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Editorial

Nutritive Value, Polyphenolic Content, and Bioactive Constitution of Green, Red and Flowering Plants

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Plants, including vegetables are a well-known source of health-promoting phytochemicals (plant secondary metabolites) that take part in several physiological processes and play a major role in plant defense and adaptation, in particular plant–environment interactions. The accumulation of these health-promoting phytochemicals depends predominantly on genetic factors and the phenological stage; nonetheless, pre-harvest factors, e.g., eustress, fertilization, irrigation, light, biostimulant application and other agronomic practices, interfere in modulating and shuffling these phytochemicals. Nowadays, healthier lifestyles are strictly related to plant consumption, especially functional foods rich in bioactive phytochemicals or "ecochemicals", knowing that low occurrence of chronic diseases are well correlated with a vegetable-rich diet. Such vegetables are nutrient dense, endowed with bioactive content that boosts the nutritional quality of food and food security particularly.

The current Special Issue, "Nutritive Value, Polyphenolic Content, and Bioactive Constitution of Green, Red and Flowering Plants", compiles 11 original research articles focusing on the quality of seeds, microgreens, leafy vegetables, herbs, flowers, berries, fruits, and by-products. This Special Issue gathers scientific papers from several research groups around the world, where preharvest and postharvest factors were assessed regarding their effect on the qualitative aspects of the different plants tested.

The quality of leafy vegetables is largely dictated by the level of nitrate present in the leaves, notwithstanding the high nutritional components presented by this commodity, especially given that leafy vegetables tend to accumulate nitrate under adverse conditions (low light or high fertilization rate). This accumulation in plant tissues is also related to N type, uptake, and metabolism. For this purpose, Di Mola and coworkers [1] assessed the quality and yield of *Spinacia oleracea* L. in relation to light and fertilization in greenhouse conditions in a winter season under Mediterranean conditions. The authors tested two greenhouse plastic films with different optical characteristics (clear and diffused light films) in combination with different nitrogen fertilization regime (optimal, sub-optimal, and unfertilized) to determine the effect on the quality and yield of spinach. Fertilization treatments and diffused light film decreased the lightness of spinach leaves. Although this film increased the yield by 22.3%, it decreased total ascorbic acid content and dry matter percentage by 61.2 and 8.5%, respectively, though it increased nitrate by 6.3-folds compared to the clear plastic film treatment. As for fertilization, the sub-optimal treatment did not decrease the yield significantly, it increased total phenols by 16.1% and decreased nitrate by 38.6% when compared to optimal fertilization. The authors suggested the feasibility of using the diffused film in winter to boost spinach yield, but with marginal quality depression since the nitrate did not reach the legal limit fixed by the European Commission. Petropoulos et al. [2] studied nutrient solution as well on the yield, mineral profile, and phytochemical composition of spinach microgreens, but in a controlled growth chamber. Nutrient deficiency stress could generate a positive effect on crop quality, based on its level, thus reducing the production cost and increasing the concentration of secondary metabolites. Based on this background, the authors applied four different nutrient solution (Hoagland) feeding regimes of 0, 5, 10 and 20 days to grown *Spinacia oleracea* L. microgreens

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in a peat-based substrate. The increase in feeding days increased linearly with fresh yield and nitrate content of the produced microgreens. The 20 day feeding regime resulted in the highest fresh yield (1.59 kg m^{-2}), ABTS antioxidant activity, total chlorophylls, lutein, β-carotene, quercetin-3-sophoroside-7-glucoside, and patuletin derivative. The 10 day feeding regime did not significantly reduce total phenols compared to 20 days, in contrast to 0 and 5 days, which decreased these secondary metabolites in a significant way and, concomitantly, increased P, K, Ca, and Mg, based on a fresh weight basis. The authors concluded that the 10 day feeding regime proved to be cost-effective and a quality booster, since the content of nitrate was reduced by 70.7% and total ascorbic acid increased by 7.0%, and there was no significant decrease in total phenols or higher dry matter content when compared to the 20 day feeding regime; however, it was compromised due to a 12.6% yield decrease.

