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## Medicinal plants as phytomedicine towards alleviating health stress

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## Abstract

Medicinal plants are essential to maintain human health and wellbeing. In India, traditional medical systems like Ayurveda, Unani, and Siddha account for 70 per cent of the pharmaceutical business, which is in line with the nation's population. Today, medicinal plants are a significant part of the contemporary economy. When it comes to the usage of medicinal plants, India perhaps has the oldest, richest, and most varied cultural traditions. The demand for medicinal plants is rising in both developed and emerging nations as a result of research into forest-based plant products for innovative new medicines. Even though, the market for therapeutic plants is expanding rapidly, until recently, neither the concerned user nor any significant conservation or cultivation efforts are made. Plants have long been utilized by traditional healers to prevent or treat infectious diseases. Numerous secondary metabolites found in plants, including alkaloids, tannins, flavonoids, terpenoids, and anthocyanins have been shown to possess antibacterial qualities *in vitro*. The demand for phytochemicals is predicted to extend in future as a replacement frontier for trade. The Indian herbal sector has to take a new dimension taking into consideration of our valuable plant biodiversity, interest of our farmers, healers, protection to the local health traditions, local tribes, processor and end users. In this review, phytomedicinal properties of medicinal plants such as Glory lily, Medicinal coleus, Stonebreaker, Safed musli, Ashwagandha, Stevia, Senna, Periwinkle and Aloe have been discussed in detail.

## 1. Introduction

Herbal remedies have been used since the Vedic period. Since the beginning of time, people have used medicinal plants to treat illnesses. Man, and his search for natural substances are closely intertwined (Alsaud *et al.*, 2021). Physicians and pharmacists comprehension of the development of ideas related to the use of medicinal plants as well as the evolution of awareness has improved their capacity to handle the problems that have emerged with the growth of professional services in promoting human existence (Tlili and Sarikurku, 2020).

The World Health Organization (WHO) estimates that up to 80% of people worldwide rely on traditional medicine for their primary healthcare needs. Only 5,00,000 of India's about 4.5 million plant species have had their phytochemical properties investigated for possible biological or medicinal benefits (Chen *et al.*, 2020). Plants having medicinal potential are widely used in all aspects of Indian life, including Siddha, Ayurveda, Unani medicines as well as processed pharmaceutical products and traditional cures (Wang *et al.*, 2020).

A vast array of chemical molecules with various structures and functions that exhibit significant biological activities and are associated with numerous advantageous properties, including antimicrobial,

anticancer, antiviral, antioxidant, enzyme inhibitory effects, as well as antiaging, anti-inflammatory, neuroprotective, antihypertensive and anticoagulant effects can be found in medicinal plants (Figure 1). Significant pharmacological characteristics of plant secondary metabolites, also referred to as phytochemicals, include hypoglycemic, antioxidative, antiallergic, antibacterial and anticarcinogenic effects (Sinan *et al.*, 2020). These secondary metabolites protect the cells from the damaging effects of free radicals, which are unstable molecules. A range of diseases can be treated with plant extracts or bioactive ingredients which can also be used as a novel formulation for pharmaceutical companies looking to develop new drugs (Halder and Cordeiro, 2019).

Cardiovascular diseases are the most prevalent ailment in the world. The plant families Asteraceae (Chrysanthemum, Dahlia, *etc.*) and Lamiaceae (Coleus, Mint, *etc.*) have been associated with the treatment of cardiovascular diseases. According to Knez *et al.* (2020), these herbs exhibit antioxidant, antithrombotic, antihyperlipidemic and vasorelaxant qualities. Both by themselves and in combination with traditional medicine, medicinal plants are highly significant worldwide. According to various sources, 25 to 50 per cent of pharmaceuticals currently produced for use in healthcare come from medicinal plants (Mahmood *et al.*, 2019). Researchers are looking for new bioactive compounds from both common and uncommon plants worldwide (Tang *et al.*, 2021).

The leaves, stems, roots, seeds, flowers and fruits of medicinal plants are rich in bioactive compounds (Knez Hrnčić *et al.*, 2020). It has been demonstrated that bioactive substances derived from plants have comparable health-promoting and protective effects on both humans and animals. Medicinal plants include a variety of secondary

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metabolites that are utilized to make medicines and have a significant impact on a number of diseases (Ali *et al.*, 2019). Tribal people around the world use many of the plants which are also said to have numerous other uses, such as antioxidant, anti-inflammatory, anti-insecticidal, antiparasitic, antibiotic and antihemolytic qualities (Huang *et al.*, 2019; Kou *et al.*, 2019; Mahmood *et al.*, 2019).

