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VOL. 2

The Basic Handbook of Indian Ethnobotany and Traditional Medicine [Volume: 2]

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# The Basic Handbook of Indian Ethnobotany and Traditional Medicine [Volume: 2]

## Editors

Mrs. Bhanumati Sarkar
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This handbook presents 'Ethnobotany and Traditional Medicine in India (Volume 2). The current book has benefited greatly, and all the authors have laid down their feelings and information with care and detail. Tthe concept of traditional medicine and ethnobotany is enlightening. Altogether, these ingredients interweave the fabric of knowledge that is commemorative of the fundamental facets of India's conventional medical practices. At the same time, this volume is a reference for scholars and practitioners and a guide for a person attentively wanting to discover the fascinating connection between cultural and modern scientific values.

We are very grateful for this as they have been working very hard and dedicating a lot of time. This handbook is a testimony of their efforts and is useful for people who want to be aware of the importance of Indian ethnobotany and traditional medicine.We are glad you have joined the journey with us. We hope this volume sparks additional interest in India's vast and valuable traditional wisdom.

On the heartfelt side, we must express our gratitude to each of the authors who helped with this book. The assistance of the following individuals is indispensable to the realization of this publication.

Suggestions on how the book could be improved are acceptable and appreciated.

**Mrs. Bhanumati Sarkar,**
**Dr. Surjyo Jyoti Biswas,**
**Dr. Alok Chandra Samal &**
**Dr. Akhil Pandey**

Among the many diverse and intertwined strands that make up the fabric of man's existence, none stands out as being as colourful or as timeless as the arts of healing through the annals of time that people of different cultures have employed. Thus, the ethnobotany of India can be recognized as one of the most profound, diverse, and sustainable theses. We are pleased to introduce to you in earnest 'The Basic Handbook of Indian Ethnobotany and Traditional Medicine (Vol II)' – the second volume of stepping into the fundamentals of the Indian ethnobotany and Traditional medicinal sciences.

This volume completes the work started in the first volume and focuses on the complex interaction of the herbal resources of the Indian subcontinent and its traditional medicine. Here, we open up the abstracted body of information of several generations and, in them, note a blend of observation and experience, as well as unrefuted cultural cognition.

Our appreciation goes to various experts who have made the production of this work easier. Thus, I am grateful to Mrs. Bhanumati Sarkar, who has been an inspiring spearhead in maintaining and advocating traditional knowledge at every step of editorial work. Based on sensational ethnobotanical research, Dr. Surjyo Jyoti Biswas has added more value to the volume by providing readers with properly analyzed qualitative data. It is essential to recognize the invaluable contribution of Dr. Alok Chandra Samal, who has vast experience in traditional medicine practices. It adds a lot of effort, time, and data to help understand traditional medicine practices in detail. Dr. Akhil Pandey has also shown a lot of innovation in creating an interface between traditional and modern medicine, which has tremendously enriched this work.

As a whole, they have created a chronicle that pays respect to past procedures and links them to the terminology of the present-day concepts of health and fitness. Looking at the details of the work, the authors' collaboration has produced a reference that satisfies both the academic and practitioners' criteria, as well as the researchers and enthusiasts.

This handbook is hoped to be useful as a guide to ethnobotany in India for those who would wish to understand the intricate cultural botanical relationship. Despite the seemingly simple nature of the practices that have been passed down over the generations, we aim to reveal the intricate knowledge contained in these modern methods and what the plant world has to offer to the present-day inhabitants of the Earth.

As we begin this journey in the pages of Volume 2, we hope you will open the minds revealed over and over again in these pages to the great storehouse of knowledge that Indian Traditional Medicine offers and contemplate the future given the past.

***Sri Manoranjan Madhu,***
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Chapter- 1

# Deciphering the pharmacotherapeutic aspects of an ethnomedicinal plant *Bacopa monnieri* (Brahmi)

**Sunita Jhulki[1], Sukanya Kundu[1] and Aparajita Pal***

**Keywords:** *Bacopa monnieri* (Brahmi), Medhya Rasayana, Ethnomedicines, Neuroprotection, Cancer.

**Abstract:**

Indian Ayurveda is the birthplace of traditional classical medicines from ancient ages as it has vast reservoir of medicinal plants. Amongst all medicinal plants, *Bacopa monnieri* or Brahmi is an ethno-medicinal herb abundantly found in tropical and sub-tropical regions of India. This herb is composed of enormous bioactive phytochemicals like bacosides, alkaloids, glycosides, sterols and flavonoids. Bacosides are the most significant among all and bear enormous neuromedicinal properties and protect brain from neuronal damage and modulate the imbalance of neurotransmitter signalling. Extracts of Brahmi can prevent brain aging, enhance memory learning and perception ability. Notably, it's reactive oxygen species (ROS) quenching, antioxidant properties, anticancer, anti-inflammatory, anti-epileptic, anti-depressant, anti-stress, gastrointestinal, endocrinological, cardioprotective, hepatoprotective features are experimentally proven in animal model. Administration of Brahmi extract can restore the cognition and other neuronal disorders in Alzheimer's and Parkinson's patients. To avoid few adverse effects of *Bacopa*, combination with synthetic drugs or formation of its nanoparticulate form may be recommended. The immense important pharmacological role of *Bacopa* will be concised in this chapter.

## Introduction:

Plants are the major sources of ethnomedicines that play a pivotal role in drug discovery (Banerjee et al., 2014; Acharya, 2021a, 2021b, 2022a, 2022b, 2023; Bhattacharjee, 2021; Basu et al., 2022). India is well known for its rich heritage of herbs or medicinal plants (Bose, 2018; Erfani, 2021; Bhowmik et al., 2022; Ghosh et al., 2022; Darro & Khan, 2023; De & Sharma, 2023; De et al., 2023; Dhakar & Tare, 2023; Jyotirmayee et al., 2023). Indian Ayurvedic is one of the great representatives of traditional medical practices (Madhu & Sarkar, 2015; *Maiti et al., 2010, 2013;* Pyne & Santra, 2017; Choudhary et al., 2021; Kar et al., 2022; Raha et al., 2022;

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Mandal, 2022; Pal et al., 2022; Pimple et al., 2023). Charak Samhita, Sushruta Samhita and Veda describe specific effects or "Prabhava" of several ethnopharmacological plant species. *Bacopa monnieri* or Brahmi is the most popular succulent annual herb, which belongs to the member of Scrophulariaceae family (Choudhary et al., 2021). Nearly 146 species of the genus *Bacopa* are abundantly distributed in subtropical countries (Manap et al., 2019). Fleshy green leaves of Brahmi consist of various bioactive phytochemicals like alkaloids, terpenes, flavonoids etc. Brahmi has immense clinical and economic importance. Brahmi is considered a "Medhya Rasayana" and was used by Vedic scholars in the ancient period for its various pharmacological properties. It is described in Ayurveda as Brahmirasayan, Brahmighritam etc., for its anti-aging and anti-seizures effect (Choudhary et al., 2021). Brahmi leaves extracts are widely used as a brain tonic for their memory-boosting and neuroprotective properties (Fatima et al., 2022). Application of natural products in modern treatment against serious life-threatening diseases is gaining importance nowadays (Sarkar et al., 2016; Sarkar, 2017; Sarkar et al., 2021; Sanyal, 2022a,b). Several studies reported that Brahmi is used as a traditional medicine to treat various neurological diseases. Brahmi root extracts have anti-venom properties and are used to treat eye problems like cataracts. Leaves of Brahmi act as anti-asthmatic compound. Its extract has free radical scavenging properties. It also has an anti-mutagenic effect and anti-tumour activity against various cancers (Ghosh et al., 2021). The nontoxic Brahmi and its phytochemicals offer new hope for patients suffering from several complex disorders.

## Phytogeographical distribution of *Bacopa monnieri*:

Brahmi is highly distributed in both tropical and subtropical nations like Nepal, China, USA etc. and native to India. It is abundantly found in West Bengal and other states like Kerala, Uttar Pradesh, Orissa, Karnataka, Himachal Pradesh, Bihar, Tamil Nadu, Panjab, Gujarat etc. (Fig. 1) (Choudhary et al., 2021). This plant generally grows in marshy- wetlands areas, ponds, river side and in humid weather where the temperature is 30-40°C. They are cultivated in sandy soil at pH 7-8 (Choudhary et al., 2021; Pal et al., 2022).

## Plant morphology:

It is a creeping herbaceous species about 60-90 cm long and consists of a soft -succulent stem with several long branches (10-35 cm) and ceramic-yellow roots. It has green, oval, sessile leaves arranged in pairs along the branches and are generally 8-15mm in size with strong medicinal values. Flowers are small-sized and whitish-purple in colour. It has purple colour fruits that are ovate pointed at the top (Choudhary et al., 2021; Pal et al., 2022).

## Active phytochemical constituents of *B. monnieri*:

Brahmi is the godown of numerous bioactive compounds with various pharmacological attributes. Saponins like bacosides are the most significant secondary metabolites among them and are related to cognition enhancement and neuroprotection (Sukumaran et al., 2019). Bacoside A, bacoside B, bacopasides, bacosaponins, betulinic acid are the most important saponines of Brahmi

(Banerjee et al., 2021). Chemical name of bacoside is 3-(a-L-arabinopyranosyl)-O-b-D-glucopyranoside-10, 20-dihydroxy- 16-keto-dammar- 24-ene (Saha et al., 2020) (Fig 2) and it possess immense neuromedicinal properties. Apart from that, saponins can promote apoptosis, superoxide quenching, lipid peroxidation reduction and antioxidant enzyme stimulation (Banerjee et al., 2021).

