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DIETARY POLYPHENOLS: AN OVERVIEW

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ABSTRACT: Dietary polyphenols, mainly phenolic acids and flavonoids, are the primary sources of antioxidants that can be generally recommended for human consumption. Polyphenols are derived from plant-based food, including fruits, vegetables, spices, herbs, *etc*. In the present era, there has been a great interest in the health benefits of dietary polyphenols against oxidative stress-related diseases such as diabetes mellitus, cancer, chronic kidney disease, *etc*. Here, the content presents an overview of dietary polyphenols in the context of relevance to human health.

Keywords: Antioxidant activity, Chronic diseases, Polyphenols

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INTRODUCTION: Polyphenols are the largest group of phytonutrients that exert different biological activities that are beneficial to human health. Fruits, vegetables, cereals, and plant-derived beverages such as fruit juices, tea, coffee, and red wine are the main dietary sources of polyphenols. It is found that human consumption of polyphenols is, generally higher than any other phytonutrient or dietary antioxidant [1, 2, 3]. The scientific and research interest in biological activities of polyphenols for maintaining human health approximately started in the late 1980s and tremendous progress has been made to date [4, 5]. Polyphenols are widely distributed in the plant kingdom. More than 8,000 distinct polyphenol structures are reported and identified from different plants [6].

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Polyphenols are the products of secondary metabolism and can vary from simple phenolic acids to highly polymerized molecules such as tannins. Polyphenols exist primarily in conjugated forms with one or more sugar residues, via glycosides, linked to one or more of the many hydroxyl groups [4, 7]. Polyphenols can be classified according to their source of origins such as tea polyphenols, grape polyphenols, and apple polyphenols, or their chemical structures. When the basic chemical structure is of concern, polyphenols can be divided into basic groups as lignans, phenolic acids, flavonoids, stilbenes [8].

The most common and important low molecular weight phenolic compounds are simple phenolic derivatives and flavonoids [9]. Phenolic acids are simple molecules such as caffeic acid, vanillin, and coumaric acid that account for approximately one-third of the total dietary intake of polyphenols. Many flavonoids present in plants as aglycones although they are most commonly found as glycoside derivatives. Flavonoids account for the remaining two-thirds. Flavonoids can be further subdivided into classes including flavonols, flavanones, flavanols, flavones, anthocyanins, isoflavones with more than 4,000 described compounds [10, 11, 12].

Occurrence: Polyphenol compounds are distributed in plants at the tissue, cellular, and subcellular levels. However, the distribution of polyphenols is not uniform. Insoluble polyphenols are mainly found in cell walls; however, soluble polyphenols are present within the plant cell vacuoles [13]. Numerous factors affect the polyphenol content of plants, such as climatic and environmental factors, processing, storage, degree of ripeness at the time of harvest, *etc*. The outer layers of plants contain higher levels of polyphenols than those located in the inner parts [10].

In most cases, food contains complex mixtures of polyphenols [14]. Flavonoids are mostly found in all plant-based food; fruits, vegetables, cereals, fruit juices, tea, wine, infusions, etc., whereas flavanones and isoflavones are specific to particular foods [15]. The degree of ripeness considerably affects the concentrations and proportions of various polyphenols [16, 17]. The easy oxidation of the polyphenols may lead to change in the content of polyphenols in plants [16]. Different types of cooking methods also affect the polyphenol content of foods since polyphenols are present in plant vacuoles and in cellular structures that require softening during the cooking process to maximize polyphenol release. However, most of the vegetables can lose 75% to 100% of their initial polyphenol content during boiling, whereas steaming and frying losses are considerably lower than fresh vegetables [18].

Bioavailability: Dietary intake of plant polyphenols can vary considerably and be quite high. However, ultimately, the nutritional impact and subsequent systemic effects depend on the fate of polyphenols in the human digestive tract [19, 20]. Physicochemical characteristics of polyphenols appear to dictate absorption and metabolism and are determined primarily by the chemical structures [6, 7]. Relatively small molecular weight phenolic acids, *i.e.*, gallic acid and isoflavones are easily absorbed through the gut followed by catechins, flavanones, and quercetin glucosides. Larger polyphenols such as proanthocyanidins are very poorly absorbed. The main difficulty with incorporating polyphenols into existing products is to present them in a form that is bioavailable [21]. Accordingly, the total polyphenol metabolite content in plasma or urine after intake of dietary polyphenols is generally low [2, 22]. It was further noted that bioavailability differs greatly from one polyphenol to another and the most abundant dietary polyphenol was not necessarily the one leading to the highest levels of active metabolites in plasma. The maximum plasma concentrations of polyphenol metabolite content are less than 10 μmol/L [23]. The physicochemical characteristics of polyphenols likely contribute to the disparity in results between the epidemiological studies and *in-vitro* data, which may reflect, in part, relatively poor bioavailability, rapid metabolism, and excretion of polyphenols [24].

Scientists are taking efforts to increase the bioavailability of polyphenols, but several considerations and potential impediments exist, including solubility, permeability, metabolism, excretion, target tissue uptake using nanoparticle-based approaches and disposition [21]. Initial strategies for improving the bioavailability of dietary polyphenol supplements include changes to polyphenol structure, which may affect the solubility and dissolution, and the use of pharmaceutical recipients [21]. An additional consideration is that degradation and absorption of polyphenols within the gastrointestinal tract depend on the intestinal microflora and gut enzymes, which may significantly change bioavailability [25].

Metabolism of Polyphenols: Dietary polyphenols are initially metabolized, within the gastrointestinal tract. Glycosides are hydrolyzed to their corresponding aglycones before the absorption, aglycones, and low molecular weight polyphenols are absorbed directly [2]. Polyphenols that are not absorbed are transported to the colon where they can be readily hydrolyzed by colonic microflora to simpler chemical compounds and eliminated in the feces or further modified. Bacterial fermentation of the glycones effectively releases the polyphenol from fiber permitting subsequent metabolism similar to other aglycones [26].

Polyphenols and Human Diseases: Correlations between the intake of polyphenols and reduced incidence of chronic diseases have been firmly established using different *in-vivo* models in the past decades. The in cooperation of polyphenols in the prevention and management of inflammation and oxidative stress related pathologies is emerging [4]. Epidemiological studies have repeatedly shown an inverse association between the occurrence of chronic diseases and the consumption of polyphenolic-rich diet [27, 28]. It is well established that polyphenol-rich foods and beverages may increase plasma antioxidant capacity [2]. This increase in the antioxidative capacity of plasma following the consumption of polyphenol-rich food may be explained either by the presence of reducing polyphenols and their metabolites in plasma, by their effects upon concentrations of other reducing agents *via* sparing effects of polyphenols on other endogenous antioxidants, or by their effect on the absorption of pro-oxidative food components, such as iron [29]. Consumption of antioxidants has been associated with reduced levels of oxidative damage to lymphocytic DNA [30]. There are increasing evidence that as antioxidants, polyphenols may protect cell constituents against oxidative damage and therefore, limit the risk of various degenerative diseases associated with oxidative stress [31, 32].

CONCLUSION: The content outlined in this review provides a general overview of dietary polyphenols, occurrence and content, bioavailability, metabolism, and their relevance to human health. Dietary polyphenols are beneficial against the development and progression of much chronic oxidative stress-related pathological conditions. The role of polyphenols in human health and disease is still an interesting area of research and warranted further scientific studies.

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