Review Article

Plant metabolites and their role in health benefits: A brief review

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Abstract

The bioactive chemical constituents of plants can be defined as secondary plant metabolites eliciting pharmacological or toxicological action in man and animals. Secondary metabolites are produced within the plants in addition the primary biosynthetic and metabolic routes for chemical constituents related with plant growth and development, and are regarded as products of biochemical “side tracks” in the plant cells and not needed for the daily functioning of the plant. Several of them are found to hold different types of important functions in the living plants such as protection, attraction or signaling hence that are called secondary metabolites such as Alkaloids, Saponin, Flavonoid, Phenol, Glycosides and others. Most species of plants seem to be able of producing such compounds. These bioactive chemical constituents of plants produce potential therapeutic role or toxicological effects in man and animal. Consequently in this review summarized the pharmacological action of that basic category of plant compounds where need to more search investigation and explore. That gives new concepts of new molecule discovery. The aim of this review is to focus on the importance of bioactive compounds and focus their effective role on human health.

Keywords: Bioactive, metabolites, toxicology, constituents

Introduction

Natural products like as plants extract, either as pure compounds or as standardized extracts, offer unlimited opportunities for any new drug discoveries because it is having unmatched availability of chemical diversity. According to the World Health Organization (WHO), more than 80% of the world's population relies on traditional medicine for their first aid healthcare needs. The use of natural medicines in Asian countries represents a long history of human interactions with the environment. Herbal plants are used traditionally, and these traditional medicines contain a wide range of substances that can be used to treat chronic as well as infectious diseases (Duraipandiyar et al., 2006). The bioactive compounds of plants can be defined as secondary plant metabolites eliciting pharmacological or toxicological action in man and animals.

The secondary metabolites or bioactive compounds are produced within the plants besides the primary biosynthetic and metabolic routes for compounds linked with plant growth and development, it is related to as products of biochemical “side tracks” in the plant cells and not needed for the daily functioning of the plant. Several of them are found to hold different types of important functions in the living plants such as protection, attraction or signalling. Most species of plants seem to be capable of producing such compounds. The chief chemical groups of bioactive compounds in plants with their main pharmacological or toxicological effects in man and animal, as well as the main producing plants/plant family are presented here (Sasidharan et al., 2011).

Definition of bioactive compounds in plants

The term "bioactive" is composed by two words: bio- and -active. In etymology: bio- from the Greek (βίο-) "bios" [bio-, -bio], refers: life. And active from the Latin "activus", word means: dynamic, full of energy or involves an activity. This activity represents all the phenomena from which manifest a form of life, a functioning or a process

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(Bernard et al., 2011; Anonymous et al., 1994). The bioactive compounds in plants are compounds, produced by plants which are having pharmacological or toxicological action. Although nutrients elicit pharmacological or toxicological effects when ingested at high dosages (e.g. vitamins and minerals), nutrients in plants are generally not included in the term bioactive plant compound. The typical bioactive chemical constituents in plants are produced as secondary metabolites (Walia et al., 2019).

Biosynthesis of secondary metabolites plants

Secondary metabolites are produced within the plants besides the primary biosynthetic and metabolic routes of compounds aimed at plant growth and development, such as carbohydrates, amino acids, proteins and lipids. They can be related as products of biochemical “side tracks” in the plant cells and not needed for daily functioning of the plant.

Phylogenetically, the secondary bioactive compounds in plants appear to be randomly synthesised but they are not useless junk. By their nature, plants protect themselves by producing some compounds called as secondary metabolites or bioactive chemical constituents. The secondary metabolites or bioactive compounds, with terpenes, phenolics and nitrogen (N) and sulphur (S) containing compounds, defend plants against a variety of herbivores and pathogenic microorganisms infection as well as various kinds of a biotic stresses. Several of them are found to hold important functions in the living plants. For example, flavonoids can protect against free radicals generated during photosynthesis. Terpenoids may attract pollinators or seed dispersers, or inhibit competing plants. Alkaloids usually ward off herbivore animals or insect attacks (phytoalexins). Other secondary metabolites function as cellular signalling molecules or have other functions in the plants. That plant producing bioactive chemical constituents seems to be the rule rather than the exception. Thus, most plants even common food and feed plants are capable of producing such compounds. However, the typical poisonous or herbal plants contain higher concentrations of highly potent bioactive compounds than food and feed plants (Mazid et al., 2011).