India has 15 Agroclimatic zones, 47,000 different plant species and 15,000 medicinal plants. Of the 1,500 medicinal plants classified by the Indian Drug System, 500 species are primarily used in the preparation of medicines. Eighty per cent of the raw materials used to make medicine are derived from medicinal plants (Ulhas, 2013; Sunitha *et al.*, 2017; Paul *et al.*, 2024). The proper use and ongoing availability of authentic raw ingredients are the primary determinants of these medications efficacy. In addition, both domestic and foreign markets are seeing an increase in demand for natural products such as cosmetics, food supplements and things with therapeutic potential. According to a WHO report, more than 80% of the population depends on traditional medicine, which is mostly plant-based for their basic medical needs (Peng *et al.*, 2018).

The conventional medication systems of India, such as Ayurveda, Unani, and Siddha, account for 70% of the nation's pharmaceutical sector. A few species with commercial relevance are grown in huge areas due to the export market. For instance, *Coleus forskohlii* is widely and effectively used for treating Asthma, glaucoma and urinary tract infections (Vaishnavi, 2022). The plant *Andrographis paniculata* possesses amazing, unique medicinal capabilities due to the presence

of diterpenoids like andrographolide, neoandrographolide and 14-deoxy-11,12-didehydroandrographolide (Pandey and Mandal, 2010).

India's main and major medicinal herbs *Gloriosa superba* L. (Glory Lily), *Coleus forskohlii* Briq. (Medicinal Coleus), *Withania somnifera* Dunal (Ashwagandha), *Andrographis paniculata* Burm. f. (King of Bitters), *Chlorophytum borivilianum* Sant. & Fern. (Safed musli), *Cassia angustifolia* Vahl. (Senna), *Catharanthus roseus* (L.) G. Don (Periwinkle), *Aloe vera* (L.) Burm. f. (Aloe) and *Stevia rebaudiana* Bertoni (Stevia) (Sivakumar *et al.*, 2024) are amassed with different bioactive molecules, which were responsible for curing various and important health stress in human beings (Figure 1).

## 2. Major medicinal plants

### 2.1. *Gloriosa superba* L. (Glory lily)

Glory lily is indigenous to Africa and tropical Asia. The genus derives its name from the Latin word 'glorious' referring to the flowers. Its flowers are fascinating and its tubers and seeds are medicinally used (Devi and Femina, 2012). Since ancient times, the plant has been utilized in Indian medicine. It is used as a tonic, antihelmentic, antiperiodic and give protection against scorpion stings and snake bites. The medication irritates the gastrointestinal tract and might result in vomiting and purging. It is occasionally used as an abortifacient and to induce labor pain. Additionally, it is applied locally to get rid of from urological discomfort and parasitic skin infections. Children's asthma is said to be cured when leaves are applied as a paste on the forehead and neck. The leaf juice is used to combat head lice (Shanmugam *et al.*, 2009).

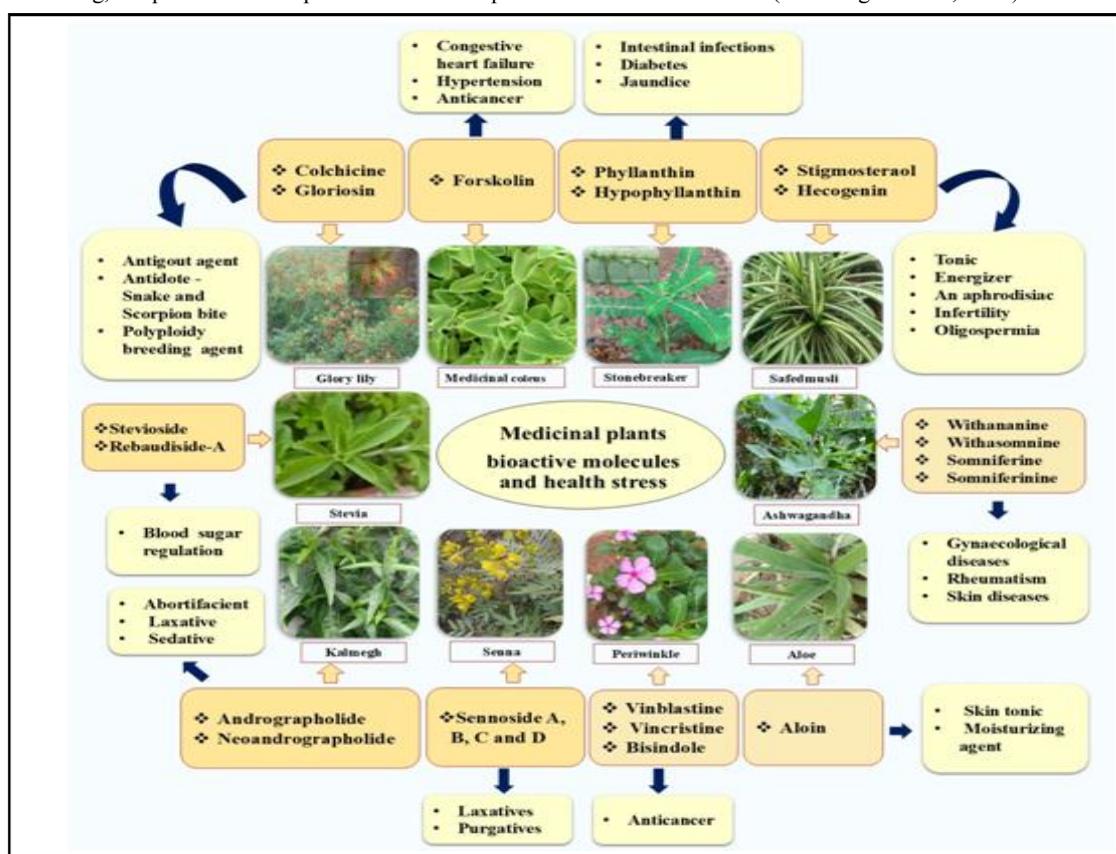


Figure 1: Role of major medicinal plants and bioactive compounds in alleviating health stress.