El-Nakhel et al. [3] grew *Daucus carota* L. and *Anethum graveolens* L. as microgreens in a floating raft technique under greenhouse conditions. The authors opted for this innovative technique for microgreens, to apply biostimulants (vegetal-based protein hydrolysate) in direct contact with the root system, thus testing how this legume-derived biostimulant would improve the yield, colorimetric parameters, minerals, carotenoids, free amino acids, and other secondary metabolites of these two species belonging to the Apiaceae botanical family. Microgreens are known to be a rich asset of minerals and bioactive metabolites, in addition to offering a range of particular tastes and alluring colors. The addition of protein hydrolysate at a dose of 0.3 mL L^{-1} in this experiment engendered an increase in dill fresh yield (13.5%) and an increase in carrot dry matter % and led to a significant improvement in the canopy colorimetric indices (a*, b*, and Chroma). The biostimulant treatment caused an increase in Ca, S, total chlorophylls, carotenoids, soluble proteins (20.6%), and free amino acids (18.5%) for both species, an increase in anthocyanins (461.7%) and total phenols (12.4%) for carrot, and an increase in total ascorbic acid (17.2%) and nitrate for dill microgreens. Seeds of the same botanical family, Apiaceae, were assessed for their nutritional value by Golubkina and coworkers [4]. Such seeds are highly appreciated for their value in traditional medicine and for their utilization as spices. The authors aimed at evaluating the biochemical profile of 11 species and 43 cultivars grown under similar conditions. Lovage and anise seeds were characterized by the highest total antioxidant activity, total phenolics, and water-soluble proteins. Moreover, some celery cultivars demonstrated high total phenolics, while fennel and coriander revealed high water-soluble proteins as well. Regarding total dissolved solids, fennel and stem celery (cv. Atlant) were the richest. The authors concluded that lovage, anise, parsley, and celery seeds contain the highest levels of antioxidants, and through this comparative study it was possible to orient the choice and implement selected Apiaceae seeds as natural food preservatives and dietary supplements.

Protected cultivation, such as growing modules, facilitate the modulation and management of plant growing conditions to improve qualitative attributes. In this situation, vapor pressure deficit (VPD) is a crucial microclimate factor influencing plant transpiration rate and subsequently physiological and biochemical responses associated with transpiration. With this in mind, Amitrano and collaborators [5] cultivated two differentially pigmented butterhead lettuce cultivars under different VPDs (0.69 and 1.76 kPa) to evaluate any potential shuffling of minerals, phytochemicals, antioxidant capacity, growth, and morpho-physiological parameters. Low VPD caused an increase in both lettuce cultivars fresh and dry biomass, leaf number and area, and a higher Fv/Fm ratio. In addition, lettuce cultivars under low VPD accumulated less nitrate. Under the same conditions, the red cultivar accumulated more calcium, magnesium, and malate, whereas the green cultivar accumulated more phosphorus. On the other hand, a high VPD boosted total ascorbic acid in both cultivars, whereas it boosted phenols and antioxidant activity in the green cultivar by 16.1 and 8.1%. Such results shed light on high VPD as a mild stress, aiming to enhance leafy greens quality. Additionally in protected cultivation, Chowdury et al. [6] cultivated kale, but in a plant factory under different environmental conditions. Kale is considered a nutrient dense leafy vegetable, endowed with medicinal properties. The aim of the authors was to estimate glucosinolates and anthocyanins accumulated in this crop based on diffuse spectral reflectance using regression methods, especially that reflectance spectroscopic techniques are alternative non-destructive techniques. In this study, the applied wavelengths ranged from 300 to 1050 nm, and the used regression procedures to relate the spectral data to the functional components were: (i) principal component regression; (ii) partial least squares regression; and (iii) stepwise multiple linear regression. The authors found that the last model performed better than the others, and they identified wavelengths in the early near-infrared region to estimate glucosinolates and anthocyanins. However, progoitrin and glucobrassicin were the most detected glucosinolates, whereas cyanidin and malvidin were the most detected anthocyanins in the laboratory analysis.