Main groups of bioactive compounds in plants

The bioactive chemical constituents in plants are classified according to different criteria. A presentation based on clinical function their pharmacological or toxicological effects are relevant for the clinician, pharmacist or toxicologist. An approach based on biological effects is complicated by the fact that the clinical outcome is not entirely connected to chemically closely related compounds; even chemically very different molecules might produce similar clinical effects. A botanical classified based on families and genera of the plants producing the bioactive chemical constituents might also be relevant, as

closely related plant species most often produce the same or chemically similar bioactive compounds. However, there are also ranges of examples that species even genetically less related produce similar secondary bioactive compounds. The main focus of bioactive chemical compounds, therefore it is useful to categorise them according to biochemical pathways and chemical classes (Mazid et al., 2011). Here some important categories of chemical constituents are described.

Glycosides

The glycosides containing of diverse categories of secondary metabolites bound to a mono- or oligosaccharide or to uronic acid. The oligosaccharide or uronic acid part is known glycone, and the other part the aglycone. The main groups of glycosides are cardiac glycosides, cyanogenic glycosides, glucosinolates, saponins and anthraquinone glycosides. Furthermore, flavonoids frequently transpire as glycosides. Following ingestion the glycosides usually hydrolyse in the colon, and the more hydrophobic aglycone might be absorbed. The therapeutic action in different studies has been reported and shown that glycosides are possess anticancer, expectorant, sedative and digestive properties (Samuelson et al., 2004).

Saponins

Saponin “means soap forming compound” occur as glycosides. The aglycones consist of either pentacyclic triterpenoids or tetracyclic steroids. They are structurally distinct, but have main functional properties in common. The saponin glycosides are large molecules having a hydrophilic glycone and a hydrophobic aglycone, which give foaming, solubilizing, sweetness, bitterness, emulsifying properties and can be used as detergents. Saponins exhibits haemolytic, antimicrobial, antioxidant, immune modulating and antineoplastic effects (Charde et al., 2011; Garg et al., 2018). Saponins are secondary metabolites with high molecular weight compounds. It is present in a wide range of plant species and is distributed throughout the parts of plants such as bark, leaves, stems, roots and even flowers. It is bitter in taste and they have received significant attention because of their different biological activities including hepatoprotective, anti-ulcer, anti-tumor, antimicrobial, adjuvant and anti-inflammatory activities. The saponins are composed of a lipid soluble aglycone parts consisting of either a sterol or more commonly a triterpenoid and water soluble sugar residues, due to their amphiphilic property. The saponins are highly surface active and their biological activities are related to their chemical structures. Both steroidal and triterpenoids

saponins show surface active agents like properties. In addition saponins are used in food, cosmetic and pharmaceutical industry (Moghimipour et al., 2015).

Health benefits of Saponins

The saponins have many health benefits like as reduced blood cholesterol levels, anti-cancer property, increase bone health and stimulation of the immune system. Most scientific studies investigate the effect of saponins from specific plant sources and the results cannot be applied to other saponins.

Flavonoids and proanthocyanidins

Flavonoids consist of a central three-ring structure. Proanthocyanidins are oligomers of flavonoids, both groups of compounds can occur as glycosides. All compounds are contains phenol-groups involved in an effect as general antioxidant. Other actions are various several structures reduce inflammation or carcinogenicity. The group of isoflavones is primarily called as phytoestrogens. Flavonoids form the largest and a diverse group of bioactive compounds, which is known as phytonutrients or phytochemicals, that are the major constituents of polyphenols and can be considered more into flavanols, flavones, isoflavones, flavanones, anthocyanidins, flavanols, and flavans (catechins and proanthocyanidins) (Ververidis et al., 2007). Each subgroup and its type of flavonoids have a distinctive range of plant source, functions, and health benefits. Flavonoid or plant bioactive compounds are known to possess benefits to human health due to their identified antioxidant and anti-inflammatory effects (Kris-Etherton et al., 2007).

