# Importance of Medicinal and Aromatic Plants in Human Life

**Mansour Ghorbanpour, Javad Hadian, Shahab Nikabadi and Ajit Varma**

**Abstract** The plant kingdom includes a high number of species, producing a diversity of bioactive molecules with different chemical scaffolds. Over the centuries, the use of medicinal and aromatic plants has become an important part of daily life despite the progress in modern medical and pharmaceutical industry. They are now being progressively cosmetics, foods and teas, as well as alternative medicines. The growing interest in herbs and their ability to offer economical uses is a part of the movement towards greener economics and life styles. This movement is based on the belief that the plants have a vast potential for their use as a curative medicine. Medicinal and aromatic plants will also maintain their importance in the search for new, valuable sources of drugs and lead compounds. In view of the steadily rising demands on these important natural resources, attention should be paid to the sustainable forms of production and utilization.

**Keywords** Medicinal and aromatic plants · Phytochemicals · Traditional-/modern medicine

M. Ghorbanpour (✉)
Department of Medicinal Plants, Faculty of Agriculture and Natural Resources, Arak University, 38156-8-8349 Arak, Iran
e-mail: m-ghorbanpour@araku.ac.ir

J. Hadian
Medicinal Plants and Drugs Research Institute, ShahidBeheshti University, G. C., Evin, Tehran, Iran

S. Nikabadi
School of Plant Biology, Faculty of Natural and Agricultural Science, University of Western Australia, Crawley, WA 6009, Australia

A. Varma
Amity Institute of Microbial Technology, Amity University Uttar Pradesh, Fourth Floor, E-3 Block, Sector 125, Noida 201303, UP, India
e-mail: ajitvarma@amity.edu



M. Ghorbanpour and A. Varma (eds.), *Medicinal Plants and Environmental Challenges*, https://doi.org/10.1007/978-3-319-68717-9_1

## Introduction

With the emergence of human civilization, plants have been the main source to cure, heal and alleviate various diseases. Medicinal plants belong to a big plant group with a great interest due to its pharmaceutical, cosmetic and nutritional values (Abdul Rasool Hassan 2012). The synthesize compounds of these plants are useful to preserve the health in humans and animals. These include aromatic substances, such as phenols or their oxygen-substituted derivatives which is called tannins. Plants have an almost limitless ability to synthesize aromatic substances mainly secondary metabolites, of which at least 12,000 have been isolated, a number estimated to be less than 10% of the total. These compounds are usually served as the molecules of plant defense against predation by microorganisms, insects, and herbivores.

Many of the herbs and spices used by humans to season food yield useful medicinal compounds. The demand for medicinal plants is currently increasing in both developed and developing countries for various reasons.

In some, it would be the growing recognition that natural products have fewer or even no side effects; for others, however it would be their accessibility and affordable costs that would tip the scales. Medicinal and aromatic plants can be processed to become essential oils through distillation, however, their cut flower marketing and the plants parts are in demand.

They are used in pharmacy, cosmetology, perfumes and the food industry among others. With increased demands for the available resources, a number of important plant species have become scarce in areas where they were previously abundant. When the collection and use is not regulated, some species may become threatened with extinction. In recent years, the use of medicinal and aromatic plants has increased greatly in western countries, India and China. In Europe, at least 2000 medicinal and aromatic plants species are traded commercially.

Medicinal plants have a promising future because there are about half million plants around the world, and most of their pharmaceutical capability have not investigated yet, which should be in demand of the present and future studies.

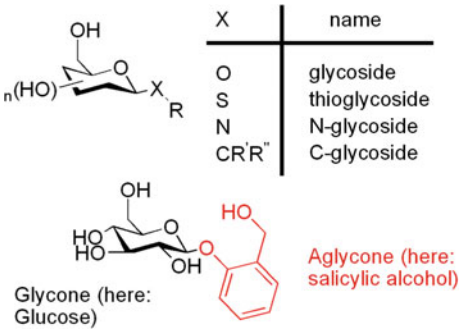
## Therapeutic Importance of Phytochemicals

Plants have evolved to synthesize an extremely diverse range of chemical compounds known as secondary metabolites. These secondary metabolites have no apparent role in primary plant growth and development processes, so they are unique to plants from a single species and increase during times of high stress such as drought, temperature and bacterial infection (Taiz and Zeiger 2006). Many of these compounds exhibit anti-microbial, anti-oxidant, cytotoxic and other medicinally useful properties (Taiz and Zeiger 2006). These activities can be attributed to the presence of a variety of phytochemical constituents, which can be divided into

three main chemically distinct groups: terpenes, phenolics and nitrogen containing compounds (alkaloids). The following is a brief presentation of the main chemical compositions of medicinal plants.

## *Glycosides*

The glycosides are the products of secondary metabolism including various categories of secondary metabolites which bounded to mono or oligosaccharide and to uronic aid. The saccharide or uronic acid part is called glycone, and the other part is aglycone. The aglycon may be a terpene, flavonoid, coumarine or any other natural products. The main groups of glycosides (based on chemical nature of aglycon and pharmacological activity) are cardiac glycosides, cyanogenic glycosides, glucosinolates, saponins and anthraquinone glycosides. However, flavonoids are frequently occurred as glycosides.




The cardiac glycosides or cardenolides are a family of steroids that bind and inhibit the intracellular $Na^+/K^+$-ATPase pumps in the membrane of cells with high selectivity and affinity. These intracellular pumps are critical for the cardiac cells' function and their effects are really remarkable on the heart which leads to contractility increase and rate reduction.

Thus, cardio glycosidic plants are commonly used in the treatment of heart failure and cardiac arrhythmia. Cardioactive glycosides are found in a diverse group of plant species including *Digitalis purpura* and *D. lanata* (Scrophulariaceae), *Nerium oleander* (Apocynaceae) and *Convallaria majalis* (Convallariaceae) (Oerther 2011; Bernhoft 2010).

The cyanogenic glycosides or cyanoglycosides have aglycones derived from amino acids. These compounds are usually interfered with the iodine utilization and result in hypothyroidism. Cyanogenic glycosides can become very toxic and lethal in high dosage, when hydrogen cyanide (HCN) release. Cyanogenic glycosides with at least 2500 taxa are relatively id in plant kingdom. Most of the taxa belong to

families Fabaceae, Rosaceae (in particular in *Prunus* spp.), Linaceae, Compositae and others (Vetter 2000).

