UNLOCKING THE SECRETS OF POLYPHENOLS AND ANTIOXIDANTS FOR EVERYDAY HEALTH

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ABSTRACT

Polyphenols are plant secondary metabolites with strong antioxidant properties that neutralize free radicals and reduce oxidative stress associated with aging and chronic diseases. Classified as flavonoids, phenolic acids, stilbenes, and lignans, they are widely found in fruits, vegetables, grains, and beverages. Their properties include anti-inflammatory, antimicrobial, cardioprotective, neuroprotective, and anticancer effects. They also show potential against multidrug-resistant pathogens and in managing degenerative and neurological disorders, partly through the inhibition of enzymes and the regulation of cellular oxidative and inflammatory pathways.

WHAT ARE POLYPHENOLS AND ANTIOXIDANTS?

Antioxidants are any molecules that can slow down or prevent damage to body's cells caused by highly reactive, unstable molecules called free radicals or reactive oxygen species (ROS). Antioxidants work by stabilizing these free radicals, stopping them from negatively impacting cells' proteins, DNA or membranes. Sources of free radicals can among others be normal metabolism, inflammation, exercise, pollution, UV radiation, smoking and poor diet[1].

When free radicals overwhelm body's antioxidant defences, it leads to a state called oxidative stress. Long-term oxidative stress is linked to cell damage that contributes to aging and the development of many chronic diseases, including heart disease, certain cancers, type 2 diabetes, and neurodegenerative diseases like Alzheimer's[1,2].

Polyphenols have gained significant interest among researchers due to their potential in chemoprevention and prevention of other various chronic diseases due to their antioxidant properties. Their intakes from fruit, vegetables, seeds, and nuts have been associated with lower risks of chronic and age-related degenerative diseases[1,3].

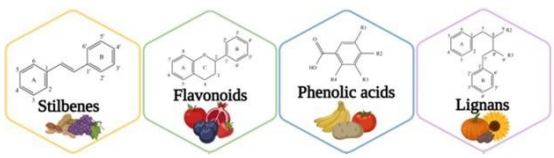

Figure 1: Types of polyphenols[7].

CLASSIFICATION OF POLYPHENOLS

There are approximately 10,000 natural analogues. These aromatic compounds are often found as bright colored (yellow to red) pigments in the microbes and plants. They are divided based on the number of aromatic (phenolic) rings they contain and the structural elements that connect these rings[1].

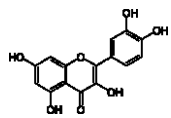

Figure 2: Structure of quercetin.

Flavonoids

They are divided into flavonols, flavones, isoflavones, flavanones, flavanols, and anthocyanins[3]. They are the most studied group of polyphenols, particularly their enzyme-blocking abilities, inhibition of enzymes, use for countering antibiotic resistance and the possibility of using them to detoxify cancerogenic cells. Because of their wide range of health benefits, quercetin and naringenin are two of the more researched flavonoids[4].

Phenolic acids

Phenolic acids are further divided into hydroxybenzoic acids (HBA) represented by gallic acid, protocatechuic acid, etc., and hydroxycinnamic acid (HCAs) represented by chlorogenic acid, ferulic acid, caffeic acid, etc.[3].

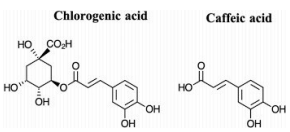

Figure 3: Structure of chlorogenic acid and caffeic acid.

HCAs are more likely to find in plants than HBA. HBA is also more common in small quantities. It is often highlighted in literature that absorption of both groups is very good[4].

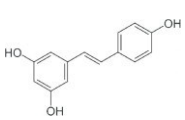

Figure 4: Structure of resveratrol.

Stilbenes

They are usually produced in plant during biotic and abiotic stress like extreme heat, oxidation, or microbial attacks[3]. Resveratrol, which is most studied of all stilbenes and is found in grapes abundantly, can stimulate Silent information regulator 2 (Sir2). It helps with calorie restriction and consequently with obesity epidemic[4].