In the same category of greens, curly endive grown in open field was assessed under iodine biofortification, with the knowledge that approximately 45% of European inhabitants are distressed by iodine deficiency, as declared by the World Health Organization. Sabatino et al. [7] aimed to evaluate the outcomes of four levels of iodine foliar application (0, 50, 250, and 500 mg L^{-1}) on yield, mineral profile, sugars, and bioactive compounds of curly endive (*Cichorium endivia* L., var. *crispum* Hegi). An increasing dose of I decreased head fresh weight and soluble solid content gradually, but did boost calcium, total phenolics, and ascorbic acid. In addition, fructose and glucose were boosted until a dose 250 mg L^{-1}. Biofortification was mostly accentuated at 250 mg L^{-1}, particularly in fall. Bioactive phenols are highly present in medicinal plants, and numerous plants around the globe are implicated in traditional remedies against type 2 diabetes. In this context, Bljajic and collaborators [8] assessed the activity of hydroethanolic and aqueous extracts of traditional antidiabetics present in Croatian ethnomedicine. For this purpose, extracts from *Achillea millefolium*, *Artemisia absintium*, *Centaurium erythrae*, *Morus alba*, *Phaseolus vulgaris*, *Sambucus nigra* and *Salvia officinalis* were assessed for their chemical composition, antioxidant ability, and α-glucosidase inhibiting activity. Rutin, ferulic, and chlorogenic acid were well present in the extracts, as revealed by HPLC analysis. The content of phenolics was correlated with ABTS and DPPH radical scavenging activity, enzyme inhibiting properties, and reducing properties (towards Fe^{3+} and Mo^{6+}), with better efficacy from ethanolic extracts. *S. officinalis* (leaves) and *A. millefolium* (areal parts) ethanolic extracts were characterized as having notable antioxidant activity and being inhibitors of α-glucosidase. Chromium, a mineral that boosts the action of insulin was only detected in *A. absinthium*. The authors suggested that the investigated plants embody a potential alternative for complementary treatment of diabetes and its complications.

The introduction of plant cultivation in space includes an investigation of cosmic radiation effects on plant growth and development. For this reason, Dzhos et al. [9] studied tomato seeds after half a year of storage in the International Space Station, by depicting the quality and biochemical characteristics of tomato fruits originating from the cultivated seeds (*Solanum lycopersicum* L. cv. Podmoskovny ranny dwarf type). Space-stored seeds generated higher plants, yield, and fruit weight, but lower fruit dry matter percentage. The same seeds also induced lower nitrate accumulation and higher β-carotene in both cultivations, whereas lutein and lycopene were significantly higher, though only in field conditions; moreover, the ascorbic acid and antioxidant activity of fruits (space-stored) were higher under greenhouse conditions, while total phenolics were higher in both conditions from the same seeds. However, space-stored seeds induced a decrease in fruit iron and copper, total sugar, titratable acidity, and taste index. Numerous processing techniques are convenient to assure shelf-life extension, as well as the quality and safety of plant food products. In this context, Araujo-Rodrigues et al. [10] investigated the impact of freezing, hot air drying, and storage time on the antioxidant capacity and bioactive compounds of pulps and powders of baby carrot and cherry tomato by-products. This study revealed the high nutritional and functional value of these by-products when converted into pulps or powders, showing a high content of phenolic compounds, carotenoids, and tocopherols. Nonetheless, the drying process decreased polyphenolic content, carotenoids, and antioxidant capacity, but dry by-products guaranteed stability during the selected storage. However, α-, β-, γ- and δ-tocopherol in tomato and γ-tocopherol in carrot increased significantly during freezing storage and after the drying process. The authors in this study demonstrated that these processing methods engender value-added products with high nutritional profile and microbiologically safe and pose an interesting economic and environmental impact. An appreciated plant beverage product is wine, where the quality relies on detecting the optimal maturity of grapes at harvest, which determines the main biochemical parameters of the berry. For this reason, Genovese and coworkers [11] tested the effects of four berry ripening stages (total soluble solids of 18, 20, 22 and 25 ^{0}Brix) on aged "Aglianico" wine, where they assessed key secondary metabolites, phenolics, and volatile compounds. The grape maturity degree increased wine color intensity, the level of anthocyanins, and total *trans*-resveratrol. Grapes issued from late harvest of Vitis *vinifera* L. cv. "Aglianico" produced wines richer in aliphatic alcohols, esters, acetates, benzyl alcohol, and α-terpineol. Eventually, grapes of 25 ^{0}Brix soluble solids content produced wines with more biologically active phenolic compounds and a stable color, as well as being richer in aroma compounds.

Conflicts of Interest: The author declares no conflict of interest.

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