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Beyond Nutrients: Exploring the Potential of Phytochemicals for Human Health

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ABSTRACT

Phytochemicals are a broad class of bioactive substances that are produced by plants and can be found in a variety of foods, including fruits, vegetables, nuts, and herbs. These phytochemicals, which include dietary fibers, polysaccharides, phytosterols, isoprenoids, carotenoids, and saponins, provide a variety of health advantages, including antiviral, antibacterial, and anti-inflammatory effects. They also have strong antioxidant qualities. This thorough analysis focuses on the several phytochemicals, their origins, and the health benefits that go along with them. Recognizing the variety and advantages of phytochemicals highlights how they might improve human nutrition and health. This article's summary material comes from reliable academic sources such as Pubmed, Google Scholar, and ScienceDirect. This page gives a brief introduction to the many and significant categories of plant-derived bioactive compounds by summarizing the major phytochemical classes, their origins, and their health advantages. Using the advantages of these substances to improve health outcomes points to a viable direction for further study and implementation in the promotion of overall wellness and health.

Keywords: Phytochemicals, Carotenoids, Polyphenols, Bioactive compounds, Phytosterols, Saponins

INTRODUCTION

Plants create bioactive molecules known as phytochemicals to defend themselves. There are many different sources of phytochemicals, including whole grains, fruits, vegetables, nuts, and herbs. To date, over a thousand phytochemicals have been identified [1-3]. Carotenoids, polyphenols, isoprenoids, phytosterols, saponins, dietary fibers, and certain polysaccharides are a few of the important phytochemicals [4]. In addition to having potent antioxidant properties, these phytochemicals have antiviral, antibacterial, antidiarrheal, anthelmintic, and antiallergic properties [5-8]. They also aid in the regulation of gene transcription, the improvement of gap junction communication, the bolstering of immunity, and the prevention of prostate and lung malignancies [9]. The features of functional foods have been expanded by the new emphasis on translational research. Following their extraction from a variety of sources, phytochemicals are widely used in the creation of nutraceuticals and functional foods. Crop type, variety, soil, cultivation environment (region, altitude, and season), and other extrinsic and intrinsic factors influence the type and concentration of phytochemicals in the source crop. The main phytochemicals, their properties, and related health benefits are covered in this article. We made use of relevant published articles from Google Scholar, Pubmed, and Scopus.

Summary of the Main Phytochemicals and Their Associated Health Benefits

Carotenoids

Carotenoids are pigments that are found in plants, algae, and photosynthetic bacteria. They have vivid yellow, red, and orange colors. Carotenoids are found in abundance in fruits, but they are also abundant in vegetables, including sweet potatoes, carrots, pumpkins, and spinach [10]. Tomatoes, carrots, parsley, oranges, daikon radish, cabbage, spinach, fenugreek, round purple turnips, and green leafy vegetables are rich sources of them. Carotenoids that are frequently detected include lutein, zeaxanthin, lycopene, fucoxanthin, α-carotene, and β-cryptoxanthin [9]. The most prevalent carotenoid in most fruits and vegetables is β-carotene, which is followed by α-carotene; major carotenoid in tangerines, persimmons, and oranges is β-cryptoxanthin; green leafy vegetables are the main source of lutein and zeaxanthin; tomatoes are the source of lycopene; and brown algae is the source of fucoxanthin. Among these, lutein, lycopene, and fucoxanthin are potent antioxidants, and α-carotene, β-carotene, and β-cryptoxanthin are the precursors of Vitamin A. Additionally, lutein is crucial for vision. Fine-feature vision is attributed to zeaxanthin, an antioxidant and fat-soluble pigment found in the macula area of the retina [11]. Other health benefits of carotenoids include lutein, α-carotene, and β-carotene regulating gene transcription [9], β-carotene improving gap junction communication [12], β-carotene and lutein enhancing immunity [12], and α-carotene, β-carotene, lycopene, and zeaxanthin protect against lung and prostate cancers [13]. According to reports, fucoxanthin has anti-inflammatory, antihypertensive, anticancer, radioprotective, and anti-obesity properties [14].

Polyphenols

A class of naturally occurring substances with phenolic structures is called polyphenols. There are four main subclasses within this family: lignans, flavonoids, stilbenes, and phenolic acids. Anthocyanidins, flavanones, flavones, and flavonols are other classifications of flavonoids. Artichokes, spinach, broccoli, chicory, flax, onion, apple, plum, pear, grape, and cherry are rich sources of polyphenols. Tea, red wine, and olive oil are among the beverages that are thought to be excellent providers of polyphenols [15]. About 350 aglycones and 100 glycosylate forms make up flavanones, which feature a flavan nucleus made up of two aromatic rings connected by a dihydropyrone ring [16]. The presence of a double bond between C-2 and C-3, along with the attachment of the B ring to C-2, characterizes flavones, a vast class of flavonoids [17]. The hydroxyl group at position three sets flavonols apart from flavanones and creates a double bond between C-2 and C-3. The majority of anthocyanidins in nature are found as their sugar-conjugated derivatives, or anthocyanins, which give fruit and flower tissues their characteristic red, blue, and purple hues [18]. Action against free radicals, defense against cancer, heart disease, and other age-related illnesses, as well as avoidance of inflammation and allergies, are just a few of the health advantages of polyphenols [19–21]. Additionally, flavonoids have been shown to help with gastrointestinal disorders, diabetes, rhinitis, angina pectoris, cervical lesions, chronic venous insufficiency, dermatopathy, lymphocytic leukemia, menopausal symptoms, and traumatic cerebral infarction [22].