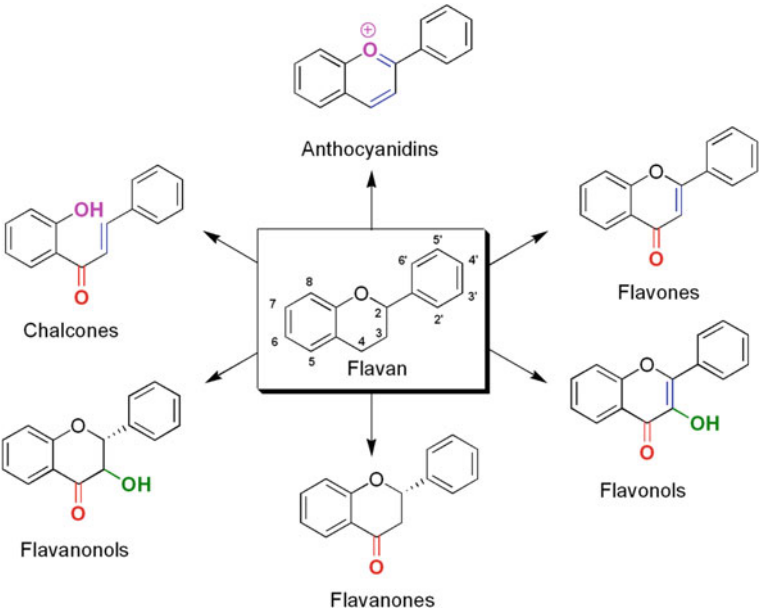
The glucosinolates (*S*-glucopyranosylthiohydroximates) contain sulphur-containing, pungent amino acid-derived a glycones. They are enzymatically hydrolyzed to produce sulfate ions, D-glucose, and characteristic degradation products such as isothiocyanates (Ishida et al. 2014). The compounds show a complex set of effects on cytochrome P450 isoforms in various cells and tend to decrease hepatic bioactivation of environmental procarcinogens. The glucosinolates cause skin irritation and also induce hypothyroidism and goitre. The Brassicaceae, Capparidaceae and Resedaceae are the main family associated with glucosinolate production.

The saponin glycosides are large molecules with a hydrophilic glycone and a hydrophobic aglycone, which give emulsifying properties and can be used as detergents. In addition, saponins exert a wide range of pharmacological activities including expectorant, anti inflammatory, vasoprotective, hypocholesterolemic, immunomodulatory, hypoglycemic, molluscicidal, antifungal, antiparasitic and many others (Sparg et al. 2004; Sahu et al. 2008). Plants rich in saponins, like *Panax ginseng* or *Glycyrrhiza glabra*, have been used for medicinal purposes since ancient times (Fiore et al. 2005) and to date continue to play a significant role not only in medicine but also in food and cosmetic industry, where they are utilized as emulsifiers or sweeteners (Guçlu-Ustundag and Mazza 2007). Saponins are also use as adjuvants in the production of vaccines (Sun et al. 2009). Aglycone component of anthraquinone glycosides is a polyhydroxyanthraquinone derivative.

Anthraquinone glycosides are generally orange, red, or brown-red compounds found in fairly limited distribution within the plant kingdom. In Polygonaceae (dock family) for instance, they could be found in *Rumex crispus* (curly dock) and *Rheum* spp. (rhubarbs). Their primary effect is induction of water and electrolyte secretion as well as peristalsis in colon.

## *Flavonoids and Proanthocyanidins*

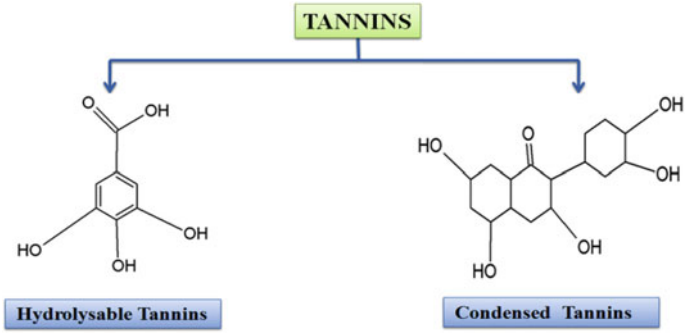
Flavonoids consist of a large group of polyphenolic compounds with a benzo-γ-pyrone structure, which are ubiquitously observed in plants. Proanthocyanidins are oligomers of flavonoids. Both groups of compounds can occur as glycosides and methylated derivatives. Flavonoids are the most common and widely distributed group of plant phenolic compounds, occurring virtually in all plant parts, particularly the photosynthesis plant cells (Kumar and Pandey 2013). All compounds contain phenol-groups involved in an effect as general antioxidant. Other actions are diverse-several structures reduce inflammation or carcinogenicity. The group isoflavones are primarily known as phytoestrogens. Flavonoids and proanthocyanidins are all pigments occurring in a long range of plant families. Isoflavones are produced by species of Fabaeceae (bean family).




## *Tannins*

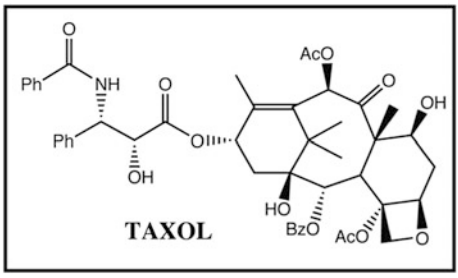
Tannins are distinctive group of polyphenolic polymers found widely in the plant kingdom. They are usually classified into two categories (on the basis of their structure and reactivity).

The first group is condensed tannins which have no carbohydrate core and comprise a group of polyhydroxy-flavan-3-ol oligomers and polymers linked by carbon-carbon bonds between flavanol subunits. The second group are hydrolysable tannins which are polyesters of gallic acid (gallo tannins) and hexahydroxy-diphenic acid (ellagitannins) with a central polyols such as sugars/glucose and phenolic such as catechin. The two types of tannins have most properties in common, but hydrolysable tannins are less stable and have greater potential to cause toxicity. The water solubility is restricted and decrease in general with the size of the tannin molecule. Tannins indiscriminately bind to proteins and larger tannins are used as astringents in cases of diarrhoea, skin bleedings and transudates. Condensed tannins are the most widely distributed tannins in vascular plants. However, hydrolyzable tannins are restricted to the dicotyledons (Bernays et al. 1989). Examples of plant families associated with presence of tannins are Fagaceae (beech family) and Polygonaceae (knotweed family).




## *Terpenoids and Phenylpropanoids*

Terpenoids, also referred to as isoprenoids or isopentenoids, represent the largest and most diverse category of chemicals among the myriad compounds produced by plants (Tholl 2015). The terpenoids are synthesized via the five-carbon building block isoprene. Based on the number of the building blocks, terpenoids are commonly classified as hemiterpenes ($C_5$), monoterpenes ($C_{10}$), sesquiterpenes ($C_{15}$), diterpenes ($C_{20}$), sesterpenes ($C_{25}$), triterpenes ($C_{30}$), tetraterpenes ($C_{40}$), polyterpenes (>$C_{40}$) (Ashour et al. 2010; Martin et al. 2003). The less diverse phenylpropanoid are based on a nine carbon skeleton and are synthesized via another pathway. Plant-based terpenoids are very lipophilic and tend to have strong flavors, which traditionally have been used by humans in the food, pharmaceutical, and chemical industries, and more recently exploited for development of biofuel products. Among these terpenoids, taxol (diterpene) of *Taxus baccata* and artemisinin (sesquiterpene lactone) from *Artemisia annua* are well known antineoplastic and antimalarial agents (Croteau et al. 2006; Pollier et al. 2011).



