury, oral administration of immature Asian pear (*Pyrus* spp.) extract yielded dose-dependent protective effects (Contribution 9). Treatment inhibited oxidative stress markers, including decreased glutathione (GSH), superoxide dismutase (SOD), and catalase (CAT) activity, while reducing lipid peroxidation (MDA) and downregulating inflammatory mediators, such as TNF-α, IL-6, CXCL1, and CXCL2. Mechanistically, the extract suppressed the activation of the NF-κB, p38 MAPK, and PI3K/Akt signaling pathways and preserved the expression of the tumor suppressor PTEN, demonstrating efficacy comparable to dexamethasone in mitigating $PM_{2.5}$-triggered subacute lung injury.

The remaining three contributions in this collection are review articles, each offering an in-depth examination of topics related to the health-promoting properties of fruits and vegetables from nutritional, agricultural, and environmental perspectives. One review critically evaluates the benefits and limitations of a whole-foods approach to increasing dietary nitrate intake, highlighting the need to move beyond the current emphasis on beetroot juice toward a more diverse and sustainable strategy involving a variety of nitrate-rich plant foods (Contribution 10). Another review examines the role of organic horticultural practices in simultaneously mitigating climate change and enhancing the nutritional quality of fruits and vegetables, with a focus on phytochemical enrichment and soil health (Contribution 11).

The third review revisits the functional properties of red beetroot (*Beta vulgaris*), emphasizing its continued relevance as a nutrient-dense superfood, rich in nitrates, betalains, phenolic compounds, and saponins, which contribute to its antioxidant, anti-inflammatory, and cardioprotective effects (Contribution 12). Collectively, these articles underscore the importance of integrating whole-food dietary strategies, sustainable agricultural systems, and bioactive-rich crops to support both human health and ecological resilience.

In summary, this Special Issue offers a comprehensive and multifaceted contribution to the expanding body of research on the health-promoting properties of fruits and vegetables. The collection spans detailed compositional analyses and innovative processing approaches, as well as functional assessments conducted through in vitro and in vivo models, culminating in broad, integrative reviews that contextualize these findings within larger nutritional, agricultural, and environmental frameworks. Together, these contributions not only advance our understanding of the bioactive compounds present in plant-based foods but also illuminate the mechanisms by which they may exert protective effects against various chronic conditions. Importantly, this volume highlights the importance of interdisciplinary approaches, which bridge food science, nutrition, pharmacology, and agronomy, to support both human and planetary health. Building on the foundation laid by the previous Special Issues, "Potential Health Benefits of Fruits and Vegetables I" and "Potential Health Benefits of Fruits and Vegetables II", this third installment further consolidates the scientific rationale for promoting fruit and vegetable consumption as a key component of preventive health strategies. Moreover, it sets the stage for the forthcoming fourth edition, which will continue to explore emerging trends, novel methodologies, and translational insights into the role of plant-based diets in disease prevention and health optimization. The collective findings presented here reaffirm the critical importance of fruits and vegetables not only as nutritional staples but also as dynamic sources of bioactive agents that can contribute meaningfully to sustainable health solutions.

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