Bountiful health benefits: Many studies have revealed that a diet rich in phytonutrients is good for human health. Flavonoids are beneficial in this regard as they act as influential antioxidants; they also neutralize free radicals and limit damage to cells and other body tissues (Silvina et al., 2006). They are also possessing anti-inflammatory and anti-aging properties (Valerio et al., 2012). Various studies have been shown that there is a relation between certain polyphenols and their preventive effects on such diseases that can bring 'oxidative stress (for example, cancers, cardiovascular disease (CVD), diabetes and neurodegenerative diseases). Flavonoids have a supportive effect on the nervous system in addition they can control the action of certain enzymes and cell receptors. These studies suggest that flavonoids can also help regulate blood flow in the brain, which may result in better cognitive function (Che-Feng et al., 2014).

Phenolics compounds

Phenolic compounds obtained from plants that are one of the largest groups of secondary metabolites of plants chemical constituents, which are synthesized by fruits, vegetables, teas, cocoa and other plants that possess certain health benefits. It is characterized by the

antioxidant, anti-inflammatory, anti-carcinogenic and other biological properties, and they protect from oxidative stress and some diseases. Simple phenolics bioactive compounds are bactericidal, antiseptic and anthelmintic. Phenol itself is a standard for other antimicrobial agents. They are distributed in almost all types of plants and subject to a great number of chemical, biological, agricultural, and medical studies (Dai et al., 2010).

Tannins

There are two distinct types of tannins, first condensed tannins which are large polymers of flavonoids and second hydrolysable tannins. Those are composed of a monosaccharide core (most often glucose) with several catechin derivatives attached. These two types of tannins having most properties in common, but hydrolysable tannins are less stable. They are water soluble. It is restricted and decrease in general with the size of the tannin molecule. Tannins indiscriminately attach to proteins and larger tannins. That is used as astringents and where used in treatment of diarrhoea, skin bleedings and transudates. Tannins are most widely distributed in the plant kingdom. Examples of plant families related with presence of tannins are *Fagaceae* (beech family) and *Polygonaceae* (knotweed family) etc.

In experimental animals, tannins have been described to reduce feed intake, growth rate, feed efficiency, net metabolize energy, and protein digestibility. However, recent studies have been specified that their major effects may be because of a reduced effectiveness in translating the absorbed nutrients to new body substances rather than due to an inhibition on food utilization or digestion of late, there is considerable interest in considering various tannins as bioactive substances because of their capability of producing beneficial effects in the body. If are ingested in the diet for long periods of time, having antioxidant properties that protect the tissues from the action of free radicals due to the cellular aging and other physiological processes. Tannins have also been exhibit to have other positive effects on health including acceleration of blood clotting, reduction in blood pressure, decrease in serum lipid levels, astringents, diarrhea, diuretic against stomach and duodenal tumors, and anti-inflammatory and modulation of immune responses; the dosage and the kind of tannins are serious to these effects (Srilakshmi et al., 2018; Chung King-Thom et al., 1988).

Mono, sequi-terpenoids and phenylpropanoids

The terpenoids are biologically synthesized which having five-carbon building block. It is measured in unit isoprene. Monoterpenoids consists of two isoprene units and

sesquiterpenoids of three units. They are referred to as low-molecular-weight and represent the mainly diversely category of plant chemical constituents with more than 25,000 individual compounds identified. The less various phenyl propanoid, that is based on a nine carbon skeleton and are synthesised via another pathway. Compounds of all three groups are having lipophilic and tend also to volatilise readily. They have strong odours and flavours characteristics. Their actions vary greatly, a range of which have been utilised in herbal remedies. Of particular importance are antineoplastic, antibacterial, antiviral effects as well as gastrointestinal stimulation (Böhme et al., 2014). However they are not associated with toxicity unless they are concentrated as volatile oils. The plant family best known for source of terpenoids, these compounds is found in *Lamiaceae* (thyme family) but is also present in a range of other families.