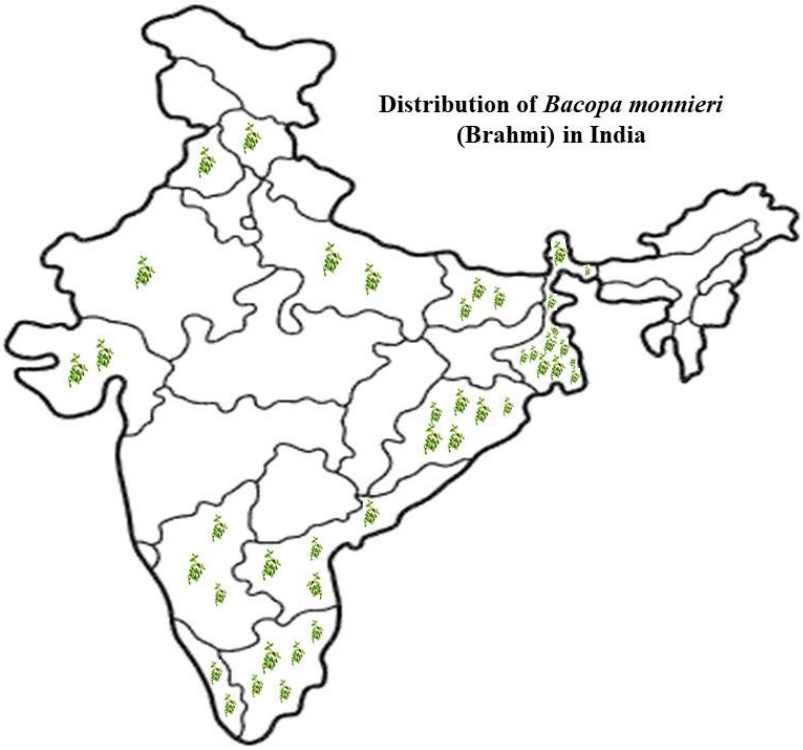


**Figure 1. Distribution of *Bacopa monnieri* in India**

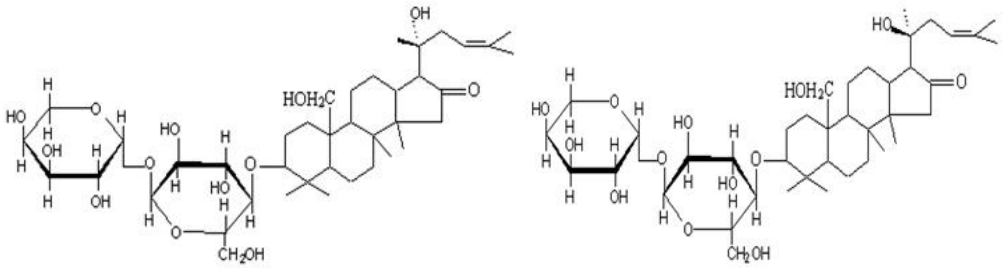

**Figure 2. Structure of Bacoside A and Bacoside B**

Other important phytochemicals include phenolic compounds, alkaloids, flavonoids, glycosides, phenylethanoid glycosides, alcohols, cucurbitacins, sterols etc. (Fatima et al., 2022; Jain et al., 2016). Nicotine, brahmin, and herpestine are some known alkaloids and pseudo-jujubogenins are glycosides extracted from Brahmi (Saha et al., 2020). Aspartic acid, stigmasterol, hydrocotyline, D-mannitol, serine, glutamic acid and alanine are also included among the phytoactive components of Brahmi (Fatima et al., 2022).

## Important therapeutic attributes of *Bacopa monnieri*:

As discussed, Brahmi has been used immensely in traditional therapies to treat different mental illnesses like memory dysfunction, anxiety, depression, Alzheimer's disease, Parkinson's disease, insanity, psychosis, dementia, amnesia, schizophrenia etc. It also cures other physical and physiological maladies like, diabetes, cancer, inflammation, oxidative brain damage, skin infection, epilepsy, digestive problems, asthma, allergies etc. (Ghosh et al., 2021; Sukumaran et al., 2019). Some therapeutic properties of Brahmi are concised below.

### Cognition enhancement:

Brahmi has traditionally been used to revitalize intellectual properties and as memory booster. As reported earlier, bacosides can enhance memory and calm the brain in hypoxic conditions. Bacosides can also induce cognitive function and learning ability. Oxidative damage initiates aging and age-related neural dysfunctions. Bacosides can destroy ROS accumulation in the brain and protect the brain from further deterioration (Banerjee et al., 2021; Vishnupriya et al., 2017).

### Neuroprotection:

One of the most known and popular actions of Brahmi is neuroprotection. According to reports, Brahmi's phytochemicals can reduce lipid peroxidation rate and nitric oxide-induced damage in rodent brain (Vishnupriya et al. 2017). Saponins from this plant can also modulate the activity of dopamine D1 receptor and its expression in hypoglycemic neonatals. Bacoside A and B can balance SOD (Superoxide dismuatse) content by scavenging free radicals and preventing cortical cell death in the brain. Thus it can relief the brain from stress by inhibiting ROS aggregation (Jain et al., 2016).

### Brain aging, oxidative stress and *B. monnieri*:

The prooxidants and antioxidants in our body maintain a state of equilibrium and allow cells to function properly (Simpson et al., 2015). With increasing age, this chemical equilibrium gets disrupted and hampers normal functioning. Like other cells and nerves, the brain is also affected by ROS imbalance occurred by unusual accumulation of free radicals. Due to high metabolism, glutamate cytotoxicity, higher amount of unsaturated fatty acids and decreased functioning of glutathione peroxidase, the brain is more prone to oxidative damage. Both *in vitro* and *in vivo* experiments proved bacosides' free radical scavenging property protects brain cells from superoxide damage and improves its functional ability in cognition management and memory enhancement (Simpson et al., 2015). Bacosides exert anti-oxidant activities in the brain's frontal cortex, hippocampus and striatum region. Brahmi extract can also trigger the expression of heat-shock-protein 70 and cytochrome 450 in the brain. It also can increase the SOD level in the brain and helps the brain in adapting stressed conditions (Jain et al., 2016).

### Alzheimer's disease treatment:

Alzheimer's disease is a chronic neural degeneration associated with dementia, memory loss and cognitive disorders like impaired perception, learning and thinking incapability in patients. Unusual aggregation of β-amyloid peptides and abnormal phosphorylation of tau proteins in brain are the main reason of this disease (Fatima et al., 2022; Saha et al., 2020). Though there is no such drug discovered to cure this malady. Acetyl choline esterase (AChE) inhibitors and glutamate modulators can make this disease less severe. Increased amount of acetyl choline can reverse pathogenicity of this disease. Researchers demonstrated that ethanolic extract of *Bacopa* can reduce the activity of AChE in the cerebral cortex and other brain regions. It has been clinically proven that ethanolic extract of *Bacopa* can ameliorate the cognitive function of the brain of Alzheimer's patients (Saha et al., 2020).

According to a study, phytochemicals from *Bacopa* can inhibit the generation of β-amyloid fibrils. There is clear evidence that it could be a novel anti-Alzheimer agent in future (Saha et al., 2020). In silico research study reported that two important saponin Bacopasaponin G and Bacosaponin $N_2$ would be more beneficial in Alzheimer's disease treatment (Fatima et al., 2022). Cigarette smoking makes Alzheimer's disease related dementia worse in patients. *Bacopa* extract can prevent lipid peroxidation rate in the brain induced by nicotine from cigarettes (Aguir et al., 2013).

### In the treatment of Parkinson's disease:

Parkinson's disease is another frequent neurodegenerative sickness assisted by abnormal accumulation of α-synuclein protein and degradation of dopaminergic neurons in the nervous system. Bacosides have the ability to protect the neural degeneration in Parkinson's disease. Researchers demonstrated the neuroprotective effect of Bacopa extract in an experimental model using *Caenorhabditis elegans.* It can prevent neuronal degradation by inducing SOD, reduce lipid peroxidation and prevent α-synuclein accumulation (Banerjee et al., 2021).

### Anti-epileptic property:

Epilepsy is a neural disease that affects the CNS and cognitive abilities. It is the imbalanced chemistry of neurotransmitter molecules and their signalling. Gamma-amino butyric acid (GABA) is the chief inhibitory neurotransmitter that regulates the nervous excitation. In epileptic patients, GABA receptors get decreased in number and obstruct the normal function of GABA. Defatted alcoholic extract of *B. monnieri* containing bacoside A, can treat the epileptic seizures by protecting the peripheral nervous system from neuronal impairments (Banerjee et al., 2021). Researchers have done an experimental research with epileptic patients, and they found that alcoholic extracts of Brahmi can ameliorate temporal lobe epilepsy and petit mal epilepsy (Jain et al., 2016).

### Anti-cancer property:

Cancer is a very complicated, deadly human disease, showing multifaceted clinical features and leading to the death of millions of people worldwide every year. Brahmi extract has potent anti-

neoplastic properties against various cancer including breast, colon, glioblastoma, liver, neuroblastoma, prostate etc. The combination of Bacopaside (I and II), which are two active triterpene compound derived from leaf extract of *Bacopa*, synergistically inhibits the breast cancer cells (MCF-7, MDA-MB-231, T47D cell lines) proliferation and metastasis by blocking G2-M phase transition and aquaporin 1 (AQP1) expression (Ghosh et al., 2021). Higher activation of AQP1 is found in many cancers that significantly induce cancer migration and invasion. Study showed that Bacopaside II can effectively reduce overexpression of AQP1 in HT29 colon cancer cell line. It can also exhibit apoptotic effects both in breast and colon cancer cells (Ghosh et al., 2021). Bacoside A is another promising anti-cancer secondary metabolite of *Bacopa* that can suppress self-renewal, progression of glioblastoma multiforme (GBM) & U87MG cell line by downregulating Notch1 signaling pathway and enhance the HES1 (hairy and enhancer of split-1) expression in dose dependant manner (Aithal and Rajeswari, 2019).

