Chapter

Bioavailability and Metabolic Pathway of Phenolic Compounds

Muhammad Bilal Hussain, Sadia Hassan, Marwa Waheed, Ahsan Javed, Muhammad Adil Farooq and Ali Tahir

Abstract

As potential agents for preventing different oxidative stress-related diseases, phenolic compounds have attracted increasing attention with the passage of time. Intake of fruits, vegetables and cereals in higher quantities is linked with decreased chances of chronic diseases. In plant-based foods, phenolic compounds are very abundant. However, bio-accessibility and biotransformation of phenolic compound are not reviewed in these studies; therefore, a detailed action mechanism of phenolic compounds is not recognized. In this article, inclusive concept of different factors affecting the bioavailability of phenolic compounds and their metabolic processes is presented through which phenolic compounds go after ingestion.

Keywords: polyphenols, bioavailability, biotransformation, metabolism

1. Introduction

In recent past, the awareness of the consumer related to the effect of diet on the health has been improved; therefore, leading to upsurge in the consumption of vegetables, cereal based foods and fruits. Numerous studies have suggested the bioactive characteristics of the bioactive moieties, i.e., phenolic compounds. Nonetheless, bioactive claims are made without taking into consideration the further modifications to which phenolic compounds are subjected once ingested [1].

Phenolic compounds are the secondary metabolites of plants which constitute an important group, i.e., phenylpropanoids. These compounds possess an aromatic ring and various OH groups which are link to it. On the basis of classification, phenolic compounds are prorated into various subgroups. They are grouped as a function of the number of phenolic rings that they contain and the radicals that bind these rings to another one [2, 3]. Phenolic compounds have fetched substantial focus as the ingestion of these bioactive moieties is correlated to lower the prevalence of chronic ailments, for example, diabetes, CVD and cancer. Cereals, fruits, and vegetables are rich sources of phenolic compounds. In fact, the health benefits of their dietary intake have been related, at least in part, to their phenolic compounds content [4]. This manuscript presents the bird's eye view of the health claims as well as bioavailability of the phenolic compounds.

2. Dietary phenolic compounds

Phenolic compounds are the derivatives of secondary metabolism of plants. Chemically phenolic compounds consist of aromatic ring to which one or more OH^- substituents are attached [1, 5]. Despite of diversity of phenolic compounds, they are mainly divided into two subgroups, (1) flavonoids and (2) non-flavonoids. First one constitutes of heterocyclic oxygen which are bonded with two aromatic rings and depends on the amount of hydrogenation. They can be further subdivided into six subgroups, i.e., flavanol, flavones, anthocyanins, flavonols, flavanones and isoflavones. While the later one, like cinnamic and benzoic compounds, they contain aromatic ring which are attached to organic acids. Lignins, stilbenes and tannins are also the subgroups of non-flavonoid compounds. Characteristics like flavor, astringency and color are instigated due to presence of these compounds [1].

3. Food sources with reported bioactivity

Latterly, due to numerous health prompting effects, for example, antimicrobial [6], neuro-protective [7], antioxidant [8], cardioprotective [9], anti-inflammatory [10] and cancer preventive [11] properties, phenolic compounds have much of the attention of the researchers. Phenolic compounds possess different derivatives which have a potential application in the prevention or treatment of these aliments [12]. Likewise, Perez-Vizcaino et al. reported numerous studies which supports the fact that upsurge in the consumption of foods rich in the phenolic compounds might be linked with the prevention of above-mentioned disorders [13]. Vegetables, fruits and cereals have high concentration of the phenolics. **Table 1** includes examples of some foods rich in phenolic compounds with reported biological effects.

Phenolic compound	Source	References
Phenolic acids (gallic acid)	Red wine	[14]
Anthocyanins (cyanidin, delphinidin, malvidin, pelargonidin, peonidin)	Blackberry, blueberry, black grape, cherry, strawberry, red wine, plum	[15]
Condensed tannins (procyanidin)	Red wine, chocolate, cranberry juice and apples	[16]
Flavan-3-ols (catechin)	Fruits, vegetables, chocolate, lentil, green and black tea, wine, grapes and ginkgo	[17, 18]
Flavanones (hespertin, naringenin)	Orange, grapefruit and lemon juices	[19]
Flavones (apigenin, luteolin)	Parsley, celery, capsicum pepper and grape	[18]
Flavonols (quercetin, kaempferol)	Fruits, vegetables, and beverages such as tea and red wine	[20, 21]
Isoflavones (genistein)	Soy	[22]
Stilbenes (resveratrol)	Legumes, grapes, red wine, soy, peanuts and peanut products	[23, 24]

Table 1.
Phenolic compounds from food sources with reported biological effects.