Lignans

They are product of polymerization of two phenylpropanoid derivatives (namely C_6–C_3 monomers)[3]. Differences in structure come from varying substitutions on the aromatic rings and because of different oxidation patterns. They are most commonly found in flaxseeds and sesame seeds, but their bioavailability heavily depends on gut microbiota composition[4].

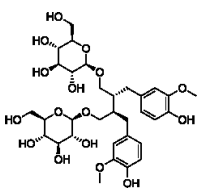

Figure 5: Structure of secoisolariciresinol diglucoside.

FUNCTION OF DIETARY POLYPHENOLS

Polyphenols have a wide range of biological activities, including anti-inflammatory, anti-infective, antiproliferative, antimicrobial, and antioxidant effects, due to their chemical structure, which includes one or more hydroxyl groups attached to a benzene ring[5]. This structural feature allows them to scavenge and neutralize free radicals and ROS, thereby protecting cells from oxidative damage, including the degradation of DNA[1,5]. As antimicrobial resistance continues to rise, polyphenols have attracted attention as potential agents for treating infections involving multidrug-resistant bacterial strains. In addition, plant-based polyphenol extracts are considered important contributors to the advancement of innovative antimicrobial treatment strategies[5]. Polyphenols have demonstrated activity against various chronic degenerative and neurological diseases [6]. Regular consumption of phenolic compounds (PCs), has been linked to a reduced risk of both cardiovascular and neurological disorders[1,6]. Flavonoids exhibit strong cardioprotective effects by inhibiting LDL oxidation and platelet aggregation, thereby helping to prevent atherosclerosis and thrombosis. Research indicates that a daily dietary intake of flavonoids may lower the risk of coronary heart disease (CHD)-related morbidity and mortality[6]. In oncology, polyphenols are utilized for both treatment and preventive purposes due to their ability to stimulate ROS production and trigger apoptotic pathways that result in cancer cell death[1,4]. Polyphenols exhibit the capacity to regulate inflammation-related signalling pathways implicated in arthropathies such as gout, osteoarthritis, and rheumatoid arthritis (RA) [1].They also act as enzyme inhibitors and are utilized in managing dementia by targeting acetylcholinesterase activity in the brain[4].

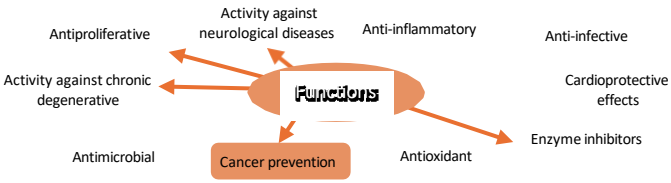

Figure 6: Functions of dietary polyphenols.

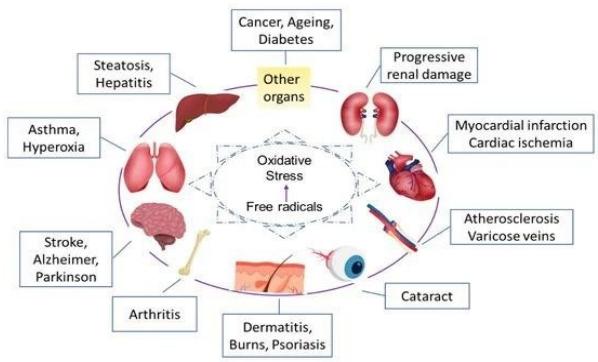

Figure 7: Most frequent pathologies related to oxidative stress[8].

CONCLUSION

Polyphenols are a large group of plant derived compounds. They are of great interest to researchers due to their antioxidant, antimicrobial, anti inflammatory, cardioprotective, neuroprotective, and anticancer properties. Regular dietary intake through plant based foods may support disease prevention and overall health. Ongoing research highlights their therapeutic potential, particularly in addressing drug resistant infections and degenerative disorders, making polyphenols valuable for future medical and nutritional applications.

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