Studies showed that the higher expression of un-phosphorylated CaMK2A (Calcium/Calmodulin Dependent Protein Kinase II A) protein is responsible for the development of aggressive, malignant brain tumor GBM. Bacoside A can block the function of CaMK2A by converting it to the phosphorylated form (Ghosh et al., 2021). In addition, Bacoside A is considered as hepatoprotective agent that reduces hepatocarcinoma growth by mitigating lipid peroxidation and increasing the antioxidants enzymes (glutathione peroxidase, superoxide dismutase etc.) production. The leaf extract of *Bacopa* (250 mg/ml) has potential anti-cancer activity against neuroblastoma, which is a pediatric cancer. This leaf extract significantly increases neuroblastoma cell death by downregulating the ERK1/2 and AKT pathways (Fatima et al., 2022). Methanolic extract of Brahmi has cytotoxic effect against prostate cancer cell (DU145) and it also significantly reduces cancer cells invasion and migration (Ghosh et al., 2021). Mallick et al. reported that the dichloromethane fraction of Brahmi is a strong anti-cancer agent against various cancers, including lung, cervical, colon, and breast. This study also demonstrated that orally administrated dichloromethane fraction of Brahmi (40 mg/kg dose) significantly reduced tumor size, weight and cancer cell number in Ehrlich ascites carcinoma (EAC) bearing mice model (Mallick et al., 2017).

## Anti-diabetic effect:

Diabetes mellitus is a lethal chronic metabolic disorder associated with hyperglycemia and hyperlipidemia. According to International Diabetes Federation report (2015) nearly 415 million patients are suffering from diabetes all over the world. Currently, many treatments are available to treat diabetes, but they are unable to cure diabetes completely. Several research demonstrated that alcoholic extract of *Bacopa* significantly reduce hyperglycemia and are effective against diabetic nephropathy. Another study reveals that *Bacopa* can reduce the mice model's body weight and blood glucose levels (Fatima et al., 2022).

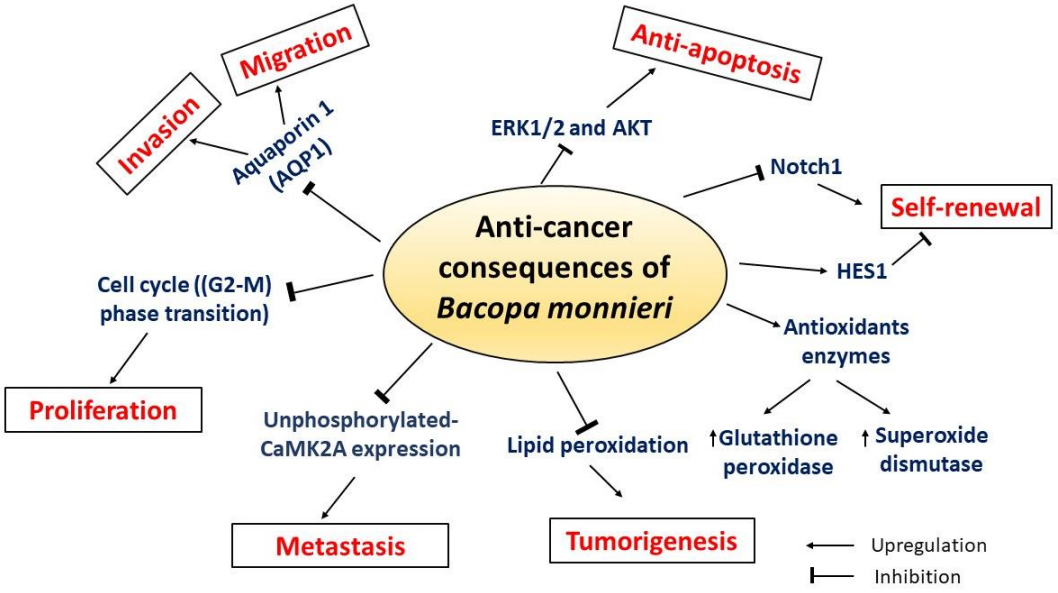


**Figure 3. Anti-cancer effects of *Bacopa monnieri***

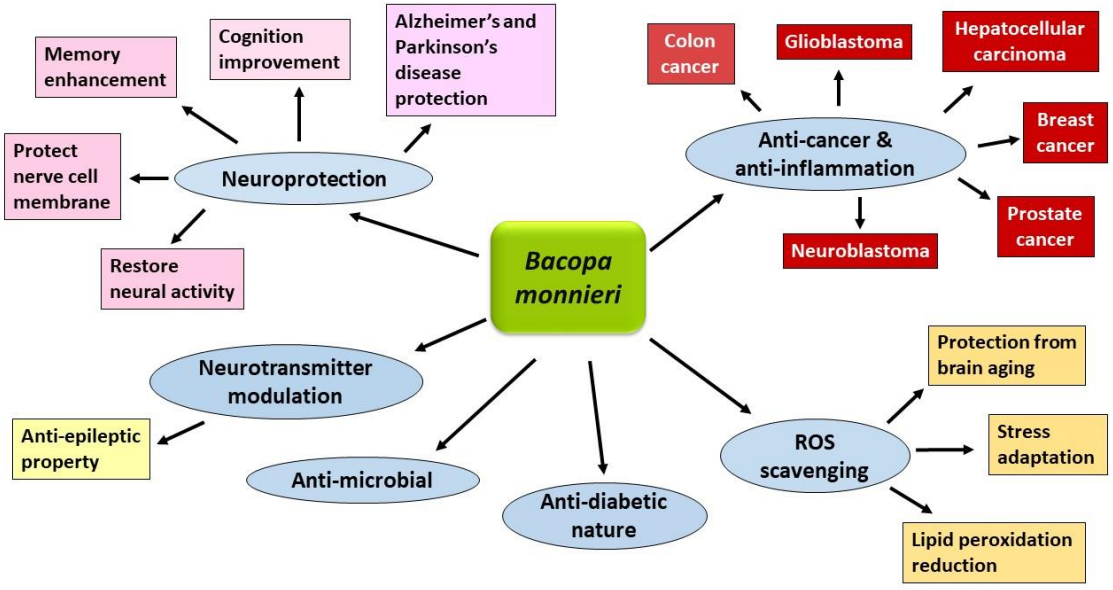


**Figure 4. Pharmacological effects of *Bacopa monnieri* and its use in treating several diseases**

## Antimicrobial effect:

Extract of Bacopa possesses antimicrobial property. Methanol, ethanol, chloroform and ether extract of *B. monnieri* can kill *Salmonella typhi*, *Aspergillus niger*, *Micrococcus luteus*, *Bacillus pumilus* and *Bacillus subtilis* respectively (Jain et al., 2016).

## Antidepressant and anti-anxiolytic effect:

Experimental evidence from forced swim test and learned helplessness tests (using animal model) suggests that ethanol extract of *Bacopa* bears anxiolytic and antidepressant activities (Banerjee et al., 2021).

## Hormonal effect:

In mice model, *Bacopa* extract can increase the level of T4 and can also regulate spermatogenesis. *Bacopa* leaves also elevate level of serotonin in human brain and reduce stress (Pal et al., 2022).

## Negative impact of *Bacopa* upon health:

Bacopa exerts some unfavourable effects upon health like loose motion, abdominal cramp, nausea, flu like symptoms etc. (Kongkeaw et al., 2013).

## Conclusion:

Brahmi is an important ethno-medicinal plant with various pharmacological perspectives. Phytochemicals of Brahmi are used as a potent neuromedicine. Superoxide scavenging property of bacosides helps in neuroprotection, memory and cognition power enhancement. As discussed epilepsy, Alzhiemer's disease and Parkinsons's disease can be treated with phytochemicals of Brahmi. Anticancer, anti-inflammatory, anti-diabetic, anti-microbial properties of *Bacopa* are well-known. Though there are some negative impacts of Brahmi extract like nausea, abdominal cramp, diarrhoea still the other efficacies of this plant made it a "wonder plant". In conclusion it maybe stated bioavailability and efficacy of Brahmi may be increased by nanoparticle mediated phytomedicinal delivery instead of direct application. Extensive research work should be required to decipher other medicinal attributes of Brahmi in future.

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## Conflict of interest:

The authors declare no conflict of interest.

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Chapter- 2

# Mosquitocidal Activity of Medicinal Plants

**Monalisa Pramanik, Biplab Bhowmik and Priya Roy***

**Keywords:** Medicinal Plants, Plant Extracts, Mosquitocidal activity, Environment friendly, Mosquito transmitted diseases.

**Abstract:**

Mosquitoes (Diptera: Culicidae) are one of the dangerous vectors that spread many life-threatening diseases like malaria, yellow fever, dengue, chikungunya, filariasis, encephalitis, West Nile Virus infection etc. To control these vectors, many chemical pesticides or insecticides are available in the market but recent works confirmed that these are actually very harmful to environment. It is also revealed that the mosquitoes are increasing their resistance power against these pesticides or insecticides. So, there has been growing interest in the use of extracts of medicinal plant parts as alternatives to insecticides or pesticides due to their biodegradability and adaptability to environmental as well as health conditions.

