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Opinion Article

Chemical Diversity of Plant Tannins: Structure and Applications

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DESCRIPTION

In the realm of natural compounds with incredible potential, plant tannins stand tall. These remarkable polyphenolic compounds, found abundantly in various plant species, have been capturing the attention of scientists, researchers, and health enthusiasts alike. From their traditional use in tanning hides to their modern applications in medicine, nutrition, and environmental sustainability, plant tannins have become the focus of extensive studies. Exploring their diverse roles and shedding light on their potential as a valuable resource for human well-being and a sustainable future. Tannins are found commonly in the bark of trees, wood, leaves, buds, stems, fruits, seeds, roots, and plant galls. In all of these plant structures, tannins help to protect the individual plant species. Tannins that become stored in the bark of trees protect the tree from being infected by bacteria or fungi. Tannins are plant secondary metabolites widely synthesized and distributed in many plant species. They play a role in plant growth regulation and also in protection from predation due to their astringent character rendering plant tissues inedible. Tannins contain aromatic rings bearing hydroxyl groups, which give them high chemical activity, causing them to form complexes with other macromolecules, such as carbohydrates or bacterial cell membranes. The chemical structures of plant tannins are diverse, and systematic classification of tannins based on specific structural characteristics and chemical properties can provide a convenient framework for related research. Plant tannins can be broadly divided into hydrolyzed tannins and condensed tannins. Hydrolyzed tannins consist of polyphenol nuclei with molecular weights ranging from 500 to 3,000 Daltons. Condensed tannins are oligomeric or polymeric flavonoids composed of flavane-3-ols, including catechin, epicatechin, gallocatechin, and epigallocatechin. Their molecular weights vary from 1,000 to 20,000 Da, they depolymerize only with strong oxidation and acid, and they are not easily degraded by anaerobic enzymes

To comprehend the significance of plant tannins, one must first understand their nature. Tannins are a class of naturally occurring compounds, primarily classified as hydrolysable tannins and condensed tannins. Hydrolysable tannins are soluble in water and are commonly found in fruits, whereas condensed tannins, also known as proanthocyanidins, are insoluble and prevalent in plants like tea, cocoa, and various tree barks. The primary function of tannins in plants is to serve as a defense mechanism against herbivores, pathogens, and UV radiation. These compounds have also been explored for their antiviral properties, contributing to the development of novel therapeutic approaches. As the world grapples with the challenges of environmental degradation and the need for sustainable practices, plant tannins offer an eco-friendly solution. Tannins have been extensively studied for their role in wastewater treatment, acting as natural coagulants and flocculants. By efficiently removing heavy metals, organic pollutants, and dyes, tannins demonstrate their potential as a sustainable alternative to conventional water treatment methods. Chemically, tannins are polyphenolic compounds with high molecular weights. Their structure can vary depending on the plant species and the specific tannin subclass. Tannins exist as polymers formed by the condensation of phenolic units. The polymerization can be achieved through different linkages, such as C-C, ether, or ester bonds. The degree of polymerization varies among tannins, resulting in different molecular weights. Tannins can be soluble in water or insoluble, depending on their chemical structure. Hydrolyzable tannins, including gallotannins and ellagitannins, are water-soluble, while condensed tannins are insoluble in water.

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