## *Resins*

The resins are complex lipid-soluble mixtures-usually both non-volatile and volatile compounds (Langenheim 2003). The non-volatile fraction may consist of diterpenoid and triterpenoid compounds, and mono- and sequiterpenoids predominate in the volatile fraction. Resins are poorly defined chemically, however, isoprene ($C_5H_8$) units are the fundamental building blocks of all true resins. Most typical resins are secreted by a number of plants, especially pines and other conifers and are a major non-wood product of forests, but resins are also present in herbaceous plants (mainly in seed bearing plants). They are all sticky and the fluidity depends on their contents of volatile compounds. The plant resins are used widespread as adhesives, ingredients of cosmetic preparations, as fragrances in daily rituals and religious ceremonies, as coating materials and as remedies in folk medicine (Langenheim 2003; Bernhoft 2010). Most resins are antimicrobial and wound healing, but their actions depend on the composition of the chemical mixture. Today resins are used in the manufacture of a wide range of products including paints and lacquers, rubber, soaps, linoleum, essential oils, furniture polishes and pesticides.

## *Lignans*

Lignans are a class of secondary plant metabolites produced by oxidative dimerization of two phenylpropanoid units at the β and β′ carbon atoms. Although their molecular backbone consists only of two phenylpropanoid (C6-C3) units, lignans show an enormous structural diversity (Saleem et al. 2005). They are derived from the shikimic acid biosynthetic pathway (Imai et al. 2006). Lignans are present at highest concentrations in oil seeds (e.g., flax, soy, rapeseed and sesame), but are 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. The plant lignans most commonly detected in foods are lariciresinol, matairesinol, pinoresinol and secoisolariciresinol (Thompson et al. 2006).

## *Alkaloids*

The alkaloids are a diverse group of low-molecular-weight, nitrogen-containing compounds, usually with potent activity and bitter taste found in about 20% of flowering plants, and are especially common in some families such as Fabaceae,

Liliaceae, Solanaceae and Ranunculaceae. Compared with other classes of natural compounds, alkaloids are characterized by a great structural diversity and there is no uniform classification of alkaloids. The various groups of alkaloids have diverse biological and pharmacological properties.

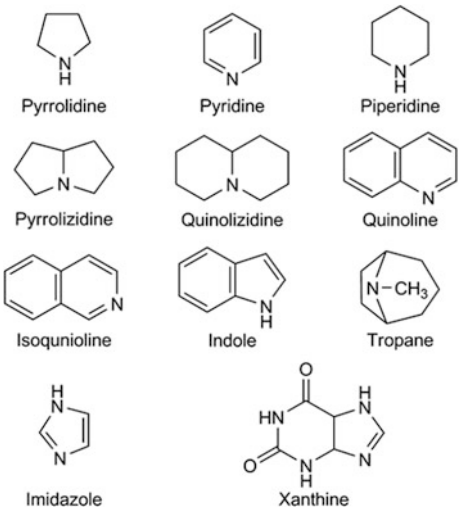
Tropane alkaloids consist of over 200 known compounds with a tropane ring in their structures, such as the anticholinergic drugs atropine and scopolamine and the stimulant cocaine (Lounasmaa and Tamminen 1993). Poisonous Solanaceae family plants, presently classified as genera: Atropa, Brugmansia, Datura, Duboisia, Hyoscyamus and Scopolia, with many alkaloid-containing species (Griffin and Lin 2000; Ghorbanpour et al. 2013), were well known already in ancient times, and records of their employment in folk medicine of various ethnic groups are abundant (Sneader 2005a, b). The compounds have anticholinergic activity (muscarine receptor antagonists) and are used medically to reduce smooth muscle spasms, hypersecretion and pain.

Pyrrolizidine alkaloids are considered to be important secondary metabolites largely on account of their biological activities, which include acute hepatotoxic, mutagenic, carcinogenic, teratogenic, anticancer properties and neuroactive properties (Asres et al. 2004). Pyrrolizidine alkaloids are produced in Asteraceae (daisy family), particularly in *Senecio* spp. (Ragworts) and in Boraginaceae (borage family).

The isoquinoline alkaloids are a large class of medicinally active alkaloids whose properties are variable. Their properties include being antispasmodic, antimicrobial, antitumour, antifungal, anti-inflammatory, cholagogue, hepatoprotective, antiviral, amoebicidal, anti-oxidant and can act as enzyme inhibitors. This class notably includes morphine and codeine. They are typically found in the Papaveraceae, Berberidaceae and Ranunculaceae families. They are derived from the amino acids phenylalanine or tyrosine.

Compared with other plant alkaloids, purine alkaloids are distributed widely throughout the plant kingdom although accumulation of high concentrations is restricted to a limited number of species, including *Coffea arabica* (coffee), *Camellia sinensis* (tea) and *Theobroma cacao*(cacao) (Ashihara and Crozier 1999).

Compounds called pseudoalkaloids most often have all of the chemical characteristics of the true alkaloids, however, they are not derived from amino acids. They are produced by species in Apiaceae (carrot family) for instance *Cicuta virosa* (cowbane), *Conium maculatum* (hemlock), and in Taxaceae (yew family) for instance *Taxus baccata* (yew). The pseudoalkaloids in *Cicutavirosa* and *Conium maculatum* have effects on the central nervous system and taxine in yews like *T. baccata* inhibits the ion transport of the hearth.




## Important Plant Families Having Given Molecules/Drugs of Importance

Plants of commercial importance (e.g. Apiaceae, Apocynaceae, Araliaceae, Araceae, Asphodelaceae, Asteraceae, Ginkgoaceae, Hypericaceae, Lamiaceae, Papaveraceae, Piperaceae, Rhamnaceae, Rubiaceae, Rutaceae, Solanaceae and Zingiberaceae) serve as main sources of pharmaceutically active compounds (Gurib-Fakim 2006). In this chapter, the pharmaceutically most important families are highlighted, especially those that have yielded many, or very important, botanical drugs.

### *Apiaceae (Umbelliferae)*

The flowering plant family Apiaceae (Umbelliferae) comprises 300–455 genera and some 3000–3750 species (Pimenov and Leonov 1993). It is cosmopolitan, being particularly abundant in the northern hemisphere. Members of this family are often rich in essential oil, which is one of the main reasons for the pharmaceutical importance for many of the apiaceous drugs.