## Introduction:

Medicinal plants are natives of the healthcare systems across cultures and civilizations as they are the foundation of them, celebrated and linked to nature for curing diseases (*Maiti* et al., 2010, 2013; Sarkar et al., 2016; Sarkar, 2017; Sanyal, 2022a, 2022b; Mandal, 2022; Jyotirmayee et al., 2023). Historically, medicine men and women have been exploring various ways of herbal treatments in ancient human history, from the very beginning of traditional Indian medicine (Ayurveda) to other traditional recipes of medicine, which were superbly preserved and are still popular in many parts of the world (Banerjee et al., 2014; Bose, 2018; Acharya et al., 2020, 2021, 2022; Bhattacharjee, 2021; Basu et al., 2022; Bhowmik et al., 2022; Darro & Khan, 2023). One of the most current pieces of evidence that research has supported is the usefulness of these botanical remedies to control pests, which has led to a kind of

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renaissance in their therapeutic impact (Erfani, 2021; Das et al., 2022; Ghosh et al., 2022; De & Sharma, 2023; De et al., 2023; Dhakar & Tare, 2023). Cultivated this material to achieve a general study of medical plants, including its historical overview, therapeutic use, cultivation and conservation (Pyne& Santra, 2017; Sarkar et al., 2021; Pal et al., 2022; Kar et al., 2022; Raha et al., 2022; Saha et al., 2022; Pimple et al., 2023; Sarkar et al., 2024).

Mosquitoes are the major vector for the transmission of many life-threatening diseases. In India, malaria, dengue and chikungunya are very common vector-borne diseases. Mosquito borne diseases are dominant in more than 100 countries, infecting about 300-500 million people and causing about one million deaths every year (Dahmana & Mediannikov, 2020). In India, more than 40 million people suffer from mosquito diseases annually (Tolle, 2009). A medicinal plant is any plant that contains substances that can be used for medical purposes or that are used for the synthesis of useful drugs (Madhu & Sarkar, 2015; Srivastava, 2018). Medicinal plants are an important natural resource for the recovery of more prevalent diseases. Several medicinal plants can be used to treat similar diseases, depending on the country in which the disease occurs. In some localities, medicinal plants are perceived according to their traditional uses and represent a low-cost alternative to treat various diseases (Ali et al., 2013; Madhu, 2018; Madhu et al., 2015). For these reasons, these medicinal plants are being used to control the different species of mosquito vectors.

## Historical Significance:

At the very core of Botanic medications is the deep roots of their connection with human history and development of civilisation. The records of antiquity recorded that plants had been used for healing purposes & control of insects and provided information to civilizations such as Sumerians, Egyptians, Greeks and Romans. Traditionally, the in-depth knowledge of medicinal plants was closely guarded; the herbalists were the ones who passed it down generations, learning from their elders by word of mouth. Due to increased trade routes, knowledge of botanical subjects stretched beyond geographical boundaries. Thus, there was an exchange of medicinal plants and enrichment of traditional health systems & control of insects and pests. These past cures leave their abiding imprint that contemporary pharmacology, healthcare and toxicology extend to today.

## Bioactive Compounds in Medicinal Plants:

Researchers have found that medicinal plants enclose mosquitocidal substances in many of the studies that they conducted. These bioactive compounds help in effective mosquito treatment. Chemical variations in such compounds cause different chemical structures and modes of action, which give them the capability to be exploited in the formulation of new-generation insecticides. Alkaloids, terpenoids, flavonoids, and essential oils are classified as natural compounds.

Alkaloid examples like pyrethrines and strychnine are found to be extremely strong insecticide agents. The use of plant products as insecticides is on the rise by obtaining them

from plants, including Chrysanthemum cinerariifolium, which causes the nervous system of the insects to malfunction and eventually lead to paralysis and death. In regards to similar considerations, the nicotine present in plants Nicotiana tabacum is neurotoxin, which affects insect neurotransmitters in some way.

**Table 1. Name of different Mosquito species and their transmitted diseases.**

(Source: Draw The Life Cycle of Anopheles Mosquito | PeepsBurgh.Com)

| Scientific Names of Mosquito species | Founding Areas | Diseases | Biting Time |
|---|---|---|---|
| *Culex tarsalis* | Rural areas in North America | Encephalitis | Dusk, After dusk |
| *Culex pipiens* | Urban areas of tropical & sub-tropical | West Nile Encephalitis | Dusk, After dusk |
| *Culex quinquefasciatus* | Urban areas of tropical & sub-tropical | West Nile Encephalitis | Dusk, After dusk |
| *Aedes aegypti* | Tropical & sub-tropical areas | Zika, Yellow fever, Dengue, Chikungunya | Day |
| *Aedes albopictus* | Native to tropical areas of Asia Europe, Africa, America (recently introduced) | Zika, Yellow fever, Dengue, Chikungunya, Encephalitis | Day |
| *Aedes vexans* | US, Europe Asia & Northern Africa | West Nile Encephalitis | Late afternoon/night |
| *Anopheles sp.* | Everywhere (Except Antarctica) | Malaria (about 40 species transmit) Encephalitis (Some species) | Dusk, night |

In addition to terpenoids, which are widespread in medicinal plants, monoterpenes and sesquiterpenes have insecticidal properties. Take, for example, citronellal, the product of citronella grass Cymbopogon nardus, which had a mosquito repellent as well as a larvicidal effect.

There is evidence that the flavonoids, most of which are from fruits and vegetables, are favorable as mosquito-targeting agents. Apart from stunting mosquito breeding, compounds like quercetin and kaempferol interrupt very important metabolic processes of mosquitoes through which they die.

Known to be a great source of mosquitoicides, the essential oils generated from medicinal plants represent a rich resource in the enclosed area. What makes plant oils like eucalyptus oil, neem oil and lavender oil unique is that they contain components called volatile compounds that repel and kill mosquitoes through different mechanisms such as messing with their olfactory receptors and affecting their physiology.

## Mechanisms of Mosquitocidal Action:

Mosquitocidal properties in plants for treatment purposes arise due to a multitude of mechanisms, each targeting a different part of mosquito life. They involve disruption of the communication between nerve cells, blockade of the essential enzymes, disturbance of the metabolic processes, and interruption of the cuticular layer.

Certain chemicals as pyrethrins and nicotine affect greater functionality of sodium channels in mosquito neurons, which in result causing paralysis and death of them. In this way, the terpenoids and flavonoids are a major obstacle to critical enzymatic systems involved in energy production, breakdown, and removal processes, leading to the weakness and in the end, death of mosquitoes.

Beyond that, essential oils act to kill mosquitoes through different mechanisms like disturbance of mosquito smell, dealing with the respiratory enzyme incorporation, and inactivation of the channels that carry ions. These diverse modes of action are very productive in controlling mosquitoes and other insects, especially in the sense that there are fewer chances of developing resistance.

**Table 2. Medicinal plant extracts and their mosquitocidal activity against various mosquito species**

| Scientific Name of Medicinal Plants | Common Name | Plant parts used (Extracted with) | Target life cycle stage of Mosquito species | Resources |
|---|---|---|---|---|
| *Curcuma longa* | Turmeric | Rhizomes (Hexane) | *Aedes albopictus (Larvae)* | Lim et al., 2023 |
| *Ocimum americanum* | Hoary basil | Leaves (Hexane) | *Aedes albopictus (Larvae)* | Lim et al., 2023 |
| *Petroselinum crispum* | Parsley | Leaves& Stems (Hexane) | *Aedes albopictus (Larvae)* | Lim et al., 2023 |
| *Annona squamosa* | Custard apple | Bark (Ethyl acetate, Methanol) | *Anopheles subpictus* & Culex tritaeniorhynchus *(Larvae)* | Kamaraj et al., 2011 |
| *Chrysanthemum indicum* | Indian chrysanthemum | Dried leaves (Ethyl acetate, Methanol) | *Anopheles subpictus* & Culex tritaeniorhynchus *(Larvae)* | Kamaraj et al., 2011 |
| *Tridax procumbens* | Coatbuttons or tridax daisy | Dried leaves (Acetone, Ethyl acetate) | *Anopheles subpictus*& Culex tritaeniorhynchus *(Larvae)* | Kamaraj et al., 2011 |
| *Eucalyptus globulus* | Southern blue gum | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |

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|---|---|---|---|---|
| *Cymbopogan citratus* | Lemon grass | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Artemisia annua* | Sweet wormwood | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Justicia gendarussa* | Willow-leaved justicia | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Myristica fragrans* | Nutmeg | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Annona squamosa* | Sugar apples | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Centella asiatica* | Indian pennywort | Leaves, seeds (Ethanol water) | *Anopheles stephensi* (Larvae & Adults) | Senthilkumar et al., 2008 |
| *Vinca rosea* | Pink periwinkle | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Leucus aspara* | Thumbai | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Clerodendron inerme* | Wild jasmine | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Pedalium murax* | Bada Gokhru | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Turnera ulmifolia* | Ramgoat Dashalong | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |

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|---|---|---|---|---|
| *Parthenium hysterophorus* | Santa-Maria | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Rauwolfia canescens* | Devil peppers | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Croton sparsiflorus* | Railway Weed | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Calotropis sp.* | Milkweed | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Adathoda sp.* | Malabar nut | Leaves, flowers, seeds & stems (Petroleum ether) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Kalyanasundaram & Das, 1985 |
| *Aloe turkanensis* | Aloes | Leaves (Ethyl acetate) | *Anopheles gambie* (Larvae) | Matasyoh et al., 2008 |
| *Aloe ngongensis* | Aloes | Leaves (Hexane, Ethyl acetate, Acetone, Chloroform, Methanol) | *Anopheles gambie* (Larvae) | Matasyoh et al., 2008 |
| *Aloe fibrosa* | Aloes | Leaves (Methanol) | *Anopheles gambie* (Larvae) | Matasyoh et al., 2008 |
| *Acacia concinna* | Shikakai | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Cassia siamea* | Kassod tree | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |

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|---|---|---|---|---|
| *Coriandrum sativum* | Coriander | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Cuminum cyminum* | Cumin | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Lantana camara* | Lantana | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Nelumbo nucifera* | Indian lotus | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Phyllanthus amarus* | Bhuiamla | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Piper nigrum* | Black pepper | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Trachyspermum ammi* | Ajowan | Leaves (Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi (Larvae)* | Kamaraj et al., 2011 |
| *Coccina indica* | Kanduri | Leaves (Ethyl acetate, Methanol, Chloroform) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Senthilkumar et al., 2012 |
| *Albizia lebbeck* | Siris | Leaves and seeds (Hexane, Benzene, Chloroform, Ethyl acetate, Methanol) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (*Egg and adult) | Govindarajan & Rajeswary, 2015 |
| *Pseudocalymma alliaceum* | Garlic vine | Leaves (Petroleum ether, Hexane, Methanol) | *Anopheles stephensi (Larvae)* | Shrankhla et al., 2012 |

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| *Allium sativum* | Garlic | Leaves (Petroleum ether, Hexane, Methanol) | *Anopheles stephensi (Larvae)* | Shrankhla et al., 2012 |
| *Clausena anisate* | Horse wood | Leaves (Ethyl acetate) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Larvae)* | Jayaraman et al., 2015 |
| *Asparagus racemosus* | Shatavari | Root (Hexane, Ethyl acetate, Benzene, Chloroform, Methanol) | *Culex quinquefasciatus Anopheles stephensi Aedes aegypti (Egg, Larvae, Adult)* | Govindarajan & Sivakumar, 2014 |
| *Vetiveria zizanioides* | Ushira | Root (ethanolic) | *Anopheles stephensi* (ovicidal and oviposition) | Aarthi & Murugan, 2012 |
| *Ocimum basllicum* | Basil | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Ocimum sanctum* | Tulsi | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Azadirachta indica* | Neem | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Lantana camara* | Red sage | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Vitex negundo* | Chinese chaste tree | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Cleome viscose* | Asian spiderflower | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |
| *Bulmea sp.* | Sanbong | Leaves, flowers, seeds, stems (Petroleum ether) | *Culex quinquefasciatus* (Larvae) | Kalyanasundaram & Babu, 1982 |

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|---|---|---|---|---|
| *Albizia amara* | Bitter albizia | Leaves (Methanol) | *Anopheles stephensi (P*upae, adult) | Vinayagam et al., 2008 |
| *Areca catechu* | Betelnut palm | Leaves (Methanol) | *Anopheles stephensi (P*upae, adult) | Vinayagam et al., 2008 |
| *Ocimum sanctum* | Tulsi | Leaves (Methanol) | *Anopheles stephensi (P*upae, adult) | Vinayagam et al., 2008 |
| *Abrus precatorius* | jequirity bean | Leaves, flowers seeds (hexane, chloroform, ethyl acetate, acetone, methanol) | *Anopheles vagus, Armigeres subalbatus, Culex vishnui (Larvae)* | Bagavan & Rahuman, 2011 |
| *Croton bonplandianum* | Bantulsi | Leaves, flowers seeds (hexane, chloroform, ethyl acetate, acetone, methanol) | *Anopheles vagus, Armigeres subalbatus, Culex vishnui (Larvae)* | Bagavan & Rahuman, 2011 |
| *Cynodon dactylon* | Bermuda grass | Leaves, flowers seeds (hexane, chloroform, ethyl acetate, acetone, methanol) | *Anopheles vagus, Armigeres subalbatus, Culex vishnui (Larvae)* | Bagavan & Rahuman, 2011 |
| *Musa paradisiacal* | French plantain | Leaves, flowers seeds (hexane, chloroform, ethyl acetate, acetone, methanol) | *Anopheles vagus, Armigeres subalbatus, Culex vishnui (Larvae)* | Bagavan & Rahuman, 2011 |
| *Syzygium aromaticum* | Clove | Leaves, flowers seeds (hexane, chloroform, ethyl acetate, acetone, methanol) | *Anopheles vagus, Armigeres subalbatus, Culex vishnui (Larvae)* | Bagavan & Rahuman, 2011 |

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| *Aristolochia indica* | Sapsada | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Cassia angustifolia* | Indian Senna | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Diospyros melanoxylon* | Coroman del ebony | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Dolichos biflorus* | Horse gram | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Gymnema sylvestre* | Gymnem a | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Justicia procumbens* | Water willow | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Mimosa pudica* | Dormeder a | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |
| *Zingiber zerumbet* | Ginger | Dried leaves, rhizome (Hexane, ethyl acetate, methanol) | *Culex gelidus, Culex quinquefasciatus* (Adult & laevae) | Kamaraj et al., 2010 |

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|---|---|---|---|---|
| *Blumea mollis* | Soft Blumea | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Chloroxylon swietenia* | Ceylon satinwood | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Clausena anisate* | Samandua | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Feronia limnonia* | Wood apple | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Lantana camera* | Caturang | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Plectranthus amboinicus* | Sugandha | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Tagetes erecta* | Marigold | Leaves (hexane, choloroform, ethyl acetate, acetone, methanol) | *Culex quinquefasciatus*, *Aedes aegypti*, *Anopheles Stephensi* (Larvae) | Jayaraman et al., 2015 |
| *Mirabilis jalapa* | Gulambasa | Leaves (Benzene, chloroform, ethyl acetate, methanol) | *Anopheles stephensi*, *Aedes aegypti*, *Culex quinquefasciatus* (Larvae) | Govindarajan et al., 2014 |
| *Alternanthera sessilis* | Sissoo spinach | Leaves (Crude extract) | *Culex quinquefasciatus* (Larvae) | Rawani et al., 2014 |

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| *Trema orientalis* | Charcoal tree | Leaves (Crude extract) | *Culex quinquefasciatus* (Larvae) | Rawani et al., 2014 |
| *Gardenia carinata* | Gardenia | Leaves (Crude extract) | *Culex quinquefasciatus* (Larvae) | Rawani et al., 2014 |
| *Ruellia tuberosa* | Minnieroot, | Leaves (Crude extract) | *Culex quinquefasciatus* (Larvae) | Rawani et al., 2014 |
| *Phyllanthus acidus* | Tahitian gooseberry tree | Fruits and leaves (Crude extract) | *Culex quinquefasciatus* (Larvae) | Gope & Rawani, 2022 |

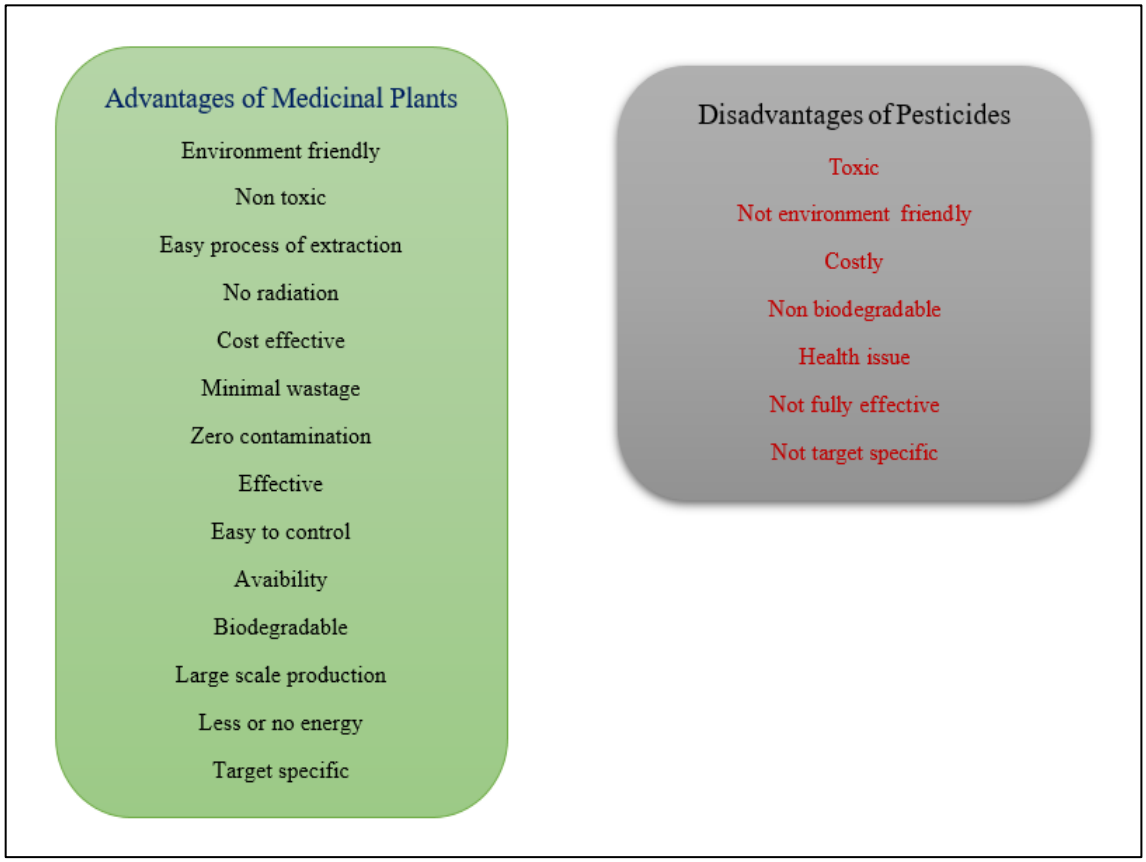


**Figure 1. The advantages of using medicinal plant extracts & the disadvantages of using chemical pesticides**

## Discussion and Conclusion:

Presently, environmental safety is considered as the foremost important part. Using pesticides not only affects the foe of the environment, also causes health problems for people. Researchers found that medicinal plants have the potential for mosquitocidal activity. Different parts of plants, such as roots, stems, flowers, bark, leaves etc, can be used as extracts for this

novel purpose. Extracts of medicinal plants can be the alternative path to control mosquito species and mosquito-borne diseases. Though medicinal plant extracts are found to be effective, nature-friendly, and friendly, there are also some challenges. Large quantities of plants are needed for the extraction process, finding the antimicrobial effectiveness of plant extracts, drying methods of plant parts, choice and amount of solvents, temperature, and duration of extraction. However, medicinal plant extracts should have been given high priority not only as mosquitocidal agents but also as therapeutic tools. Thus, medicinal plants are the new hope for further use in different fields in the future.