4. Bioactivities of polyphenols

Since from the ancient times, bioactive moieties extracted from the natural sources have guarantee medicinal characteristics in combating against certain

disorders [25]. These bioactive components have a wide range of potential applications, i.e., antimicrobial, antitumoral, antimicrobial, hepato-protection and antioxidant. Few phenolic compounds show higher free radical scavenging properties individually, while numerous others showed these characteristics in synergism [26]. The free radical scavenging properties generally influenced by the chemical structure, position and number of OH^- group as well as glycosylation or other forms of replacement [27]. Additionally, despite of nullification of the ROS, nitrosative and oxidative stress such as CVD, neurological disorders, diabetes mellitus, cancer, and hypertension have also been prevented by phenolic compounds [28]. Likewise, literature also showed the anti-inflammatory properties of the phenolic compounds [29]. It is observed during the inflammation several RNS (reactive nitrogen species) as well as ROS (reactive oxygen species) are formed which escalate the action of proinflammatory factors. Phenolic compounds limit the pro-inflammatory enzymes thus prevent the human body from adverse effects [30].

In both developed and developing nations, cancer is the major cause of millions of demises each year [31]. For the treatment of numerous aliments, plants are the important ally in the traditional medicine. In pharmaceutical sector natural components impart important proportion in the synthesis of new anticancer drugs [32]. In the treatment of tumor cell, the uses of synthetic moieties are linked with the toxicity problems. Carocho and Ferreira suggested that without any toxicity or side effects natural compounds extracted from plants can be administered. By using both human trial and *in vivo* models, the effects of phenolic compounds on tumor cells have been comprehensively investigated [26]. Huang et al. reported the capacity of phenolic compounds to induce apoptosis by regulate carcinogen metabolism, ontogenesis and cell cycle arrest, suppress cell adhesion and DNA binding, proliferation, migration and block signaling pathways [11]. Similarly, the effects of phenolic compounds against hepatoprotective capacity have also been comprehensively studied both *in vitro* and *in vivo*. Phenolic acid and flavonoids have fetched the attention due to high free radical scavenging properties which overcome liver injuries frequently caused due to oxidative reaction which endorse lipid peroxidation in hepatic tissues [33].

Beside above-mentioned bioactivities, polyphenols have exhibited numerous other health beneficial effects.

5. Bioavailability of phenolic compounds

It is necessary to have the knowledge about the availability of the bioactive component as they are very effect against in the prevention of the disorders. By definition, the concentration of nutrient that is ingested, absorbed and metabolized via normal passages [34]. The bioavailability profile is not directly improved by the intake of high content of phenolic compounds [35]. Rein and his fellows purposed that to guarantee the bio efficacy of phenolic compounds, bioavailability is recognized as ultimate step, for example, at dietary level; the bioavailability is the proportion of a food which is ingested and consumed and thus a matter of nutritional efficacy [36]. Hence, numerous other factors affected may impart interference in the direct bioavailability of the phenolic compounds present in the food. Examples of several external aspects are interaction with other moieties, food processing and various other intestinal factors [37]. Likewise, different and complex processes, i.e., distribution, liberation, elimination, absorption and metabolism phases also affect the bioavailability whereas, limiting factor, i.e., intestinal level absorption decreased the bioavailability [36].

Through the GIT tract, gallic acid and isoflavones which has small molecular weight are easily absorbed [35]. On the other hand, numerous phenolic compounds

of their antioxidant, antimicrobial, and other beneficial effects in the prevention and treatment of certain diseases. The incorporation of these compounds in food can be carried out directly in free form; however, microencapsulation technology has emerged as a very effective and promising strategy to ensure the bioavailability of these compounds and help overcome the problems of food processing and intake [84]. After ingestion, these compounds are absorbed into the blood, causing changes in various cellular mechanisms, thus preventing various diseases. Many kinds of literature have proved the biological activity of phenolic compounds in various plants and fruits, and few studies have reported its application in the development of functional food or nutritional preparations (**Table 3**).

9. Potential toxicity

In recent past years, the potential toxicity of some polyphenols, such as catechins, to DNA of mouse spleen cells has been reported. DNA can be damaged due to high concentration of catechin on spleen cells of mice [100]. In addition, grape extract could also promote sister chromatid exchange induced by mitomycin C in human peripheral blood lymphocyte at a concentration of 75–300 μg/mL [101]. At the same concentration, the mixture of caffeic acid, gallic acid, and rutin hydrate could enhance mitomycin C induced fragmentation. In addition, after 24 h or more of high concentration epicatechin treatment, there was a significant negative effect on fibroblasts and keratinocytes. In addition, compounds with gallate groups showed more potential toxicity than compounds without gallate groups [102]. The results showed that polyphenols could play a positive role in the safe concentration range. However, polyphenol concentration is not the only determinant, and its negative effects are related to synergistic effects and exposure time. Therefore, the dosage and composition of polyphenols should be further studied for safe and healthy application [103].

10. Conclusion

Phenolic compounds, group of antioxidant phytochemicals have health promoting effects and potential to decrease the chances of chronic diseases linked with high consumption of fruits, vegetables and cereals. Several epidemiological studies relate health promoting effects of plant-based foods to phenolic compounds. Still, there is a deficiency of studies and research work regarding metabolic pathway of these compounds; leading to a less understanding of their mechanism of action. Therefore, it's essential to conduct further research to create improved approaches to take advantage of health promoting effects of these compounds.

Conflicts of interest

No competing interest.

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