Important medicinal plants in the family and their uses are the following (Gurib-Fakim 2006):

- *Carum carvi* L. (caraway), a carminative and also important as a spice.
- *Coriandrum sativum* L. (coriander), a carminative and also important as a spice.
- *Foeniculum vulgare* Miller (fennel), a mild carminative.
- *Levisticum officinale* Koch (lovage), a carminative and antidyspeptic.
- *Pimpinella anisum* L. (anise-fruit), an expectorant, spasmolytic and carminative.

## *Apocynaceae*

Apocynaceae is a family of flowering plants that includes trees, shrubs, herbs, stem succulents, and vines, commonly called the dogbane family (Endress and Bruyns 2000). This family has wide distribution both in temperate and tropical regions of the world. Among the world famous species is the Rosy Periwinkle (*Catharanthus roseus*). Members of this family are well known for their alkaloidal contents with potent pharmacological activity.

## *Araliaceae*

Araliaceae include 43 genera and almost 1400 species. Majority of them are prone to be grown in the tropical zones of both hemisphere, and are rarely observed in temperate climates.

Important medicinal plants from the family:

- *Hedera helix* L. [(common) ivy], used as a cough remedy. The *H. helix* leaves contain saponins, flavonoids, phenolic acids, emetine alkaloid, amino acids, sterols, proteins, vitamins, polyacetylenes, etc. (Parvu et al. 2015).
- *Panax ginseng* C.A. Meyer (ginseng), used as an adaptogene (a very ill-defined category) to combat mental and physical stress [and sometimes replaced by *Eleutherococcus* (*Acanthopanax*) *senticosus* (Rupr and Maxim) Maxim from the same family]. The triterpenoids (ginsengosides) are implicated in the pharmacological effects of *P. ginseng*, while saponins (hederasaponins) are used for the secretolytic effect of *H. helix*.

## *Palmaceae (Arecaceae)*

The palms which comprises of approximately 2700 species are almost exclusively woody and is an important family as it includes many species widely used as food, and over the past years at least one of its members has become medicinally important.

The *Serenoa repens* (Sawpalmetto) is now being used for difficulty in micturition in benign prostate hyperplasia in the early stages.

The accumulation of polyphenols, some relatively simple alkaloids (especially pyridine derivatives), steroidal saponins, fatty acids [coconut (*Cocos nucifera* L.) and oil palm (*Elaeis guineensis* Jacq.)] is typical. The pharmaceutical use of the Sawpalmetto seems to be due to the presence of a relatively large amount of the triterpenoid-β-sitosterol (Gurib-Fakim 2006).

## *Asphodelaceae*

This family are often included in the Liliaceae (lily family). This family, with about 600 species, are widely distributed in South Africa and some species occur in the Mediterranean regions (Gurib-Fakim 2006). The best-known members in this family are *Aloe vera* (L.) Burman f. (syn. *Aloe barbadensis*, Barbardos aloe) and *A. ferox* Miller (Cape aloe), both strong purgatives. The genus Aloe is characterized by the presence of polysaccharides accumulating in the leaves as well as anthranoids and anthraglycosides (aloe-emodin), which are responsible for the species' laxative effects.

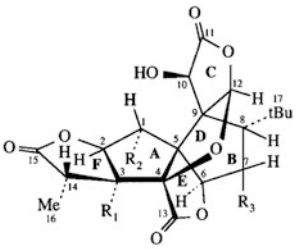
## *Asteraceae (Compositae)*

This large family comprises of some 25,000 species and 1400 genera and is distributed and well represented in most ecosystems except for Antarctica (Gurib-Fakim 2006). A typical chemical trait of this family is the presence of polyfructanes (especially inulin) as storage carbohydrates (instead of polysaccharides) in perennial taxa. Important medicinal plants from the family are the following:

- *Arnica Montana* L. (arnica), used topically, especially for bruises.
- *Artemisia absinthum* L. (wormwood or absinthium), used as a bitter tonic and choleretic.
- *Calendula officinalis* L. (marigold), used topically, especially for some skin afflictions.
- *Cnicus benedictus* L. (cnicus), used as a cholagogue (a bitter aromatic stimulant).
- *Cynara scolymus* L. (artichoke), used in the treatment of liver and gallbladder complaints and several other conditions.
- *Echinacea angustifolia* DC., *E. pallid* Nuttall and *E. purpurea* (L.) Moench (Cone flower), now commonly used as an immunostimulant.
- *Matricaria recutita* L. (chamomille/camomille; several botanical synonyms are also commonly used, including *Chamomilla recutita* and *Matricaria chamomilla*).
- *Tussilago farfara* L. (coltsfoot), a now little used expectorant and demulcent.

## *Ginkgoaceae*

This is one of the most ancient families of the seed bearing plants and had been widely distributed during the Mesozoic (180 million years ago). Only one species namely *Ginkgo biloba* L. has survived phytochemically, this plant is characterized by the presence of the gingkolides, which are unusual two-ringed diterpenoids with three lactone functions. Biflavones and glycosylated flavonoids are other groups of typical natural products.

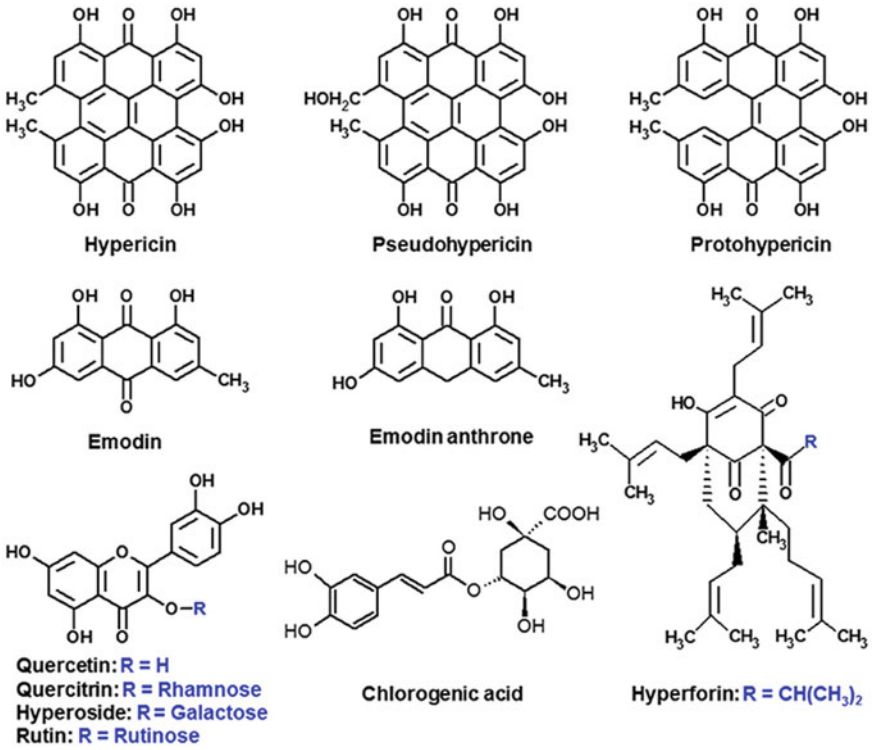



| | $R_1$ ($C_3$) | $R_2$ ($C_1$) | $R_3$ ($C_7$) |
|---|---|---|---|
| Ginkgolide A | OH | H | H |
| Ginkgolide B | OH | OH | H |
| Ginkgolide C | OH | OH | OH |
| Ginkgolide J | OH | H | OH |

## *Hypericaceae*

This family of some 900 species, are pharmaceutical importance because of St. John's wort (*Hypericum perforatum* L.), which in the last decade of the 20th century became one of the most important medicinal plants in modern medicine.