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Chapter- 3

# Unlocking the Potential of Phytochemicals in Combating Inflammatory Bowel Disease: Insights from Studies with Selected Plants Commonly Utilized in India

**Shantanabha Das*, Atri Das and Puja Mishra**

**Keywords:** inflammatory bowel disease (IBD), ulcerative colitis (UC), T-cells, cytokines.

**Abstract:**

The incidence of inflammatory bowel disease (IBD) is increasing in India, with a total of 2.7 lakh cases in 2019. IBD includes two categories of chronic inflammatory conditions of the gastrointestinal tract: ulcerative colitis (UC) and Crohn's disease (CD). Both conditions cause severe morbidity to individuals and increase the risk of GI tract cancers. Long-term use of conventional synthetic drugs like corticosteroids has significant adverse effects. Patients increasingly choose to adopt plant-derived products as an alternative or complementary medicine (CAM). In India, since ancient times, plant products have been used to treat and prevent numerous digestive tract ailments. Here, we have mentioned recent research highlights of eight commonly utilized plants (*Curcuma longa*, *Zingiber officinale*, *Allium sativum*, *Boswellia serrata*, *Trigonella foenum-graecum*, *Garcinia cambogia*, *Aloe vera*, and *Punica granatum*) and their bioactive compounds used to treat IBD in both model systems and clinical trials. Many of the bioactive compounds mentioned in this article can target different drivers behind IBD pathology. Phytochemicals can modulate immune cell subsets, enhance gut epithelium regeneration, and improve gut microbiome homeostasis to inhibit aberrant immune response and promote gut barrier function leading to remission of IBD. Evidence from clinical trials indicates that these plant-derived products are safe to use, but efficacy varies depending on the nature of the preparation of the phytochemicals. New developments in targeted delivery and better absorption promise exciting advances for phytochemicals in IBD treatment.

## Introduction:

Inflammatory bowel disease (IBD) is a chronic inflammatory condition of the gastrointestinal (GI) tract. It encompasses ulcerative colitis (UC), a continuous inflammatory condition mainly restricted to the colon and rectum, and Crohn's disease (CD), which is an intermittent inflammatory condition affecting any part of the GI tract. The estimated global burden of IBD in 2019 was 4.9 million cases, with India noticing a doubling of the total number

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of patients between 1990 and 2019 (Dharni et al., 2023). The clinical presentation of IBD includes abdominal pain, diarrhoea with or without blood, rectal bleeding, weight loss, faecal inconsistency, fever, anaemia, increased risk of colon cancer, etc. The interaction between several factors, such as aberrant immune response, underlying genetic factors, gut microbiome, and environmental factors, drives IBD. When T-cells, dendritic cells, macrophages, and other mononuclear cells infiltrate the lamina propria during IBD, they release excessive inflammatory cytokines [such as Tumor necrosis factor- alpha (TNF-α), interleukin-1beta (IL-1β), interferon-gamma (IFN-γ), and IL-12], leading to pathology. Patients with IBD can display elevated Th1 and Th17 biased responses. Currently, 5-aminosalicylic acid, corticosteroids, and immunomodulators are used for the treatment of IBD. Issues with poor tolerability and ineffectiveness of conventional therapies have driven over 50% of IBD patients towards herbal medicine as a form of complementary and alternative medicine (CAM) (Sarkar et al., 2016, 2022, 2024; Jyotirmayee et al., 2023). Phytochemicals contain many bioactive compounds that can modulate the inflammation pathway, restore barrier function, and improve gut microbiota homeostasis to induce and maintain remission of IBD. Extensive *in vitro*, *in vivo* studies and some clinical trials have confirmed the efficacy of various plants found in India for treating IBD. Here, we have discussed the notable recent developments of a few selected plants and their constituents for the treatment of IBD.

## Turmeric - *Curcuma longa* :

*Curcuma longa*, or turmeric, is a perennial, rhizomatous plant in the ginger family, Zingiberaceae. The roots of turmeric are used as a spice. In Ayurvedic and Unani medicine, turmeric has been used for centuries to treat liver disorders, allergies, skin lesions, bronchitis, and as a general antiseptic. The chief active ingredient of turmeric is the polyphenolic compound curcumin, which has received extensive attention from researchers and clinicians over the past decades. Research has been conducted on the beneficial properties of curcumin, including its anti-inflammatory, antioxidant, anti-cancer, neuroprotective and hepatoprotective effects, as well as the molecular pathways it modulates (Kotha & Luthria, 2019).

Several *in vitro* and *in vivo* studies on colitis models have identified various molecular targets that curcumin can influence to exert its prophylactic and therapeutic potential against IBD. Inflammation in IBD results from aberrant activation of various cell signalling pathways. Curcumin modulated nuclear factor kappa β (NF-κβ), JAKs/STATs, mitogen-activated protein kinases (MAPKs) that were activated in chemically-induced experimental colitis models. This, in turn, reduced the production of numerous pro-inflammatory factors such as IFN-γ, TNF-α, IL-1, IL-6, IL-8, IL-12, and IL-23. Amelioration of colonic damage following curcumin treatment was associated with reduced inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), Myeloperoxidase (MPO), and caspase-1 activities and lowered levels of nitrite, Matrix metalloproteinases (MMP-1, MMP-3, and TIMP-1), monocyte chemoattractant protein-1 (MCP-1). Curcumin can also obstruct the activation of the NLRP3 inflammasome in the

dextran sodium sulfate (DSS)-induced colitis model (Karthikeyan et al., 2021). The development of IBD involves changes in the balance of various immune cells. Curcumin has been demonstrated to modulate both T and B-cells to improve the disease outcome. Curcumin reduced excessive Th1, and Th17 activation and proliferation and promoted infiltration and enrichment of regulatory T-cells in colon tissue (Xiao et al., 2022). In DSS-induced colitis mice, curcumin can upregulate regulatory B cells by inhibiting TLR/MyD88 pathway to improve disease pathology (Huang et al., 2023). Recently, it has been shown that curcumin can protect the intestinal epithelium and promote its repair after injury by down-regulating miR-195-3p (Wang et al., 2024).

Very importantly, many clinical trials in different age groups have investigated curcumin's safety and efficacy for managing IBD. The first multi-center randomized placebo-controlled double-blind clinical trial in UC patients found curcumin (1 g) two times per day together with sulfasalazine or mesalamine showed a markedly improved relapse rate (4.7%) compared to the placebo group with only the standard drug treatment (20.5%). This was accompanied by a noticeable drop in the clinical activity index (CAI) and endoscopic index (EI) scores of the disease following curcumin intake. Bioenhanced curcumin (BEC) as add-on therapy in UC patients led to better clinical and endoscopic remission with improved clinical response compared to placebo (Banerjee et al., 2021). Currently, a lot of attention is being given to colon-targeted delivery of curcumin in micro- and nano-formulations to improve its solubility and bioavailability for better clinical effects (Laurindo et al., 2023).

### Ginger - *Zingiber officinale* :

Ginger, the rhizome of *Zingiber officinale* from the Zingiberaceae family, is globally one of the most commonly used spices and has a long history of medicinal use for various ailments (e.g., asthma, diabetes, nausea, gingivitis, etc.) and is a component of numerous tonics. Ginger contains more than 400 bioactive compounds, but most of its medicinal effects are attributed to four phenolic compounds: gingerols, shogaols, paradols, and zingerone (Erfani, 2021).

Recent clinical trials have shed light on the safety and efficacy of ginger in treating UC. Daily consumption of 2000mg dried ginger powder in capsules for 12 weeks has been shown to reduce serum TNF-α and Malondialdehyde (MDA) [an indicator of oxidative stress] among mild to moderate UC patients compared to control. At 12 weeks, the disease severity scores and quality of life were also improved following ginger intake compared to placebo (Nikkhah-Bodaghi et al., 2019).

Mechanistic insights into ginger's beneficial effects on IBD have been revealed in many *in vivo* studies. Ginger has been found to act on NF-κβ, STAT, MAPK, and mTOR pathways, and also on NLRPs and TLR. Both gingerol and 6-shogaol can reduce inflammatory TNF-α, IL-6, and IL-1β in animal models of UC. Gingerol treatment can also reduce COX-2 and MCP-1 activity (Ballester et al., 2022). Ginger extract ameliorated the IBD symptoms and significantly improved body weight, fecal bleeding, and stool consistency in DSS-induced colitis in mice.

