

Medicinal uses of plant secondary metabolites: A brief review

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Abstract

Plants are considered to be the best source for the discovery of medicinal products for medication development, pharmaceuticals food additives and other industrial qualities. Plant-derived medicines are important to human health and well-being. Although many of these beneficial medications have been synthesised, only a small percentage of them are commercially manufactured. As a result, the plant source remains critical, not only in terms of drug production, but also in terms of generating innovative biologically active molecules from which more potent and less toxic medicines might be synthesized. There has been a lot of interest in their production and investigating ways to improve it utilising tissue culture technology in recent years. So far, large number of research articles has been published for evaluating antioxidant, anti-microbial, and anti-diabetic activities of various secondary metabolites derived from different plants. This review has the goal to explain the types of secondary metabolites. We emphasize the drugs made from secondary metabolites and bioactive compounds found in plants. Lastly, emphasis has been laid on the groups of plant metabolites.

Key words : Anti-diabetic, Pharmaceuticals, Secondary metabolites, Medicines,

Allelopathic compounds are secondary metabolites synthesized by fungi, microorganisms and plants, which are formed from the secondary metabolites. These secondary metabolites are not essential for growth and development, but they are required for the interaction of plants with environment and produced in response to stress. They are mainly the organic products formed due to the mutation in the primary metabolic pathways. Unlike primary metabolites, absence of

secondary metabolites does not result in the immediate death, but rather in long term impairment of the organism's survivability, fecundity, or aesthetics, or perhaps in no significant change at all³³. They are used against pathogens, herbivores, attract pollinators, symbiotic nitrogen fixation, and mechanical support, reduce plant-plant competition, and have medicinal values¹³. Secondary metabolites used as a mixture or if used as a single compound, are medicines that can be effective

and safe when synthetic drugs fail³². Plants play an important role in conventional and western medicines. Recently it has been shown that there occurs a huge shift from synthetic to herbal medicines which are said as “return to nature ‘Drugs derived from nature has been a part of evolution of human¹⁹”.

According to world health organisation, any plant which contains a substance which has any therapeutic use or which are precursors of chemo-pharmaceutical semi-synthetic drugs called as a medicinal plant. In the last two decades, the use of herbal remedies has also been increased in many developed countries as complementary and alternative medicine, but under the following tight legislation and under surveillance⁹. There has been a lot of advancement in the field of synthetic drug chemistry and antibiotics, but plants still continue to be one of the major raw materials for the drugs which are used to treat various human ailments. Humans have always suffered from infections by bacteria, viruses, fungi, and parasites but also from inflammation, cold, digestive problems and many other health disorders and diseases. Synthetic drugs and antibiotics have only become available during the last 150 years^{3,14,22,31}. Previously people had to rely on drugs from nature, mostly from plants, but also from fungi and animals³⁴.

Types of secondary metabolites :

Modern chemistry has outlined the roles of main plant metabolites in fundamental biological processes such as cell growth and division, respiration, storage, and reproduction¹⁶. Plants produce a range of chemical compounds that are necessary for their growth and

development. Photosynthesis, translocation, and respiration all require supplies, which primary metabolites give. Secondary metabolites are compounds formed from primary metabolites that are not directly engaged in growth and development. Secondary metabolites are created by biosynthetic modifications such as methylation, glycosylation, and hydroxylation, and are the product of primary metabolites. In comparison to primary metabolites, secondary metabolites have a more complicated structural makeup and side chains^{8,10}.

Based on the biosynthetic pathway, there are three major groups of plant metabolites:

- 1) Phenolic groups (made primarily of simple sugars and benzene rings)
- 2) Terpenes (composed of mainly carbon and hydrogen)
- 3) Nitrogen containing compounds

Phenolic compounds :

One of the most common and diverse groups of plant materials are phenolic compounds, which have at least one aromatic ring and one or more hydroxyl groups in their structures. The basic phenols are C_6H_5OH ^{7,12,30}. It can be classified into two groups: the first group includes soluble molecules that exist in vacuoles, such as flavonoids, phenylpropanoids, and quinones. The second category includes insoluble substances such as lignins, hydroxy cinnamic acid, and the bound form of cell wall's condensed tannins²⁴. One of the main categories of dietary additives found in vegetable foods is phenols. There are more than 8,000 different chemical compounds in this large group, which is thought of as

secondary plant metabolites. They have varying chemical structures and activities. Phenolic compounds could be an important part of the plants defense system against pests and disease including root parasite nematodes³⁵. However, due to their links to the prevention of cancer and atherosclerosis, there is really a rise in interest in these substances. The antioxidant behaviour of phenolics, which is explained by their capacity to chelate metals, inhibit lipoxygenase, and scavenge free radicals, may be related to their bioactivity¹⁷. Phenolic compounds can also be employed as an antioxidant, analgesic, anti-inflammatory, antibacterial, antiviral, anticancer, and more^{4,29}.

Terpenes :

According to the amount of isoprene units, terpenes or terpenoids are the most diverse group that naturally occurs in plants and can be divided into mono, di, tri, tetra, and sesquiterpenes. They predominantly exist in plants provide the primary component of essential oils. Typical sources of plant terpenes from plants are cannabis, citrus, thyme, tea, and Spanish sage⁵. Although the terms “terpenes” and “terpenoids” are frequently used interchangeably, they do have some slight differences. Terpenes are a combination of isoprene units that are naturally occurring, volatile, unsaturated 5-carbon cyclic compounds that emit a scent or a taste to defend themselves against organisms that feed off of certain types of plants. Terpenes serve a variety of purposes in plants, including thermo protection, signalling, and taste. They also have a number of medical applications⁶.

