

Plants and Chemical Classes of Secondary Metabolites: Natural Chemicals

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Commentary

Received: 03-Oct-2022,
Manuscript No. JOMC-22-
79704; **Editor assigned:** 06-Oct-
2022, Pre QC No. JOMC-22-
79704 (PQ); **Reviewed:** 20-Oct-
2022, QC No. JOMC-22- 79704;
Revised: 27-Oct-2022,
Manuscript No. JOMC-22-
79704 (R); **Published:** 04-Nov-
2022, DOI: 10.4172/J
Med.Orgnichem.9.4.004
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DESCRIPTION

Secondary metabolites are organic chemicals produced by any lifeform, such as bacteria, fungi, animals, or plants that are not directly involved in the organism's regular growth, development, or reproduction. Instead, they typically mediate ecological interactions, which might result in a selection advantage for the organism by improving its survivability or fecundity. Secondary metabolites are frequently confined to a small number of species within a taxonomic group. Secondary metabolites are frequently involved in plant defences against herbivory and other interspecies defences. Secondary metabolites are used by humans as medications, flavourings, colours, and recreational substances.

Albrecht Kossel, a Nobel Prize recipient in medicine and physiology in 1910, created the phrase secondary metabolite. Friedrich Czapek, a Polish botanist, defined secondary metabolites as end products of nitrogen metabolism 30 years later.

Secondary metabolites are often used to moderate antagonistic interactions like competition and predation, as well as mutualistic interactions like pollination and resource mutualism. Secondary metabolites are typically restricted to a single lineage or even species, despite mounting evidence that horizontal transmission of whole pathways between species or genera plays a significant role in bacterial (and, most likely, fungal) evolution. Secondary metabolism can potentially affect various species in different ways, according to research. Four distinct species of *Arboreal marsupial folivores* reacted differently to a secondary metabolite in eucalypts in the same forest. This demonstrates that different forms of secondary metabolites can distinguish two herbivore ecological niches. Furthermore, some species have

evolved to withstand secondary metabolites and even utilize them to their advantage. Monarch butterflies, for example, have developed to be able to consume milkweed (*Asclepias*) despite the presence of harmful cardiac glycosides. The butterflies are not only resistant to the poisons, but they can also benefit from them by actively sequestering them, which can prevent predators.

Secondary metabolites of plants

Plants may produce and synthesize a wide range of organic chemicals, which are classified into two categories: Primary and Secondary metabolites. Secondary metabolites are metabolic intermediates or products that are not required for plant growth and survival but are required for plant interaction with their environment. Plants are protected from UV damage by secondary metabolites such as phenyl propanoids. Plant secondary metabolites have been known to have biological impacts on people since ancient times. *Artemisia annua*, which includes Artemisinin, has been used in Chinese traditional medicine for two thousand years. Terpenes, phenylpropanoids (i.e. phenolics), polyketides, and alkaloids are the four primary families of plant secondary metabolites.

Chemical classes of secondary metabolites

Terpenoids: Terpenes are a vast class of natural compounds made up of isoprene molecules. Terpenes are unoxygenated hydrocarbons, whereas terpenoids are oxygenated hydrocarbons. Terpenes have a general molecular formula of $(C_5H_8)_n$, where 'n' is the number of connected isoprene units. Terpenes are hence also known as Isoprenoid chemicals. The number of isoprene units in its structure determines their classification. Terpenoids (including numerous sterols) are main metabolites. Gibberellins, brassinosteroids, and strigolactones are examples of terpenoids that may have originated as secondary metabolites and have now been recruited as plant hormones. Examples: Artemisinin, found in *Artemisia annua* (Chinese wormwood); Tetrahydrocannabinol, found in *Cannabis sativa*.

Phenolics: Phenolics are a type of chemical molecule that has an aromatic ring structure with one or more hydroxyl groups. The most numerous secondary metabolites of plants are phenolics, which range from simple molecules like phenolic acid to highly polymerized compounds like tannins. Examples: Resveratrol, a C_{14} stilbenoid produced by grapes.

Alkaloids: Alkaloids are a broad collection of basic nitrogen molecules. They usually come from plants and contain one or more nitrogen atoms. They are chemically highly diverse. They can be divided into two broad categories based on their chemical structures:

- Alkaloids that are neither heterocyclic nor unusual, such as hordenine or N-methyltyramine, colchicine, and taxol.
- Heterocyclic or common alkaloids, such as quinine, caffeine, and nicotine. Examples: Cocaine, found in the Coca plant *Erythroxylum coca*; Scopolamine, found in the *Solanaceae* (nightshade) plant family.