Presence of alkaloids, chiefly colchicine ( $C_{22}H_{25}NO_6$ ) and gloriosine ( $C_{21}H_{23}NO_6$ ) gives the medicinal property to *G. superba*. Colchicine is widely used to treat the Gout, a frequent ailment in temperate nations. Colchicine also known as anti-gout agents. Since, Colchicine is used to prevent or treat attacks of gout, also called gouty arthritis. An excess of uric acid in the blood is the cause of this disorder. When uric acid creates inflammation (pain, redness, swelling, and heat) in a joint, it can lead to a gout syndrome. It functions by halting the natural mechanisms that result in edema, familial mediterranean fever (FMF) and gout symptoms (Schaneberg and Khan, 2003).

*G. superba* seeds contains  $\beta$  and  $\gamma$ -lucicolchicines, as well as silosterol and its glucoside. Whereas, flowers contain, luteolin and its glucoside, N-formyl-De-Me-colchicine (Nikhila *et al.*, 2016). Furthermore, in agricultural research, these alkaloids are employed as polyploidizing agents in polyploidy breeding. *G. superba* contains 0.70 to 0.90% colchicine. Until recently, only the tubers are exploited but after knowing the fact that the seeds have higher quantity of alkaloids, the crop is grown now mainly for seeds which are in good demand worldwide (Simon and Jayakumar, 2016).

## 2.2 *Coleus forskohlii* Briq. (Medicinal coleus)

The genus *Coleus* consists of 150 species and the naturally occurring species are *C. amboinicus*, *C. forskohlii*, *C. spicatus* and *C. malabaricus*. *C. forskohlii* Briq. [syn: *Coleus barbatus* (Andr.) Benth.] is originated from India. Medicinal coleus belongs to Mint family, Lamiaceae. It is an important medicinal crop which contains forskolin ( $C_{22}H_{34}O_7$ ) in their roots. It is the primary source of forskolin, which is used to treat congestive heart failure, glaucoma, asthma, hypertension and some types of cancer (Paul *et al.*, 2024). Following the discovery of forskolin, a special adenylate cyclase activating medication that is exceptionally effective in triggering the cardiovascular system, the medicinal coleus species entered commercial cultivation. Forskolin is useful against cholesterol. Dry roots have a forskolin content of 0.10 to 0.80% (Ulhas, 2013). *Coleus* is one of the Indian medicinal plants which were very little known until a few years ago has now been raised as a single medicinal plant of international importance (Zharama, 2016).

## 2.3 *Phyllanthus amarus* Schum. and Thonn. (Stone breaker)

*Phyllanthus*, a medicinal plant used for many centuries is now an export oriented commercial species. It is a common weed in India. Also named as seed on leaf, Gale of Wind, Carry Me Seed. During the rainy season, it grows organically. Though the plant is primarily found in tropical and sub-tropical regions of the world, its origin is America. The leaves are used to treat intestinal infections, diabetes, liver diseases, jaundice caused by hepatitis-B virus. Phyllanthin ( $C_{24}H_{34}O_6$ ) and hypophyllanthin ( $C_{24}H_{30}O_7$ ) are the main substances extracted from *Phyllanthus* leaves (Sunitha *et al.*, 2017). Due to the fact that natural collections are not of homogeneous quality and cannot provide the necessary quantity at the needed period, they have been substituted by systematic cultivation (Kumar and Shankar, 1986). Companies are offering buy back to promote cultivation of this species (Joseph and Raj, 2011).

## 2.4 *Chlorophytum borivilianum* Sant. and Fern. (Safed musli)

Safed musli is a little perennial herb. The long, tuberous, 1-2 foot safed musli root has an 8 month lifespan. The roots contain the largest concentration of saponins. It is estimated that 500 t of safed

musli are consumed annually in India alone. In Indian system of Ayurveda safed musli is known as white gold. Also popularly known as the Indian Ginseng. The tuberous root is a popular tonic and energizer. It is mostly used for general debility and as an aphrodisiac. Carbohydrates (39%), galactose (0.73%), glucose (0.76%), protein (8-9%), saponins (2-17%) and root fibers (4%) are the main constituents. The main therapeutic substance found in safed musli roots is saponin (Grover, 2021), and the major saponins are stigmaterol ( $C_{29}H_{48}O$ ) and hecogenin ( $C_{27}H_{42}O_4$ ), the former one is responsible for the aphrodisiac properties.