The vast majority of terpenoids are

restricted to a certain lineage or even a single species, and are consequently referred to as specialised terpenoids. There are, however, a small number of terpenoids that are present in all or almost all plants, making those primary metabolites. Hormones, elements of electron transfer systems, protein modification agents, and determinants of membrane fluidity, antioxidants, and other functions are just a few of the diverse roles that the terpenoids of primary metabolism play. These diverse roles must have evolved early in the history of green plants (some even predate the origin of plants). It has usually been hypothesised that the lineage-specific terpenoids, which have developed during the development of green plants, have a role in the ecological interactions of plants with biotic and abiotic elements of their environment²⁵.

Alkaloids :

Alkaloids are a group of chemical compounds that are found in nature and often have simple nitrogen atoms. Various related chemicals with weak acidic and neutral characteristics are also a part of this category. Some synthetic substances with a comparable structure might also be referred to as alkaloids^{2,26}. Alkaloids can also contain sulphur, oxygen, and, more rarely, additional elements like phosphorus, chlorine, and bromine, in addition to carbon, hydrogen, and nitrogen. The first alkaloid discovered was morphine derived in 1804 from the *Papaver somniferum*¹¹. As new and more difficult diseases emerge worldwide, the significance of the possibility for bioactive alkaloids to be used in chemotherapy has boosted their bioactivity. Although, alkaloids definition has loosened but their application have increased²¹.

Table. Effects of different chemicals on humans extracted from various plant species

| Plant Species | Chemical/Active principle | Part used | Effect |
|---|---------------------------|--------------|--------------------------------------|
| <i>Brassica nigra</i> L. | Allyl isothiocyanate | Seed | Rubifacient, Fumigant |
| <i>Aesculus hippocastanum</i> L. | Aescin | Seed | Anti-inflammatory, Vasoprotective |
| <i>Areca catechu</i> L. | Arecolin | Seed | Anthelmintic, Laxative |
| <i>Coffea arabica</i> L. | Caffeine | Seed | CNS and Metabolic stimulant |
| <i>Aconitum napellus</i> L. | Aconitine | Root | Analgesic., Antipyretic |
| <i>Rauwolfia serpentina</i> B. (L.) Benth. ex Kunz. | Ajmaline, Reserpine | Root | Circulatory disorders |
| <i>Anisodus tanguticus</i> (Maxim.) Pascher | Anisodamine | Root | Anticholinergic |
| <i>Atropa belladonna</i> L. | Atropine | Root, Leaves | Anti-cholinergic |
| <i>Berberis vulgaris</i> L. | Berberine | Root, Bark | Anti-inflammatory, Anti-microbial |
| <i>Andrographis paniculata</i> (Burm.f.) Nees | Andrographolide | Stem, Leaf | Anti-cancerous, Rheumatoid arthritis |
| <i>Digitalis lanata</i> Ehrh. | Digoxin | Leaf | Cardiotonic |
| <i>Adonis vernalis</i> L. | Adonidin | Flower | Cardiotonic |
| <i>Artemisia annua</i> L. | Artemisinin | Aerial parts | Anti-malaria |
| <i>Centella asiatica</i> (L.) Urban | Asiaticoside, brahmoside | Aerial parts | Vulnerary |
| <i>Ananas comosus</i> (L.) Merr. | Ananos comosus Bromelain | Fruit, Stem | Anti-inflammatory, Indigestion |

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The majority of alkaloids, which are organic heterocycles components with nitrogen and involved in plant secondary metabolism, are poisonous by nature and contain at least one atom of nitrogen heterocycles. The primary secondary metabolites are alkaloids which have therapeutic qualities. Numerous researches suggested that certain plant alkaloids have numerous medicinal applications²⁷. The effects of several alkaloid chemicals, such as coniine, atropine, nicotine, cocaine, codeine, morphine, quinine, strychnine,

papaverine, and caffeine, on People are healthy²⁰. Alkaloids are abundant in flora and include members of the Papaveraceae family (poppies), Solanaceae crops (potatoes, tobacco) and Rubiaceae (the quinine tree¹⁸. Alkaloids have a wide range of pharmacological potentials in modern medicine due to their powerful and diverse actions, which include analgesic (such as morphine), anti-hyperglycaemic (such as piperine), anti-cancer (such as berberine), antiarrhythmic (such as

quinidine), and antibacterial properties (e.g., ciprofloxacin). Other alkaloids, including as cocaine, caffeine, and nicotine, have stimulant and psychoactive effects on the central nervous system (e.g., psilocin)¹⁵.

Drugs made from secondary metabolites or bioactive compounds found in plant :

Natural products, according to Newman and Cragg²³, continue to play an important part in the drug discovery and development process. Morphine, the first semi-synthetic pure drug based on a natural product Salicin obtained from *Salix alba*, was introduced by Bayer in 1899, while Aspirin, the first semi-synthetic pure medicine based on a natural product Salicin isolated from *Salix alba*, was presented by Merck in 1827¹. Early drugs like Cocaine, Codeine, Digitoxin, Quinine, and Pilocarpine were isolated as a result, and several are still in use today. The following are some of the bioactive chemicals found in plants that are used in modern therapeutics¹⁵.

Secondary metabolites found in plants are very selective and can be toxic at higher concentrations. They constitute a fascinating library of bioactive molecules with a wide range of activities in human cells, bacteria, fungus, and parasites. Secondary metabolite research has got a lot of attention in recent time for economic and medicinal uses. The study of secondary metabolites has been the subject of intense efforts contributing to the advancement of phytochemistry in a variety of areas. Furthermore, researchers, industries and environmental agencies need to do more work in the above field.

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