The former name Guttiferae is an important indicator of a characteristic chemical feature: the presence of resins, balsam and other glands containing excretory products. For example, the hypericin glands, with red colour, are present especially in the flowers and contain naphthodianthrones, including hypericin (a naphthodianthrone) and pseudohypericin, which are characteristic for some sections of the genus. Typical for the family in general are also xanthones (found nearly exclusively in this family and in the Gentianaceae). The genus is known to accumulate flavonoids and their glycosides (rutoside, hyperoside), as well as hyperforin (a lipophilic phloroglucinol) and its derivatives (Barnes et al. 2001), which are derived from the terpenoid pathway.




## *Lamiaceae*

The Lamiaceae is a family yielding a high number of medicinal taxa (over 5000 species), especially due to their high content of essential oil. Important medicinal plants from the family are as below:

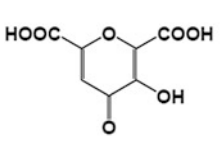
- *Lavandula angustifolia* Miller (lavender), a mild carminative and spasmolytic.
- *Melissa officinalis* L. (balm), a mild sedative, carminative and spasmolytic.
- *Mentha arvensis* L. var. *piperascens* Malinvaud (Japanese mint), yields a commonly used essential oil (e.g. for respiratory problems).
- *Mentha piperita* L. (peppermint), a commonly used carminative and spasmolytic and a hybrid between *M. spicata* L. and *M. aquatic* L.
- *Mentha spicata* L. (spearmint), commonly used in toothpaste and chewing gum, with mild carminative effects.
- *Rosmarinus officinalis L.* (rosemary), a carminative and spasmolytic.
- *Salvia officinalis* L. (sage), used as a topical antiseptic (gargling) and orally as a carminative and spasmolytic.
- *Thymus vulgaris* L. (thyme), a carminative and spasmolytic.

Some segments of the family are known to accumulate monoterpenoid glycosides. Many species also accumulate rosmarinic acid (and other derivatives of caffeic acid. Besides the antioxidant potential, rosmarinic acid has been reported to present a multitude of pharmacological and biological activities (Amoah et al. 2016).

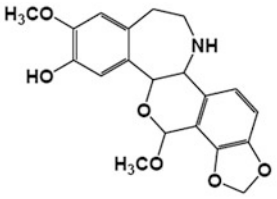
## *Papaveraceae*

The Papaveraceae are an economically important family of about 42 genera and approximately 775 known species, has produced a multitude of pharmacologically or toxicologically important genera (e.g. chelidonium, glaucium, papaver). This family is particularly rich in the isoquinoline alkaloids including morphine, papaverine, codeine, thebaine and noscapine. Other alkaloids present include the benzylisoquinoline such as papaverine (vasodilator and smooth muscle relaxant) and noscapine (antitussive and antitumorogenic) (Dewick 2002; Schmeller and Wink 1998). The two most important medicinal plants from the family are:

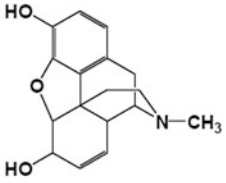
- *Chelidonium majus* L. (greater celandine), which yields the alkaloid chelidonine, employed as a cholagogue.
- *Papaver somniferum* L. [(opium) poppy], which yields a multitude of pharmacologically active alkaloids and is a well-known and dangerous narcotic.



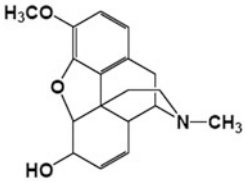
Meconic acid



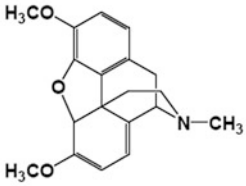
Porphyroxine



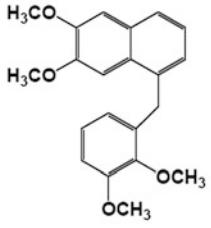
Morphine



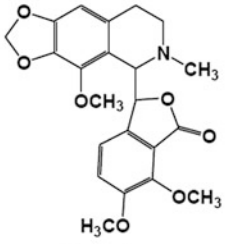
Codeine



Thebaine



Papaverine



Noscapine

## *Piperaceae*

The Pepper family consists of herbs and shrubs comprise some 2000 species is mostly restricted in the tropics.

Important medicinal plants from the family are the following:

- *Piper methysticum* Forster f. (kava-kava), traditionally used as a mild stimulant in Oceania and now used for conditions of nervous anxiety; recent reports of liver toxicity has resulted in withdrawal in many countries.
- *Piper nigrum* L. (black and white pepper), occasionally used in rubefacient preparations and as a spice.

Some of the isolated molecules from the family are:

Pungent acidic amides, such as piperine, are known from several members of this family, and sometimes essential oil is present. The α-pyrone derivatives (e.g. kavain) from *P. methysticum* are another group of commonly found compounds known from species of Piper.

## *Rhamnaceae*

This family consists of 50 genera and more than 900 species. This family has a worldwide distribution but is more common in the tropical and subtropical regions of the world. The family is best known pharmaceutically because some taxa accumulate anthraquinones. Also alkaloids of the benzylisoquinoline type and the cyclo-peptide type are known from many taxa.

Important medicinal plants from the family are:

- *Rhamnus purshiana* DC. (American cascara) and *R. frangula* L. (syn. *Frangula alnus*, European alder, buckthorn), both used as strong purgatives (Gurib-Fakim 2006).

## *Rubiaceae*

This large family of over 10,000 species has yielded one of the most important stimulants, coffee (*Coffea arabica* L. and *C. canephora* Pierre ex Froehner) and one of the first and most important medicinal plants brought over from the 'New World', cinchona bark.

The family is known for a large diversity of classes of natural products, including iridoids (a group of monoterpenoids), alkaloids (including indole alkaloids such asquinine from *Cinchona* spp.), methylxanthines such as caffeine, theobromine and theophylline, and anthranoidsin some taxa (e.g. the now obsolete medicinal plant *Rubia tinctorum*, which was withdrawn because of its genotoxic effect).

