



SECONDARY METABOLITES IN PLANTS: STRUCTURE, BIOSYNTHESIS, BIOACTIVE PROPERTIES

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Abstract: Conversely, secondary plant metabolites are the products of auxiliary pathways, such as the shikimic acid pathway. In the study of the medicinal properties of herbs, secondary plant metabolites are the focus of attention. These compounds have played an important role in traditional and folk medicine in alleviating various ailments. Secondary metabolites of plants are numerous chemical compounds produced by plant cells through metabolic pathways derived from primary metabolic pathways. Each plant family, genus and species produces a specific mixture of these secondary metabolites, sometimes contributing to the taxonomic classification of plants. In modern medicine, they have served as starting points for developing drugs to treat a wide range of conditions. Secondary plant metabolites are classified into different classes based on their chemical structures. In this article, we will explore the different categories of plant secondary metabolites, their localisation in the plant, their biosynthesis and their significant bioactivities.

• Introduction

Secondary metabolites in plants are highly diverse phytochemicals that accumulate in plant tissues and fulfil several important roles such as protecting plants from insect invasion, herbivores and disease. Many secondary metabolites exhibit a broad spectrum of therapeutic effects, directly interacting with receptors, cell membranes and nucleic acids and are usually classified according to their biosynthetic pathways into three main groups: phenolics, terpenes and alkaloids.

• Phenolics

Chemical structure, localisation, biosynthesis and bioactivities of phenolics in plants

From a structural perspective, phenolic compounds consist of an aromatic ring accompanied by one or more hydroxyl substituents. Among the main biologically active compounds are phenolic acids, flavonoids, tannins, isoflavonoids, anthocyanins, quinones, and stilbenes. These compounds are primarily produced through the malonic and shikimic acid pathways that are present in both eukaryotes and prokaryotes, with some exceptions.

The impact of phenolic compounds found in plants on human health and disease prevention and treatment are varied, including their role as antioxidants, antibacterial agents, anti-cancer agents, anti-inflammatory agents, and protectors against U.V. radiation damage to the skin.

• Terpenes

Chemical structure, localisation, biosynthesis and bioactivities of terpenes in plants

Isoprene, which has the molecular formula C₅H₈, serves as the fundamental unit for terpenes in chemical terms. Terpenes can be classified into seven categories based on their carbon chain length, namely hemiterpenes (C₅), monoterpene (C₁₀), sesquiterpenes (C₁₅), diterpenes (C₂₀), sesterterpenes (C₂₅), triterpenes (C₃₀), and tetraterpenes (C₄₀). Terpenes can be synthesised using two pathways: the cytosolic pathway and the chloroplast pathway. The cytosolic pathway, exclusive to eukaryotes, produces triterpenes, sesquiterpenes, sterols, and brassinosteroids, while the chloroplast pathway is present in prokaryotes and the plastids of eukaryotic cells.

They significantly impact the treatment of various diseases, and numerous *in vitro* and *in vivo* studies demonstrate their effectiveness in providing antitumoral, antimicrobial, anti-inflammatory, antioxidant, and antiallergic.

• Alkaloids

Chemical structure, localisation, biosynthesis and bioactivities of alkaloids in plants

Alkaloids are small organic compounds containing nitrogen, mainly present in plants but also found in microorganisms and animals to a lesser degree. Most alkaloids comprise carbon, oxygen, hydrogen, and nitrogen, but occasionally phosphorus, chlorine, sulphur, and bromine are present in the structures. Alkaloids can be classified based on the heterocyclic structure of their base into two groups. The first group, non-heterocyclic alkaloids, includes hordenine, mescaline, colchicine and taxol. The second group, heterocyclic alkaloids, is further subdivided into four categories based on the chemical ring structure: piperidinic (conine, piperine, lobeline, lobelanine), pyridinic (nicotine, anabasine, niacin), pyrrolidinic (hygrine, cuscohygrine, stachydrine) and quinolinic (quinine, quinidine). The synthesis of alkaloids primarily depends on using pyruvate and shikimic acid. These organic molecules are derived from phosphoenolpyruvate and erythrose-4-phosphate.

Alkaloids have multiple medicinal uses. They possess antitumor properties, and their potential for antidiabetic, antibacterial and antifungal activities is currently under investigation.

• Conclusions

Plants have long been utilised for medicinal purposes. Still, in today's world, their potential for improving human health is gaining recognition due to their widespread availability, affordability and reduced risk of adverse effects. Despite their vast benefits, the potential of plants remains largely untapped. Pharmacological development has demanded extensive exploration and research within medicinal plants, aiming to expose potential avenues for furthering these natural resources with the goal of cultivating novel and useful medicinal compounds from them. The secondary metabolites play a crucial role in the healthcare system due to their exceptional pharmacological and biological properties. They serve as natural precursors for most synthetic drugs and effectively bridge the gap between the natural and synthetic worlds of medicine. Hence, there is significant potential for the efficient utilisation and investigation of these compounds in modern medical research to discover new pharmaceutical agents.

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