Terpenoids accounts for the foremost class of secondary metabolites produced by plants. It is shows defense activity against environmental stress and help to heal injuries. The medicinal plants are rich in monoterpenoids, diterpenoids, sesquiterpenes, triterpenes, tetraterpenes, and ceramide etc. A number of therapeutic applications of terpenoids such as antibacterial, antimicrobial, antitumor, anti-inflammatory activity have been identified. Terpenoids are compounds similar to terpenes which are modified from 5-carbon monomer isoprene units. The review puts and detail insight on different class of compounds isolated from natural source from 2000 to 2016 showing anti-inflammatory potential of pharmacologically interesting agent and their mechanism of action (Prakash et al., 2017).

Resins

The resins are complex lipid-soluble mixtures usually both non-volatile and volatile bioactive compounds. It is non-volatile fraction may consist of diterpenoid and triterpenoid compounds, and mono and sesquiterpenoids predominate in the volatile fraction. Most typical resins are secreted by wood structures, and are also present in herbaceous plants. They are all sticky and the fluidity depends on their contents of volatile compounds. When exposed to air they become harden. Most resins are antimicrobial and wound healing, but their actions depend on the composition of the chemical mixture. The resins are generally safe, but on contact allergy may occur (Leandro et al., 2012).

Lignans

Lignans are consists of two phenylpropanoid units to form an 18-carbon skeleton, with various functional groups connected. They are commonly lipophilic and that have structural functions within the plant cell membranes. The lignans are present at maximum concentrations in oil seeds, it is also found in other parts of a long range of plants of different families. Several lignans show clinical activity as phytoestrogenic, cathartic or

antineoplastic effects (Petrovska et al., 2012).

Alkaloids

The alkaloids are heterocyclic, nitrogen containing compounds, usually with highly potent activity and bitter taste. They are of limited distribution in the plant kingdom. The different groups have diverse clinical properties. The pharmacological effects of some common alkaloid such as Atropine- anti-muscarinic action, Berberine-anti-inflammatory antibacterial; Codeine-analgesic, antitussive, antidiarrheal, sedative-hypnotic; Morphine-analgesic, Nicotin-insecticide; Quinine-antimalarial, antipyretic; Solanine-antifungal, anticonvulsant; Vincristine- anticancer are well known alkaloidal plant (Aniszewski et al., 2007).

Proteins and peptides

Proteins from plants are an important source which is found in food and other natural sources. Amino acids thereof are absorbed from the intestine of man and animals and that are built up into adapted proteins. They are often not hydrolysed in the digestive tract, but may to a certain extent be absorbed and apply their specific action on the body.

Euphorbiaceae (spurge family) include others plants producing such proteins such as ricin in seeds of *Ricinus communis* (castor bean). They are having potent protein (lectin) ricin, which inhibits protein synthesis and induce systemic effects in animals and humans, with gastrointestinal symptoms dominating. Far less potent lectins, those are also present in seeds of several species of *Fabaceae* (bean family). Colic and other gastrointestinal symptoms may occur if seeds are eaten without taking precaution (Verpoorte et al., 1998).

All the medicinal plants have been investigated bioactive chemical compounds such as saponins, tannins, steroids, alkaloids, cardiac glycosides, phenolics and flavonoids. The secondary metabolites are considered products of primary metabolism and are usually not involved in metabolic activity (alkaloids, phenolics, essential oils and terpenes, sterols, flavonoids, lignins, tannins, etc.). These secondary metabolites are the key source of pharmaceuticals, food additives, fragrances and pesticides, and herbicides (Okwu et al., 2005; Ramawat et al., 2009; Ramu et al., 2012). Further studies are required with these medicinal plants to evaluate their ayurvedic, allelopathic potentials, isolate, characterize and elucidate the structures of the bioactive molecules responsible for their antimicrobial activity, allelopathic activity, and other medicinal values.