Important medicinal plants from the family are:

- *Cinchona succirubra* Weddell, *C. calisaya* Weddell and *Cinchona* spp. (cinchona, Peruvian bark), used as a bitter tonic, febrifuge and against malaria.

## *Rutaceae*

This family comprises of 1700 species distributed throughout the world however the tropics are particularly rich in them (Gurib-Fakim 2006). The family includes some of the most important fruit bearing plants known: the genus Citrus with orange, lemon, lime, mandarin, grapefruit, etc.

Essential oil is common in many taxa (Citrus, Ruta) and can be found in lysigenous secretory cavities in the parenchyma and pericarp. Alkaloids are also frequently found, especially benzyl tetrahydroisoquinoline, acridone and imidazole types (pilocarpine). The acridone alkaloids have so far only been reported from the Rutaceae. Other groups of natural products typically encountered are furano- and pyranocoumarins (e.g. bergapten from *Citrus aurantium* sub sp. *bergamia*, used to flavour Earl Grey tea), as well as simple coumarins.

Important medicinal plants from the family are:

- *Pilocarpus jaborandi* Holmes and *Pilocarpus* spp. (pilocarpus), for the isolation of pilocarpine, which is used in ophthalmology.
- *Ruta graveolens* L., formerly widely used as an emmenagogue and spasmolytic, shows strong phototoxic side effects. Many species (especially of the genus *Citrus*) are aromatic and used in foods, pharmacy and perfumery.

## *Solanaceae*

Solanaceae with 2600 species includes some of the most important staples-the Potato (*Solanum tuberosum*) and several other medicinal and toxic plants, known for the highly active natural products. Typical for the family are alkaloids, especially of the tropane, nicotine and steroidal type. Many taxa are characterized by oxalic acid, which often forms typical structures (e.g. sand-like in *Atropa belladonna,* irregular crystals in *Datura stramonium*).

Important medicinal plants from the family are:

- *Atropa belladonna* L. (deadly nightshade, atropa), *Datura stramonium* L. (stramonium) and *Hyoscyamus niger* L. (henbane), which yield alkaloids with spasmolytic and anticholinergic properties; atropine is used in ophthalmology.

### *Zingiberaceae*

This family are distributed in tropical regions and rich in essential oils with terpenes (borneol, camphene and cineole (all oxygenated monoterpenes), sesquiterpenes (zingiberene) and phenyl propanoid derivatives (cinnamic acid derivatives). Important medicinal plants from this family are as follows (Gurib-Fakim 2006):

- *Curcuma zanthorrhiza* Roxburgh (Temulawak, Javanese turmeric).
- *Curcuma longa* L. (syn. *C. domestica*, turmeric), a commonly used spice and popular remedy used, for example, for inflammatory, liver diseases, and in most Asian medical systems for a large variety of illnesses.
- *Elettaria cardamomum* (L.) Maton (cardamom), which is mostly used as a spice but also as a medicine.
- *Zingiber officinale* Roscoe (ginger), used for a large variety of illnesses, including travel sickness, respiratory and gastrointestinal disorders.

## Medicinal, Pharmacological and Industrial Applications of Medicinal Plants

The fact that plant organisms produce chemical substances cause a positive or negative interfere with plant's processes which can regulate human life based on what has been reported since ancient time. The value of medicinal plants and their molecules with therapeutic potential have historically proven, and nowadays still represent an important pool for the identification of novel drug leads.

### *Traditional Medicine*

Traditional medicine refers to health practices, approaches, skills, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination of treat, diagnose and prevent illnesses or maintain well-being.

The first written records on medicinal applications of plants date back to 2600 BC which report the existence of a sophisticated medicinal system in Mesopotamia, comprising about 1000 plant-derived medicines. Egyptian medicine dates back to about 2900 BC, however, its most useful preserved record is the "Ebers Papyrus" from about 1550 BC, containing more than 700 drugs, mainly of plant origin (Borchardt 2002; Cragg and Newman 2013; Sneader 2005a, b). Traditional Chinese medicine has been extensively documented over thousands of years (Unschuld 1986), and the documentation of the Indian Ayurveda system dates back to the 1st millennium BC (Patwardhan 2005).

Up to know, millions of people around the world consume plant-based medicines as part of traditional medicine for a range of medical disorders. The use of traditional medicine in developing countries contributes directly to the socio-economic status and well-being of the rural communities (Tabuti et al. 2003; Chiranjibi et al. 2006). People especially herbalists and traditional healers generate income from medicinal plants.

Countries in Africa, Asia and Latin America use traditional medicine to help meet some of their primary health care needs. In Africa, up to 80% of the population uses traditional medicine for primary health care. In industrialized countries, adaptations of traditional medicine are termed "complementary" or "alternative".

To promote the proper use of traditional medicine/complementary or alternative, WHO has elaborated a Traditional Medicine Strategy (WHO 1998, 2002) that focuses on Policy, Safety/Quality/Efficacy, Access and Rational use of traditional medicine/complementary or alternative. The strategy aims to support Member States in developing proactive policies and implementing action plans that will strengthen the role traditional medicine plays in keeping populations healthy.

Traditional medicine has maintained its popularity in all regions of the developing world and its use is rapidly spreading in industrialized countries:

- In China, traditional herbal preparations account for 30–50% of the total medicinal consumption.
- In Ghana, Mali, Nigeria and Zambia, the first line of treatment for 60% of children with high fever resulting from malaria is the use of herbal medicines at home.
- WHO estimates that in several African countries traditional birth attendants assist in the majority of births.
- In Europe, North America and other industrialized regions, over 50% of the population have used complementary or alternative medicine at least once.
- In San Francisco, London and South Africa, 75% of people living with HIV/AIDS use TM/CAM.
- 70% of the population in Canada has used complementary medicine at least once.
- In Germany, 90% of the population has used a natural remedy at some point in their life. Between 1995 and 2000, the number of doctors who had undergone special training in natural remedy medicine had almost doubled to 10,800.
- In the United States, 158 million of the adult population use complementary medicines and according to the USA Commission for Alternative and Complementary medicines, US$17 billion was spent on traditional remedies in 2000.
- In the United Kingdom, annual expenditure on alternative medicine is US$230 million.
- The global market for herbal medicines currently stands at over US$60 billion annually and is growing steadily (http://www.who.int/mediacentre/factsheets/2003/fs134/en/).

## *Phytotherapy*

Herbalism (also herbal medicine or phytotherapy) is the study of botany and use of plants intended for medicinal purposes or for supplementing a diet. Plants have been the basis for medical treatments through much of human history, and such traditional medicine is still widely practiced today. Modern medicine recognizes herbalism as a form of alternative medicine, as the practice of herbalism is not strictly based on evidence gathered using the scientific method. Modern medicine makes use of many plant-derived compounds as the basis for evidence-based pharmaceutical drugs.