Apart from reducing proinflammatory cytokines, it increased the expression of tight junction proteins in colon tissue, leading to better disease outcomes. Specifically, it increased the expression of ZO-1, E-cadherin, occludin, mucin-1, and mucin-2 (Kim & Kim, 2018). Ginger can restore gut microbiota diversity and function, promoting UC healing by reversing dysbiosis (Guo et al., 2021).

Recently, considerable interest has developed in edible ginger-derived nanoparticles (GDNPs), which have an average size of ~230 nm and negative zeta potential. GDNPs contain a considerable amount of 6-gingerol and 6-shogaol, along with some proteins, lipids, and microRNAs. Oral administration of GDNPs has been shown to accelerate tissue repair and reduce symptoms in UC and UC-associated cancer models in animals. They can reduce inflammatory cytokines such as TNF-α, IL-6, and IL-1β, increase anti-inflammatory cytokines like IL-10 and IL-22, and promote the survival and proliferation of intestinal epithelial cells (Zhang et al., 2016).

### Garlic - *Allium sativum* :

*Allium sativum* L., or garlic, is one of the most used plants in cooking and also in ethnomedicine. It contains more than 200 bioactive substances such as diallyl disulfide, S-allyl cysteine, diallyl thiosulfonate (allicin), diallyl trisulfide, E/Z-ajoene, N-acetylcysteine, steroids, peptide, saponins, flavonoids, terpenoids, etc. This wide array of garlic components is responsible for its anti-inflammatory, anti-viral, anti-bacterial, anti-oxidant, and other therapeutic activities.

Studies have shown that garlic extract could stimulate the secretion of anti-inflammatory IL-10 while simultaneously suppressing the production of various proinflammatory cytokines such as TNF-α, IL-6, IL-1α, IL-8, and IL-12 in whole blood or peripheral blood mononuclear cells (PBMCs) taken from IBD patients. Furthermore, when combined with methylprednisolone, a drug commonly used in IBD treatment, garlic extract displayed an additive effect (Hodge et al., 2002). Allicin, a derivative of alliin, is a major component of raw garlic extract and has been attributed to Th1-inhibitory effects. Also, alliin can reduce inflammation in the gut by MAPK-NF-κβ/AP-1/STAT-1 inhibition and PPARγ modulation (L. Shi et al., 2017).

Allicin rapidly decomposes into other sulfur compounds like diallyl sulfide (DAS), diallyl disulfide (DADS), etc. These compounds have also shown their curative effect in Dinitrobenzene sulfonic acid (DNBS)-induced colitis models by decreasing colon weight/colon length ratio in inflamed gut tissue. This study found that diallyl disulfide reduced IL-6 and IP-10 levels, while diallyl sulfide inhibited NO and STAT1 activity in IFN- γ-induced inflammation in intestinal cells (Fasolino et al., 2015).

Due to some reported adverse effects associated with fresh garlic extract intake, aged garlic extracts are sometimes preferred and are rich in several bioactive and more bioavailable compounds such as S-allylcysteine (SAC) and S-allylmercaptocysteine (SAMC). S-

Allylcysteine has been shown to reduce the production of various cytokines, including IL-1β, TNF-α, and IL-8, that contribute to IBD pathology (Zugaro et al., 2023).

Recent publications suggest that other substances from garlic, such as Propyl-propane thiosulfonate (PTSO) and a water-soluble garlic polysaccharide, can have anti-inflammatory activities leading to an amelioration of colitis in mice models. They can enhance the intestinal barrier function and promote a healthier balance of microbiota in the gut (Vezza et al., 2019).

### Indian olibanum - *Boswellia serrata* :

*Boswellia serrata*, found in dry, hilly areas of India, has been used in traditional Indian medicine systems for treating inflammatory conditions and arthritis-associated pain. The gum resin obtained from this tree contains different active ingredients in its extract, namely, β-boswellic acid (β-BA), 11-keto-β-boswellic acid (KBA), and acetyl-11-keto-β-boswellic acid (AKBA). All these ingredients have been shown to exert several antioxidant and anti-inflammatory effects.

*Boswellia serrata* extracts (BSE) are known to reduce several proinflammatory cytokines in different cellular models of inflammation and also can improve tissue lesions, reduce nitric oxide and lipid peroxidation levels in animal models of UC (Hartmannet al., 2014). A semisynthetic form of acetyl-11-keto-beta-boswellic acid (sAKBA) has been shown to reduce the infiltration of leucocytes and platelets to inflamed venules by inhibiting P-selectin in experimental murine colitis induced by DSS (Anthoni et al., 2006).

Over the years, several clinical trials have reported the beneficial effect of BSEs compared to standard care. One of the earliest clinical trials reported that a dose of 350 mg thrice daily for 6 weeks was as good as sulfasalazine (1 g thrice daily) treatment in alleviating different parameters in UC grade II and III patients. Importantly, BSE treatment achieved a better remission rate of 82% of treated UC patients compared to 75% among sulfasalazine-treated patients (Gupta et al., 1997). BSE administration in a lecithin-based delivery system (Casperome®) attenuated symptoms in the UC remission phase, reducing the need for other medications (Pellegrini et al., 2016). Several other clinical trials with BSE have found it to be either better or equivalent to the standard treatment options in terms of efficacy and usually safe (Gupta et al., 2001).

### Fenugreek - *Trigonella foenum-graecum* :

In Ayurveda, the seeds and leaves of the plant *Trigonella foenum-graecum* (family Fabaceae), commonly known as fenugreek, have been used as medicine since ancient times. These are native to India and are also distributed throughout the world. In India, fenugreek is consumed as a condiment, and it is reported to help in digestion, act as a tonic to improve overall well-being, induce labour, and stimulate lactation. Usually, the leaves and seeds are used to prepare extract or powder.

Several model systems have demonstrated the anti-inflammatory effects of diosgenin, a steroidal saponin found in *T. foenum-graecum*. Diosgenin can suppress the production of IL-1, IL-6, ROS, and NO in macrophages by preventing NF-κβ and AP-1 activation (Jung et al., 2010). In the trinitrobenzene sulfonic acid (TNBS)-induced colitis model in rats, diosgenin reduced several proinflammatory cytokines, such as TNF-α, IL-1β, IL-6, and IFN-γ, as well as inflammatory markers COX-2 and iNOS in the colon. It also promoted the secretion of anti-inflammatory IL-10 and relieved oxidative stress by increasing SOD and GSH levels. Histopathological observations also indicated attenuated colonic damage in diosgenin-treated animals. Administration of diosgenin inhibited NF-κβ/Ikβ-α and Bax/Caspase-1 signaling pathways (Tang et al., 2020). The potential of diosgenin in managing IBD warrants further research, specifically in its ability to promote regulatory T-cell enrichment and activity in the intestine (Huang et al., 2010).

### Malabar Tamarind - *Garcinia cambogia* :

*Garcinia gummi-gutta* [formerly known as *Garcinia cambogia* (Malabar tamarind)] has several reported ethnomedicinal properties. This plant is native to India, Sri Lanka, and Nepal and has culinary applications to impart sharp sour flavour in food preparations. *G. gummi-gutta* fruit extract is used against gastrointestinal disorders, rheumatism, oedema, irregular menstruation, and intestinal parasites in traditional Indian medicine. Analysis of phytochemistry reveals the presence of alkaloids, flavonoids, phenolic compounds, saponins, tannins, carbohydrates, and proteins in the extracts. The major bioactive constituents are hydroxycitric acid (HCA) (an organic acid) and garcinol (a benzophenone) along with different xanthones and amino acids (Semwal et al., 2015). According to research, these bioactive compounds possess anti-obesity, hypolipidemic, anti-cancer, and anti-parasitic properties.

*G. cambogia* extract containing 51.2% HCA was found to be promising in the treatment of TNBS/ethanol-induced colitis in rats. Application of the extract significantly reduced inflammatory IL-1β and PGE2 levels with improved macroscopic colonic damage. The treatment was accompanied by lowered myeloperoxidase, COX-2, iNOS activity, and reduced DNA damage in colonocytes (dos Reis et al., 2009). Other active ingredients, such as Garcinol, have shown anti-inflammatory effects in LPS-stimulated RAW 264.7 macrophage cell line by downregulating activation of NF-κβ and/or JAK/STAT1 pathways. Garcinol-treated cells had lower iNOS and COX-2 expression, leading to reduced intracellular ROS levels in LPS-treated cells (Liao, Sang, Liang, Ho, & Lin, 2004). Reduction in proinflammatory cytokines by garcinol, guttiferone K, and guttiferone M has been demonstrated in other cell lines as well (Semwal et al., 2015). The blend of multiple bioactive compounds in *G. gummi-gutta* extract makes it an intriguing plant for further exploration. Several clinical studies containing *G. gummi-gutta* extract or its constituents have been carried out to assess efficacy for anti-obesity, hypolipidemic potential. Most formulations have been safe, but some trials and products lacked efficacy.

### Ghrita Kumari - *Aloe vera* :

The perennial green herb, *Aloe vera* (*Aloe barbadensis* Miller, family Xanthorrhoeaceae), commonly referred to as Ghrita Kumari in Sanskrit and Bengali, is extensively used for the treatment of several skin problems, cuts, injuries, digestive issues, diabetes, etc. Although this plant is native to North Africa, the *Aloe barbadensi*s has been naturalized and commercially cultivated in semi-arid and arid parts of India. Its extract has anti-oxidant, anti-inflammatory, anti-microbial, and wound-healing properties. *Aloe vera* contains more than 75 bioactive compounds, including several vitamins, enzymes, minerals, lignin, saponins, sugar, salicylic acids, and about 20 non-essential and 7 essential amino acids (Surjushe et al., 2008; Sarkar, 2017).