Table 1. Summary of different types of plant metabolites

Plant Metabolites	Examples	Health benefits	References
Glycosides	Cardiac glycosides, cyanogenic glycosides, glucosinolates, saponins and anthraquinone glycosides	Anticancer, expectorant, sedative and digestive properties hypertension	Samuelson et al., 2004; Marinkovic et al., 2008.
Saponins	Hydrophilic glycone and aglycone, triterpenoids saponins	Anti-inflammatory, hemolytic, hepatoprotective, anti-ulcer, anti-tumor, antimicrobial, adjuvant and anti-inflammatory activities	Charde et al., 2011; Garg et al., 2018; Nyarko et al., 1990
Flavonoids and Proanthocyanidins	Flavanols, flavones, isoflavones, flavanones, anthocyanidins, flavanonols, and flavans	Antioxidant, anti-inflammatory. cancers, cardiovascular disease, diabetes, neurodegenerative diseases	Ververidis et al., 2007; Kris-Etherton et al., 2007; Che-Feng et al., 2014
Phenolics compounds	Eugenol	Antioxidant, anti-inflammatory, anti-carcinogenic antimicrobial, antiseptic and anthelmintic	Dai et al., 2010
Tannins	Condensed and hydrolysable tannins	Blood clotting, hyperlipidemic, astringents, diarrhea, diuretic tumors, antioxidant, antimicrobial and antiviral effects	Srilakshami et al., 2018; Chung King-Thom et al., 1988; Sayyah et al., 2004
Terpenoids and phenylpropanoids	monoterpenoids, diterpenoids, sesquiterpenes, triterpenes, tetraterpenes, and ceramide	Antibacterial, antimicrobial, antitumor, anti-inflammatory activity	Prakash et al., 2017
Resins	Diterpenoid, triterpenoid compounds, mono and sesquiterpenoids	Antimicrobial and wound healing	Leandro et al., 2012
Lignans	Phenylpropanoid phytoestrogenic, cathartic, antineoplastic	Cathartic or antineoplastic	Petrovska et al., 2012
Alkaloids	Atropine, Berberine, Codeine, Morphine, Nicotin, Vincristine, Quinine, Solanine	Anti-muscarinic, anti-inflammatory antibacterial, antitussive, antidiarrheal, sedative-hypnotic; analgesic, insecticide, antimalarial, antipyretic; antifungal, anticonvulsant; anticancer	Aniszewski et al., 2007
Proteins and peptides	Essential and non essential amino acids	Colic gastrointestinal discomfort, Potent cathartic	Verpoorte et al., 1998

Future prospective

Bioactive compounds are the chief active ingredients of any ayurvedic formulations to make effective. Then can be used successful for treatment. But these are ideal properties of bioactive compounds depend on quality of crude drug. Hence it should be compulsory to follow standardization of herbal drugs. Herbolism concept is one of the most popular and oldest therapeutic systems. That has nourished and flourished from earliest ages to till date. India can come into sight as the major country and playing the leader role in improvement of standardized, therapeutically valuable ayurvedic formulation and development. It is mandatory to applied all the factors or rule which affecting the quality of natural products, international level or export quality. All these parameters which are responsible for good quality of herbal drugs or products, it should

maintain and improve the bioactive potency of compounds and their products (Mahta et al., 2018; Sharma et al., 2013). The pharmacological action of that basic category of plant compounds where need to more search investigation and explore. That gives new concepts of new molecule discovery. The aim of this review is to focus on the importance of bioactive compounds and focus their effective role on human health.

Concluding remarks

The various bioactive chemical compounds have been studied for their protective effects on human health. They are having unique antioxidant, anti-inflammatory, and anti-carcinogenic properties, with associated physiological and cellular effects. It is protective against various chronic diseases and metabolic disorders like as diabetes, CVD,

cancer etc. They are usually found in fruits and vegetables; and their utilization in diets with pertinent beneficial health effects make them best candidates for development of new functional food with potential protective and therapeutic properties. Although additional research work is needed to identify with the exact mechanisms of their biological actions, it is beyond doubt that consumers should eat more of fruits and vegetables, which they get these bioactive compounds and benefit from their positive health effects. Plants, including most food and feed plants, produce an extensive range of bioactive chemical compounds via their so called secondary metabolism. These compounds may elicit a various range of different effects in man and animals eating the plants, which are dependent on plant species and amount eaten. The plants with potent bioactive chemical constituents are often characterised as both poisonous and medicinal, and a beneficial or an adverse result that depend on the amount eaten and the context of intake. For typical food and feed plants with bioactive compounds with less pronounced effects, the intakes are usually regarded as beneficial.

Conflict of interest

None

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