Closely related to herbalism, phytotherapy is the intended medical use of plants and plant extracts for therapeutic purposes (Heinrich 2016; Capasso et al. 2003). A possible differentiation with herbalism is that phytotherapy may require constituents in the plant extract be standardized by adhering to a minimum content of one or several active compounds in the therapeutic product (Heinrich 2016).

Modern phytotherapy may use conventional methods to assess herbal drug quality, although more typically relies on modern processes like high-performance liquid chromatography (HPLC), gas chromatography (GC), ultraviolet/visible spectrophotometry or atomic absorption spectroscopy to identify species, measure bacteriological contamination, assess potency, and create certificates of analysis for the material (Gad et al. 2013). Phytotherapy is distinct from homeopathy and anthroposophic medicine, and avoids mixing plant and synthetic bioactive substances.

## *Aromatherapy*

The use of plants for therapeutic purposes has always been in human life, and is still valid despite the vast power and responsibility of the pharmaceutical chemistry, mainly based on the active principles of synthesis.

Nowadays, use of alternative and complementary therapies with mainstream medicine has gained the momentum. Aromatherapy is one of the complementary therapies which use essential oils as the major therapeutic agents to treat several diseases. The essential or volatile oils are extracted from the flowers, barks, stem, leaves, roots, fruits and other parts of the plant by various methods. This therapy is a natural way of healing a person's mind, body and soul (Worwood 2000). Literature survey reveals that this therapy has gained a lot of attention in the late 20th century and has become very popular in the 21st century due to its importance, popularity and widespread use, it is recognized as aroma science therapy (Esposito et al. 2014). These aroma molecules are very potent organic plant chemicals that make the surroundings free from disease, bacteria, virus and fungus (Liu et al. 2013). The penetration potential of these oils to reach the subcutaneous tissues is one of the important characters of this therapy.

## *Food Additives*

Food safety is a global issue with significant implications for human health. The WHO annually reports that unsafe food results in the illnesses of at least 2 billion people worldwide which can be deadly.

Food additives are substances added to foods to keep them fresh or to enhance their colour, flavour or texture. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, as with bacon, preserving sweets or using sulfur dioxide as with wines. With the advent of processed foods in the second half of the twentieth century, many more additives of plant-based origin have been introduced to food industry. The significance of medicinal aromatic and spice plants in food additives is raised by their antimicrobial (bactericidal and fungicidal) properties, owing to which they make highly valued preservatives for fresh vegetable or meat preparations as well as canned products (Davidson et al. 2005). Given the consumer demand for natural preservatives and/or consumer negative response to chemical compounds, it is imperative that more research is focused on the application of plant antimicrobials to food safety.

## *Cosmetic Products*

The knowledge of herbal cosmetics is represented now-a-days by both orally transmitted folk information and newer information generated by modern scientific studies. Herbal products like extracts; oils and powders have been used in cosmetics as either active moieties or as excipients. Herbal extracts are primarily added to the cosmetic preparations due to several associated properties such as antioxidant (e.g. carotenoids, flavonoids and polyphenols) and anti-inflammatory characteristics (Glaser 2004; Draelos 2003).

The name itself suggests that herbal cosmetics are natural and free from all the harmful synthetic chemicals however it has proved to be toxic for skin. Instead of traditional synthetic products different plant parts and plant extracts are used in these products, e.g. aloe-vera gel and coconut oil. They also consist of natural nutrients like vitamin E that keeps skin healthy, glowing and beautiful (Akinyele and Odiyi 2007).

## *Medicinal Plants as a Future Source of New Drugs*

The process of drug discovery is so long involves the identification of candidates, synthesis, characterization, screening, and assays for therapeutic efficacy. Despite competition from different drug discovery methods, natural products are still providing their fair share of new clinical candidates, new drugs and new drug leads.

These compounds were still a significant source of new drugs, especially in the anticancer, antihypertensive, anti-infectives, immuno-suppression, and neurological disease therapeutic areas, and some of them have since progressed further into clinical trials or onto the market (Butler 2004).

It is considered that because of the structural and biological diversity of their constituents, medicinal plants offer a unique and renewable resource for the discovering of potential new drugs and biological entities (Lahlou 2007). Therefore, plant-based metabolites can be predicted to remain an essential component in the search and development for new, safe and economical medicaments.

Unfortunately, as a result of ongoing climate changes and anthropogenic factors, a significant decrease in global vegetative species in future is predicted (Maclean and Wilson 2011; Thomas et al. 2004), endangering the sources of potential new drugs from nature and prompting urgent actions.

## References

Abdul Rasool Hassan B (2012) Medicinal plants (importance and uses). Pharmaceut Anal Acta 3:10

Akinyele BO, Odiyi AC (2007) Comparative study of the vegetative morphology and the existing taxonomic status of Aloe vera. J Plant Sci 2:558–563

Ashihara H, Crozier A (1999) Biosynthesis and metabolism of caffeine and related purine alkaloids in plants. Adv Bot Res 30:117–205

Ashour M, Wink M, Gershenzon J (2010) Biochemistry of terpenoids: monoterpenes, sesquiterpenes and diterpenes. In: Wink M (ed) Annual plant reviews: biochemistry of plant secondary metabolism, 2nd edn. Wiley, New York

Asres K, Sporer F, Michael Wink M (2004) Patterns of pyrrolizidine alkaloids in 12 Ethiopian Crotalaria species. Biochem Syst Ecol 32:915–930

Barnes J, Anderson LA, Phillipson JD (2001) St. John's wort (Hypericum perforatum L.): a review of its chemistry, pharmacology, and clinical properties. J Pharm Pharmacol 53:583–600

Bernays EA, Cooper Driver G, Bilgener M (1989) Herbivores and plant tannins. Adv Ecol Res 19:263–302

Bernhoft A (2010) Bioactive compounds in plants; benefits and risks for man and animals. The Norwegian Academy of Science and Letters, Oslo

Borchardt JK (2002) The beginnings of drug therapy: ancient Mesopotamian medicine. Drug News Perspect 15:187–192

Butler MS (2004) The role of natural product chemistry in drug discovery. J Nat Prod 67: 2141–2153

Capasso F, Gaginella TS, Grandolini G, Izzo AA (2003) Phytotherapy a quick reference to herbal medicine. Springer. ISBN 978-3-540-00052-5

Chiranjibi P, Sudhakar R, Dhal NK, Rashmita D (2006) Some phytotherapeutic claims by tribals of Rayagada district, Orissa, India. Ethnobotanical Leaflets 10:189–197

Cragg GM, Newman DJ (2013) Natural products: a continuing source of novel drug leads. Biochim Biophys Acta 1830:3670–3695

Croteau R, Ketchum RE, Long RM, Kaspera R, Wildung MR (2006) Taxol biosynthesis and molecular genetics. Phytochem Rev 5:75–97

Davidson MP, Sofos JN, Branen AL (2005) Antimicrobials in food, 3rd edn. Taylor & Francis, Boca Raton, p 720