## 2.5 *Withania somnifera* (L.) Dunal (Ashwagandha)

The name ashwagandha describes the smell of its roots, meaning "like a horse". It is one of the world's oldest herbs used in medicines. Ayurvedic and Unani treatments use ashwagandha roots and sometimes its leaves and seeds. Numerous alkaloids and withaniols are found to be responsible for the roots' pharmacological action (Figure 1). Total alkaloidal content of Indian ashwagandha roots ranges from 0.13 to 0.31% (Guo and Rezaei, 2024). Roots are used to treat a number of gynaecological diseases, bronchitis, rheumatism, dropsy, lung inflammation and skin diseases. Its roots and green leaf paste are used to treat inflammation and joint pain. It is also a component of medications that are prescribed to treat male sexual weakness and impairment. Warm leaves of ashwagandha are used for providing comfort during eye diseases.

Guo and Rezaei (2024) isolated eight amorphous bases in which withaniols are major, constituting 38 per cent of the total alkaloids. Other alkaloids that have been identified include withananine, withasomnine ( $C_{12}H_{12}N_2$ ), somniferine and somniferinine. Chromatographic investigations showed that the root contains up to 13 Dragendroff positive components (Belonwu *et al.*, 2014). Aspartic acid, glycine, tryosine, alanine, proline, tryptophan, glutamic acid and cystine are among the free amino acids found in the roots. There are twelve distinct withanolides found in leaves. In addition, the leaves also contain unidentified alkaloids, glycosides, glucose and many free amino acids. Withaferin 'A' is most important of withanolides isolated so far, to which the curative properties of leaves are attributed. It possesses antitumor and antibacterial properties also (Guo and Rezaei, 2024). Cortisol is the primary stress hormone in human body. The stress hormone level is reduced by ashwagandha and the normal condition of the body is maintained.

## 2.6 *Stevia rebaudiana* Bertoni. (Stevia)

*Stevia* is an herb that produces calorie-free sugar. Compared to sugarcane, the sugar derived from *Stevia* is ten times sweeter. It produces the pricey sweeteners stevioside ( $C_{38}H_{60}O_{18}$ ) and rebaudiside-A ( $C_{44}H_{70}O_{23}$ ). It needs red soils that drain well or loamy soils that have a lot of water. A pH of 6.5 to 7.5 is ideal. The ideal temperature range for this cool-loving crop is 22-35° C. Rooted cuttings are used to propagate *Stevia*. A spacing of 45 × 30 cm is adopted which requires about 30,000 plants/ac. Commercial cultivation of *Stevia* was initiated in Paraguay in 1964, despite its first domestications was in Japan. Ahsan *et al.* (2020) found that *Stevia* extract improved pancreatic  $\beta$ -cell function in diabetic rats, because steviol glycosides can boost glucose-induced  $Ca^{2+}$  oscillations and insulin release by pancreatic islets.

Weight management, blood sugar regulation, dental health assistance and anti-inflammatory qualities are just a few of the health advantages

that *Stevia* leaves provide. It's a zero-calorie sweetener, making it a good alternative for diabetes. *Stevia*, the natural sweetener tastes 200 to 300 times sweeter than table sugar. It may also help to lower blood pressure and improve cholesterol levels. It is classified as "zero-calorie", because the calories per serving are very low. It is a nutritious substitute for added sugar in a variety of dishes and drinks.

### 2.7 *Andrographis paniculata* Burm. f. (Kalmegh or King of bitters)

The plant *Andrographis*, also called the "King of bitters," belongs to the Acanthaceae family and has been used for centuries in Asia to cure a wide range of infectious and chronic illnesses, including fever, herpes, sore throat, upper respiratory and gastrointestinal tract infections. In Traditional Chinese Medicine (TCM), *Andrographis* is a significant "cold property" herb that is used to remove toxins from the body. When taken as prescribed, *Andrographis* has a surprisingly wide range of pharmacological effects, some of which are very beneficial, according to research done during 1980s and 1990s (Sharma *et al.*, 2009; Pandey and Mandal, 2010). Diterpenes, flavonoids, xanthenes, and other various substances were isolated from *Andrographis* plants (Okhuarobo *et al.* 2014). A number of diterpenoids and diterpenoid glycosides were isolated from *Andrographis*, mainly the most bitter compounds among them are andrographolide, neoandrographolide, deoxyandrographolide. Some of the other phytochemicals are 14-deoxyandro-grapholide, 14-deoxy-1,12-didehydroandrographolide, andrographiside, deoxyandrographiside, homoandrographolide, andrographan, andrographosterin and stigmaterol (Mishra *et al.*, 2007) The leaves of *Andrographis* contain the highest amount of andrographolide (2.39%), the most medicinally active phytochemical in the plant, while the seeds contain the lowest.