Isoprenoids

Terpenoids, or isoprenoids, are a class of naturally occurring substances that include menthol, camphor, limonoids, ubiquinone, terpenes, and sesquiterpenes. These are compounds that are organic and contain two or more hydrocarbons organized in a certain manner. Poplar, oaks, eucalyptus, turpentine tree, juniper, lime, orange, and cannabis all contain these [23]. Among the isoprenoids found in plants are limonene, myrcene, and pinene. The most prevalent monoterpene found in

fragrant plants and fruits is limonene, which gives them a fragrance and flavor reminiscent of lemons. An acyclic monoterpene chemical, myrcene is an alkene found in nature. It's also referred to as the hops and lemongrass active sedative principle. Isoprenoids are beneficial in lowering stress, anxiety, and appetite as well as supporting digestion, having antioxidant potential, promoting sleep, helping to relieve pain, and being effective in Alzheimer's disease [23].

Phytosterols

The collective term for the sterols and stanols found in plants that control their physiological processes is called phytosterol. They have an abundance of olive oil as well as oils from almonds, beans, peanuts, macadamia nuts, sunflowers, corn, and sesame. Plant stanols include campestanol, sitostanol, and stigmastanol, and some of the sterols include campesterol, sitosterol, and stigmasterol. Except for the five or six double bonds in the B-ring, campesterol is the most basic sterol. Its saturated bonds are distributed throughout the sterol structure, and its hydroxyl group is located in position C-3 of the steroid skeleton. At position C24, a methyl group is present. A beta-hydroxy group has taken the place of stigmast-5-ene at position 3 in the phytosterol sitosterol. It possesses anti-inflammatory and anti-androgenic qualities, enhances urine flow rate, and affects benign prostatic hyperplasia (BPH). The presence of unsaturated bonds in the fifth and sixth positions of the B-ring, as well as the hydroxyl group in the steroid structure's C-3, serve as markers for the steroid group stigmasterol. It possesses cholesterol-lowering, anti-inflammatory, antioxidant, and anti-osteoarthritis qualities. 3-beta-sterol, or campestanol, is a hydride that is obtained from 5-alpha-campestane [24]. It has been shown that sitostanol, a plant stanol derived from sitosterol, lowers serum cholesterol levels by preventing the absorption of cholesterol [24]. Stigmastanol is a steroid group that has saturated bonds in the fifth and sixth positions of the B-ring and a hydroxyl group in the C-3 of the steroid structure. It is a 3-hydroxy steroid that is created when a 5-alpha-stigmastane hydride is dissolved. Generally speaking, phytosterols have been shown to have strong antioxidant action, promote hair growth, lower LDL cholesterol, and improve prostate health [25].

Saponins

Plants include glycosides called saponins, which are composed of sugar and sapogenin moieties. Depending on the kind of aglycone, they are divided into steroidal and triterpenoid saponins [26]. These are widely available in legumes, such as common beans, black grams, garden peas, and pigeon peas. Oleanane, tirucallanes, and dammaranes are a few of the saponins. Triterpenoid saponins are produced by the tetracyclic triterpene dammarane, which is found in sapogenins. It was initially separated and given the name dammar resin, a naturally occurring resin present in tropical Dipterocarp plants. In nature, oleanane is a triterpenoid. It is a member of the oleanoid family, which also includes pentacyclic triterpenoids with six members, such as beta-amyrin and taxerol. Tetracyclic triterpenoid saponin tirucalane is primarily present in euphorbia [27]. These have antifungal, antibiotic, virucidal, hypoglycemic, and hypolipidemic properties. There have also been reports on the effects of saponins on systemic lupus erythematosus, venous edema in chronic deep vein incompetence, erectile dysfunction, and acute impact injuries. It has also been discovered that saponins, at a concentration of 10 µg/mL, have an effective effect on the sarcoplasmic reticulum and transverse tubular system [28].

Polysaccharides and Dietary Fibers

A collection of monomer sugar molecules joined by glycosidic bonding is called a polysaccharide. They could be non-digestible substances like cellulose, pectin, beta-glucan, hemicelluloses, resistant starch, lignin, etc., which are all referred to as dietary fiber, or they could be energy stores like starch and glycogen.

These substances are broken down by the gut microbiota in the large intestine, where they specifically promote the growth of beneficial microbes, rather than by the digestive enzymes found in humans [29]. Dietary fiber can be found in abundance in all plant-based foods, particularly fruits. Some of the best sources of dietary fiber are chicory, tamarind, Jerusalem artichokes, barley, corn, oats, wheat, and green beans [30]. Frequent dietary fiber consumption improves insulin sensitivity, supports a healthy gut flora, and lowers the risk of cancer, inflammation, hypertension, obesity, hyperlipidemia, and cardiovascular disorders. Furthermore, dietary fibers can lower production costs and cooking loss, enhance sensory and health qualities, and replace fat in nutritious meals [31, 32].

CONCLUSION

A wide range of health advantages are provided by the vast variety of phytochemicals contained in plants, such as dietary fibers, polysaccharides, phytosterols, isoprenoids, carotenoids, and saponins. These bioactive substances have strong antioxidant qualities and numerous health benefits. They are widely found in fruits, vegetables, nuts, and herbs. It is important to comprehend the origins, categories, and effects of these phytochemicals since they have a significant impact on human nutrition and health. These chemicals have great promise, ranging from their functions in antioxidant defense to their contributions to gene transcription regulation, immune augmentation, and potential in disease prevention. The potential of phytochemicals to enhance human health is further expanded by their use in the creation of nutraceuticals and functional foods. Utilizing these substances' advantages to improve health outcomes points to a viable direction for further study and implementation in the promotion of holistic wellness. Exploring and comprehending phytochemicals further is essential to maximizing their potential as natural substances to improve human health.

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