Dewick PM (2002) Medicinal natural products: a biosynthetic approach, 2nd edn. Wiley, Chichester
Draelos ZD (2003) Topical anti-inflammatory agents. Cosmetic Dermatol 16(10):41–42
Endress ME, Bruyns PV (2000) A revised classification of the Apocynaceae. Bot Rev 66(1):1–56
Esposito ER, Bystrek MV, Klein JS (2014) An elective course in aromatherapy science. Am J Pharm Educ 78(4):79
Fiore C, Eisenhut M, Ragazzi E et al (2005) A history of the therapeutic use of liquorice in Europe. J Ethnopharmacol 99:317–324
Gad HA, El-Ahmady SH, Abou-Shoer MI, Al-Azizi MM (2013) Application of chemometrics in authentication of herbal medicines: a review. Phytochem Anal 24(1):1–24
Ghorbanpour M, Hatami M, Khavazi K (2013) Role of plant growth promoting rhizobacteria on antioxidant enzyme activities and tropane alkaloids production of *Hyoscyamusniger* under water deficit stress. Turk J Biol 37:350–360
Glaser DA (2004) Anti-aging products and cosmeceuticals. Facial Plast Surg Clin North Am 12:363–372
Griffin WJ, Lin GD (2000) Chemotaxonomy and geographical distribution of tropane alkaloids. Phytochemistry 53:623–637
Guçlu-Ustundag O, Mazza G (2007) Saponins: properties, applications and processing. Crit Rev Food Sci Nutr 47:231–258
Gurib-Fakim A (2006) Medicinal plants: traditions of yesterday and drugs of tomorrow. Mol Aspects Med 27(1):1–93
Heinrich M (2016) Phytotherapy. Encyclopaedia Britannica Inc
Imai T, Nomura M, Fukushima K (2006) Evidence for involvement of the phenylpropanoid pathway in the biosynthesis of the norlignan agatharesinol. J Plant Physiol 163:483–487
Ishida M, Hara M, Fukino N, Tomohiro Kakizaki T, Morimitsu Y (2014) Glucosinolate metabolism, functionality and breeding for the improvement of Brassicaceae vegetables. Breed Sci 64(1):48–59
Kumar S, Pandey AK (2013) Chemistry and Biological activities of flavonoids: an overview. Sci World J (162750): 16
Lahlou M (2007) Screening of natural products for drug discovery. Expert Opin Drug Discov 2:697–705
Langenheim J (2003) Plant resins: chemistry, evolution, ecology, and ethnobotany. Timber Press, Portland, p 586
Liu SH, Lin TH, Chang KM (2013) The physical effects of aromatherapy in alleviating work-related stress on elementary school teachers in Taiwan. Evid Based Complement Altern Med. doi:10.1155/2013/853809
Lounasmaa M, Tamminen T (1993) The tropane alkaloids. In: Cordell GA (ed) The alkaloids, vol 44. Academic, New York, pp 1–114
Maclean IM, Wilson RJ (2011) Recent ecological responses to climate change support predictions of high extinction risk. Proc Natl Acad Sci U.S.A. 108:12337–12342
Martin JJ, Pitera DJ, Withers ST, Newmann JD, Keasling JD (2003) Engineering a mevalonate pathway in *Escherichia coli* for production of terpenoids. Nat Biotechnol 21:796–802
Oerther SE (2011) Plant poisonings: common plants that contain cardiac glycosides. J Emerg Nurs 37(1):102–103
Parvu M, Vlase L, Parvu AE, Rosca-casian O, Gheldiu AM, Parvu O (2015) Phenolic compounds and antifungal activity of *Hedera helix* L. (Ivy) flowers and fruits. Not Bot Horti Agrobo 43 (1):53–58
Patwardhan B (2005) Ethnopharmacology and drug discovery. J Ethnopharmacol 100:50–52
Pimenov MG, Leonov MV (1993) The genera of the Umbel- liferae. Royal Botanic Gardens, Kew, Richmond, Surrey, UK
Pollier J, Moses T, Goossens A (2011) Combinatorial biosynthesis in plants: a (p) review on its potential and future exploitation. Nat Prod Rep 28:1897–1916

Sahu NP, Banerjee S, Mondal NB, Mandal D (2008) Steroidal saponins. Fortschritte der Chemie Organischer Naturstoffe/progress in the chemistry of organic natural products, vol 89. Springer, Vienna, pp 45–141

Saleem M, Kim HJ, Ali MS, Lee YS (2005) An update on bioactive plant lignans. Nat Prod Rep 22(6):696–716

Schmeller T, Wink M (1998) Utilization of alkaloids in modern medicine In: Roberts MF, Wink M (eds) Alkaloids-biochemistry, ecology and medicinal applications. Plenum Press, New York, pp: 435–459

Sneader W (2005) Plant products analogues and compounds derived from them. In: Sneader W (ed), Drug discovery; a history. Wiley & Sons, Ltd, Chichester, pp 115–150

Sneader, W (2005) Drug discovery: a history. Wiley

Amoah SKS, Sandjo LP, Kratz JM, Biavatti MW (2016) Rosmarinic acid-pharmaceutical and clinical aspects. Planta Med 82(5):388–406

Sparg SG, Light ME, Staden J (2004) Biological activities and distribution of plant saponins. J Ethnopharmacol 94:219–243

Sun HX, Xie Y, Ye YP (2009) Advances in saponin-based adjuvants. Vaccine 27:1787–1796

Tabuti JRS, Dhillion SS, Lye KA (2003) Traditional medicine in Bulamogi County, Uganda. its practitioners, users & viability. J Ethnopharmacol 85:119–129

Taiz L, Zeiger E, (2006) Plant physiology. Sinauer Associates Inc., Sunderland, Massachusetts, USA. [A general text of plant physiology]

Tholl D (2015) Biosynthesis and biological functions of terpenoids in plants. Adv Biochem Eng Biotechnol 148:63–106

Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC et al (2004) Extinction risk from climate change. Nature 427:145–148

Thompson LU, Boucher BA, Liu Z, Cotterchio M, Kreiger N (2006) Phytoestrogen content of foods consumed in Canada, including isoflavones, lignans and coumestan. Nutr Cancer 54:184–201

Unschuld PU (1986) Medicine in China: a history of Pharmaceutics. University of California Press

Vetter J (2000) Plant cyanogenic glycosides. Toxicon 38:11–36

WHO (1998) General guidelines for methodologies on research and evaluation of traditional medicine. WHO/EDM/TRM/2000.1, Geneva, pp 128

WHO (2002) Traditional medicine strategy 2014–2023. http://apps.who.int/iris/bitstream/10665/92455/1/9789241506090

Worwood VA (2000) Aromatherapy for the healthy child: more than 300 natural, non-toxic, and fragrant essential oil blends. New World Library, Novato