### 2.8 *Cassia angustifolia* Vahl. (Senna)

Senna, a small perennial plant in the Caesalpiniaceae family is grown as an annual in rainfed areas primarily for its laxative effects and other therapeutic uses. It is widely used as a natural remedy for a number of ailments, particularly constipation. The plant's main biological activity, including its antibacterial, antifungal, antiviral, antiparasitic, anti-insecticidal and antioxidant properties are attributed to its abundance of anthraquinone glycosides, such as sennosides (sennosides A, B, C, and D) and flavonoids. The herb also has hepatoprotective, hypolipidemic, antidiabetic and anticancer properties. Senna is accepted by ethnopharmacological research worldwide as a treatment for weight loss, skin issues, respiratory, digestive and neurological system disorders in addition to its use as a laxative.

Senna is used to alleviate constipation temporarily. Additionally, it is used to clear the colon before to surgery and other medical treatments. Senna belongs to a group of drugs known as stimulant laxatives. It causes a bowel movement by causing the intestines to become more active. Sennosides A, B, C, and D which are found in senna leaves and pods, are widely used to make laxatives and purgatives worldwide. Additionally, senna leaves and pods are used to make confections, powder, decoction and numerous other herbal medicines. In European nations, it is widely used in conjunction with "herbal tea." Typically, leaves and pods make up to 30% of the biological yield by weight and are important marketable products. In terms of sennoside content, the seeds are totally inactive. Senna

contains dianthrone glycosides (1.5 to 2%), primary sennosides A and B, as well as trace amounts of sennosides C and D and other closely related amalgams (Balasankar *et al.*, 2013).

### 2.9 *Catharanthus roseus* (L.) G. Don (Periwinkle)

Periwinkle is a perennial attractive herb that grows on sandy tracts and wastelands. Vinblastine and vincristine, two alkaloids found in the leaves, are components of patented cancer medications. Since there is less demand for the raw materials outside of India, there is plenty of scope for this crop if the raw ingredients are utilized in the country's own medicine manufacturing. It is preferred by farmers due to its broad adaptability and capacity to tolerate drought while growing on marginal land. According to Kumar *et al.* (2022), *C. roseus* is a well-known herbal remedy because of its anticancer bisindole alkaloids, vindesine, vinblastine and vincristine. The highest concentration of alkaloids (0.75-1.20%) is found in the roots, followed by 0.60-0.65% in the leaves. The Central Institute of Medicinal Aromatic Plants has launched the high-yielding variety Nirmal, which has the capacity to produce 1200 kg of dried leaves and 80 kg of roots. This plant is used to treat diabetes, gastrointestinal issues, renal, liver and cardiovascular diseases.

### 2.10 *Aloe vera* (L.) Burm. f. (Aloe)

*Aloe* is native to Mediterranean and African nations. The best *Aloe* gel is golden brown in colour, hard externally and soft internally. The smell is distinct and aromatic. It is orange-brown when powdered or sliced in to thin pieces. The powder is dull yellow. Aloin, the active ingredient in the medication is a combination of glucosides found in aloe. Aloin and its gel are used to make creams, lotions, shampoos and other related items because they are utilized as skin tonics, have cooling properties and are moisturizing agents. Additionally, it is utilized to rejuvenate aging skin and in gerontology. According to Radha and Lakshmipriya (2015), it has a number of therapeutic benefits including antitumor, anticancer, antidiabetic, constipation, gastrointestinal issues, antiarthritic and antirheumatoid effects.

## 3. Bioactive molecules

Phytochemicals are the chemical compounds found in medicinal plants that cause physiological reactions in either humans or animals. These plant compounds are used to treat human illnesses in herbal and homeopathic remedies. Consequently, it is essential to screen medicinal plants for bioactive compounds. The two main mechanisms for the synthesis of bioactive compounds are the mevalonic acid and shikimic acid pathways. Flavonoids, alkaloids, tannins and phenolic compounds are the most significant bioactive chemicals (Figure 2) used as raw materials in medication synthesis (Li *et al.*, 2004). Humans who consume more foods high in antioxidants are less likely to develop cardiovascular disease and several forms of cancer. In addition to being consumed, phytoconstituents help to increase radiation protection, postpone the ageing of the skin and reduce inflammation by promoting the proliferation and differentiation of skin cells (Sharma, 2006).

### 3.1 Extraction of bioactive molecules

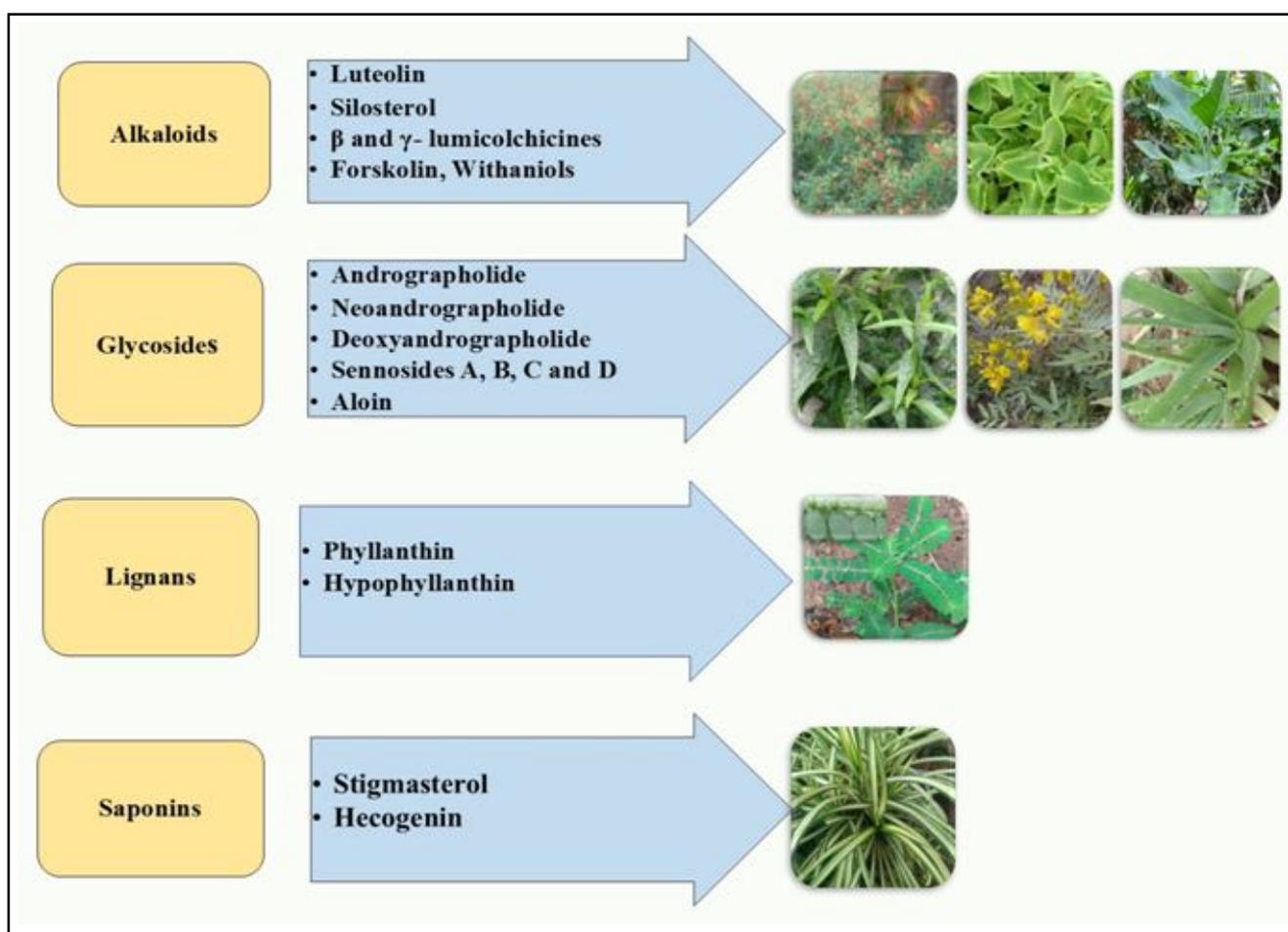
It is necessary to identify the plant from which the bioactive components are derived. Biologically active principles of medicinal significance are more likely to be found in plants that are traditionally employed as treatments for specific ailments. Following the

collection of plant material, the sample needs to be dried and finely powdered. Various solvents at varying temperatures and times are employed to extract bioactive components from medicinal plants. Compound separation is crucial after extraction. The separated compounds will undergo further fractionation according to their polarity, acidity or molecular size. Commonly used solvents for the extraction of bioactive molecules in plants are summarized in Table 1. Solvent extraction, cold extraction, ultrasound, solid phase micro extraction, pressurized liquid extraction, microwave assisted extraction (MAE), solid-phase extraction, surfactant-mediated techniques and solid phase micro extraction are the common extraction techniques (Azmir *et al.*, 2013).

### 3.2 Identification of bioactive molecules

Adsorption chromatography, partition chromatography, ion-exchange chromatography, affinity chromatography, size exclusion

chromatography, thin layer chromatography (TLC), high performance thin layer chromatography (HTLC), paper chromatography, gas chromatography (GC), column chromatography (CC), high performance liquid chromatography (HPLC) and optimal performance laminar chromatography (OPLC) are the various separation techniques used to identify the bioactive molecules (Table 1). In addition to chromatographic approaches, immunoassay which uses monoclonal antibodies and phytochemical screening assay are equally used (Belonwu *et al.*, 2014). Mass spectrometry (MS), UV/VIS and IR spectrophotometry, carbon and proton NMR, x-ray diffraction are used to further analyze the structure and biological activity of the pure chemicals that are isolated. Analytical methods such as nuclear magnetic resonance spectroscopy (NMR) and fourier transform infrared spectroscopy (FTIR) are employed (Karayil *et al.*, 2014).



**Figure 2: Therapeutic and pharmacological components of medicinal plants under four major bioactive chemicals**

## 4. Important bioactive principles present in medicinal plants

### 4.1 Alkaloids

Alkaloids are a well-explored class of alkaline secondary metabolites that are known to include bioactive components. It is a low molecular weight nitrogenous organically clustered cyclic molecule. In addition to oxygen and sulfur, alkaloids also contain carbon, hydrogen and

nitrogen. There is nitrogen in the state of negative oxidation. They fall into four main categories: a. Tyrosine, tryptophan, ornithine, lysine, histidine, anthranilic acid and nicotinic acids are examples of amino acid derivatives b. Purine derivatives, such as caffeine and zanthone Aconitine (a diterpenoid alkaloid) and c. solanine (triterpenoid alkaloid) are examples of aminated terpenes. d. Coniine and coccinellin are examples of polyketides.

**Table 1: Commonly used solvents for extraction of bioactive molecules from medicinal plants**

Solvents	Chemical constituents of plant extracts	References
Water	Carbohydrates, polypeptides, aminoacids, lectin, phenylpropanoids, phenolic acids, glycosides, polar flavonoids and alkaloids	Jones and Kinghorn (2012)
Ethanol	Tannins, glycosides and polar flavonoids	Cowan (1999)
	Phenols, alkaloids, flavonoids and tannins	Kamle <i>et al.</i> (2017)
Methanol	Carbohydrates, aminoacids, polypeptides, lectin, polar flavonoids, phenolic acids, phenylpropanoids, alkaloids and glycosides	Scalbert <i>et al.</i> (2005); Dailey and Vuong (2015)
	Lignans	Muthusamy <i>et al.</i> (2017)
Petroleum ether	Alkaloids, flavonoids, glycosides and phenols	Simon and Jayakumar (2016)
Ethyl acetate and methanol	Alkaloids	Kamle <i>et al.</i> (2017)
Isopropanol	Fatty acids	Lee <i>et al.</i> (2017)
Aqueous base or aqueous acid	Alkaloids	Bruneton (1999)
Acetone	Tannins, glycosides, terpenoids, polar flavonoids	Bruneton (1999); Scalbert <i>et al.</i> (2005)
n-Hexane and Chloroform	Wax, fattyacids and terpenoids	Perrett <i>et al.</i> (1995)
Ethyl acetate and Dichloromethane	Tannins, terpenoids, polar flavonoids	Bruneton (1999); Scalbert <i>et al.</i> (2005)

Alkaloids are commonly distributed in higher plants as well as in lower plants, insects, microorganisms and marine organisms. Alkaloids are utilized in scientific research as medicines, Euphoric and addicting drugs. Alkaloids are pharmacologically active substances that are employed as local anesthetics in medicine. Alkaloids with antimalarial, antihypertensive, muscle relaxant, antitumor, vasodilating and stimulant properties include quinine, reserpine, tubocurarine, vinblastine, vincamine and yohimbine (Neha, 2015). The bioactive primary alkaloid has diuretic, central nervous system and appetite-reducing effects. Some, such as nicotine, caffeine, theobromine, methylated derivatives of xanthine and methylated uric acids are used medicinally as stimulants and local anesthetics. Some have bactericidal activity which includes piperidine used as anticancer drugs, antihypertensive agent, spasmolysis agent, antiarrhythmia, antiasthma and antimalaria (Neha, 2015).

#### 4.2 Tannins

Water-soluble polyphenols are called tannins. They are hydrolyzable substances that attach to proteins, alkaloids and amino acids and precipitate them. Condensed tannins and hydrolyzable tannins are the two different kinds of tannins. Large polymers of flavonoids make up condensed tannins, but hydrolyzable tannins are less stable and more likely to be harmful. Their polymers indiscriminately bind to proteins and are made of a monosaccharide (glucose) to which multiple catechin derivatives are linked. Condensed tannins called proanthocyanidins have strong antioxidant properties (Chikezie *et al.*, 2015). Tannins are utilized as astringents to treat transudates, diarrhoea and skin bleeding.

#### 4.3 Saponins

Glycosides are the natural form of saponins. They can be used as detergents and are a component that forms soap. These are big

molecules that have emulsifying qualities due to their hydrophilic glycone and hydrophobic aglycone. It has been observed that saponins are found in more than 100 plant species. Saponin rich foods lowers plasma cholesterol levels, improves immune function, possess antimutagenic activities, prevents cancer, heart diseases, possess antitumorigenic effects, anticarcinogenic activity, inhibitory effect on infectivity of HIV, protective effect on liver injury, antiviral, antiheptic, antidiabetic and protective role on bone loss. Saponins are classified into eleven different classes such as ascyloartanes, cucurbitanes, lanostanes, lupanes, oleananes, ursanes, taraxasteranes, tirucallanes, dammaranes, hopanes and steroids. Food beans have hepatoprotective qualities because they contain B saponins. The dietary saponins in soybeans aid in the prevention of aortic atherosclerosis and hypercholesterolemia (Kumar *et al.*, 2022).

#### 4.4 Flavonoids

Flavonoids are a group of plant metabolites thought to provide health benefits through cell signaling pathways and antioxidant effects. Numerous fruits and vegetables contain these compounds. The anthocyanins (cyanidin, pelargonidin, petunidin), flavonols (quercetin, kaempferol), flavones (luteolin, apigenin), flavanones (myricetin, naringin, hesperetin, naringenin), flavan-3-ols (catechin, epicatechin, galliccatechin), isoflavones (genistein, daidzein) are examples of phytochemicals that are low molecular weight phenolic groups (flavonoids). Flavonoids are soluble in water and are polyphenolic molecules with 15 carbons. They are made up of two benzene rings joined by a brief chain of three carbons. A third middle ring is created when one of the carbons in this chain is directly or via an oxygen bridge joined to a carbon in one of the benzene rings. Chalcones, flavones, isoflavonoids, flavanones, anthoxanthins and anthocyanins are the six main subtypes of flavonoids. In the plant kingdom, flavonoids are widely distributed and have been shown to have strong antioxidant activity (Lila, 2004).

Flavonoids provide a number of health benefits and are significant antioxidants. According to Neha (2015), the flavonoids have antiviral, anticancer, anti-inflammatory and antiallergic qualities in addition to their antioxidant activities. Quercetin is one flavonoid that can aid with pollinosis, sinusitis, asthma and eczema. Flavonoids limit the oxidation of low-density lipoproteins, lowering the risk of atherosclerosis. Flavonoids are extremely varied plant pigments found in a large variety of fruits, vegetables, nuts and drinks. They have a variety of biological actions, such as anti-inflammatory, anticancer and antiviral qualities, and are frequently included in the human diet. Because flavonoids are tiny chemical substances that the body naturally absorbs over time, they are considered as the safe non-immunogenic medications (Neha, 2015).

#### 4.4.1 Effect of flavonoids on human health

Plant pigments known as flavonoids serve a variety of purposes. The antioxidant activity of flavonoids is typically stronger and more efficient than that of conventional antioxidant substances like zinc,  $\beta$ -carotene, selenium, vitamins C and E. Flavonoids are referred as nature's biological response modifiers because of their anti-inflammatory, antiviral, anticancer and antiallergic qualities. By promoting the release of endothelial nitric oxide (NO) and preventing blood channel narrowing, flavonoids, especially flavan-3-ols and proanthocyanidins have been linked to a lower risk of cardiovascular diseases. Because of their strong antioxidant properties, anthocyanidins may help to reduce the oxidation of cholesterol. Proanthocyanidins (PAs') ability to scavenge radicals may lower the risk of cancer, blood coagulation and urinary tract infections. Additionally, flavonoids have the capacity to chelate (bind) metals, boost immunity, lessen allergic reactions and offer protection from viruses and bacteria.

#### 4.4.2 Classes of major flavonoids

Typically, seven kinds of flavonoids found in food are thought to provide therapeutic benefits:

1. Anthocyanidins
2. Proanthocyanidins
3. Flavones
4. Flavonols
5. Flavan-3-ols
6. Flavanones
7. Isoflavones

#### 4.5 Anthocyanins

Many therapeutic plants contain phenolic flavonoid pigments called anthocyanins. These pigments are soluble in water and found in plant cells vacuoles. Strong anti-inflammatory and antioxidant qualities are possessed by anthocyanins. They are used to treat neurological problems, cancer, heart disease and diabetes (Lorencini *et al.*, 2014). Anthocyanins are mostly found in nature as heterosides and are not considered as necessary nutrients (He and Giusti, 2010). Their antioxidant qualities, which are impacted by the molecular mechanism pertaining to the expression and control of important genes are the primary cause of their health advantages (Lorencini *et al.*, 2014).

## 5. Conclusion

Many bioactive compounds found in medicinal plants are secondary metabolites that have therapeutic effects on a range of illnesses in humans and animals. Secondary metabolites support beneficial health outcomes, such as antiviral, antifungal, antioxidant, anticancer and antibacterial properties that can be used in the food, pharmaceutical and agricultural industries. Although, bioactive molecules often do not play a part in the growth and metabolism of plants, they are essential to their survival because of their roles in protecting them against diseases. Investigating substances from herbal plants for their phytochemical components is therefore necessary. Additional research on medicinal plant species can be carried out by determining their potential for usage as medicinal plants to treat a variety of illnesses or for development into new drugs.

## 6. Future thrust

Personalized phytotherapy, medication delivery facilitated by nanotechnology and investigating the function of plant-based vaccinations and microbiome regulation are potential avenues for future study in phytomedicine for stress reduction. Key areas also include using synthetic biology for scalable manufacturing and combining omics data, *viz.*, genomics, transcriptomics and metabolomics to comprehend phytochemical pathways.

## Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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