*Aloe vera* gel, or its different constituents, has been evaluated in several animal models of colitis. Rats with DSS-induced colitis were treated with *Aloe vera* compounds such as aloin, aloesin, and aloe-gel which resulted in the decrease of disease activity index, plasma level of leukotriene-B(4), TNF-α, and PGE2.. Myeloperoxidase activity and TNF-α and IL-1β m RNA expression were significantly reduced in the colonic tissue of the treatment groups compared to the control group (Park et al., 2011). Another study in rats identified aloin A as the key bioactive component of *Aloe vera* extract that could enhance mucus secretion in the colon to alleviate UC. Oral intake of *Aloe vera* decreased pro-inflammatory cytokines (IL-6, TNF-α, and IL-1β) and increased IL-10 levels. It also attenuated pPI3K and p-AKT expression but enhanced p-PKC and p-ERK expression (Shi et al., 2021). *Aloe vera*-derived nanovesicles have improved epithelial cell junctions and reduced permeability and damage in mouse UC models (Choi et al., 2023). Aloe polysaccharides have also been identified as contributors to UC disease improvement in animals. Glucomannan, an *Aloe* polysaccharide, can improve UC in animals by preventing intestinal barrier disruption and promoting epithelium regeneration through activation of intestinal stem cells (Zhang et al., 2023).

In a randomized, double-blind, placebo-controlled trial conducted on patients with active ulcerative colitis, oral *Aloe vera* treatment was administered for four weeks (100 ml twice daily). The results showed a significant decrease in the colitis activity index and histological disease activity in the treatment group compared to the placebo group (Langmead et al., 2004).

### Pomegranate - *Punica granatum* :

*Punica granatum* (Pomegranate), referred to as “dadima” in Sanskrit, is a deciduous shrub distributed throughout the world. Over the centuries, in Indian culture, many different parts of the plant have been used to treat various ailments. The fruit of the plant *P. granatum* (PG) has the potential to prevent cancer, cardiovascular disease, Alzheimer’s disease, diabetes, dental conditions, arthritis, obesity, and UV radiation-induced skin damage. Pomegranate is rich in polyphenolic compounds such as ellagitannins (ET) and ellagic acid (EA), which contribute to its anti-inflammatory and antioxidant activities. Punicalagin is the major ellagitannin extracted from pomegranate. In different preclinical animal models of IBD, the researchers have

investigated the effectiveness of pomegranate extracts, several polyphenolic compounds found in pomegranate, and their different metabolites. Supplementation of pomegranate extract or its different constituents can reduce inflammation and improve anti-oxidant activities. Thus, it alleviates symptoms of IBD, prevents leakage by reducing tissue damage in the colon, and promotes wound healing (Marin et al., 2009). The protective effect of pomegranate beverage containing ellagic acid and ellagitannins in DSS-induced colitis model in rats is attributed to lowered proinflammatory cytokines TNF-α and IL-1β production as well as reduced COX-2 and iNOS expression. Pomegranate beverage intake was able to modulate the miR-145/p70S6K/HIF1α axis (Kim et al., 2017). Pomegranate juice or ellagic acid can inhibit NF-κβ, ERK1/2 MAPKs, JNK, and STAT3 signalling pathways to suppress inflammation (Marin et al., 2013). Intestinal commensal bacteria convert ellagic acid to Urolithin A (UA) which can upregulate miR-10a-5p. This halts CD4+ T cell activation and proliferation in murine gut (Zhang et al., 2019). Pomegranate extract enhances intestinal barrier regeneration by modulating epithelial and stromal cell communication and inhibiting pathogenic bacterial biofilm formation (Rizzo et al., 2023). Supplementation of *P. granatum* peel aqueous extract (6 g of dry peel/day) along with standard treatment showed effectiveness in managing UC cases in a randomized, placebo-controlled clinical trial (Kamali et al., 2015).

## Conclusion:

Significant progress has been made in the past decades to decipher the complex immune network, genetic predisposition, gut microbiota dysbiosis, and other factors like diet and stress behind the development of IBD pathology. Since the management of IBD includes both induction and maintenance of remission, the adverse effects of conventional synthetic drugs become more prominent with long-term use. With the increase in IBD cases in India, it may be wise to pay close attention to the traditional knowledge of Indian plant-derived molecules to develop cost-effective and safe drugs. Figure 1 summarizes previous research indicating that various phytochemicals found in plants can target multiple IBD-promoting factors, ultimately reducing symptoms of the disease. However, attention must be paid to instances of adverse interaction of conventional drugs with phytochemicals if they are administered together. Long-term efficacy and safety must be established in clinical trials for the widespread use of these plant-derived compounds to treat IBD. Evidence-based research on immunomodulatory phytochemicals, their bioavailability, and targeting using newer delivery technologies presents hope for a breakthrough in IBD therapy.

## Conflicts of Interest:

None

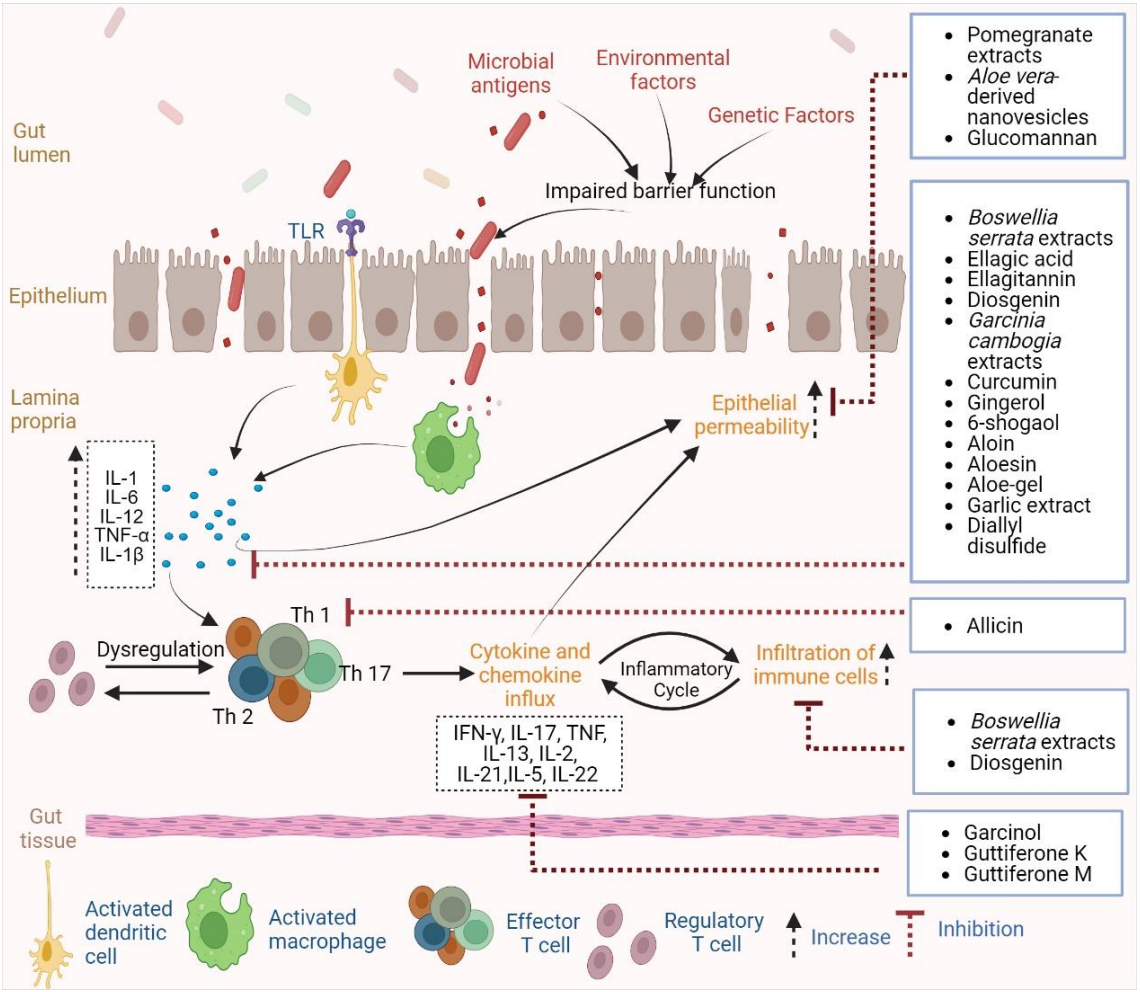


**Figure 1. Phytochemicals can modulate different targets to induce and maintain inflammatory bowel disease remission. Created with BioRender.com**

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Chapter- 4

# Indigenous Medicinal Plants against Alzheimer's disease: A Review

**Shubham Ghosh, Biplab Bhowmik, Saptarshi Chatterjee and Susmita Mondal***

**Keywords:** Alzheimer's disease, Amyloid-β, Antioxidant, *Coriandrum sativum*, *Curcuma longa*, Medicinal plant, Phytochemical, *Withania somnifera*.

**Abstract:**

Alzheimer's disease (AD) is caused due to degeneration of the brain cells that leads to dementia, which is characterized by impaired thinking, remembering and independence in personal daily activities. It is a multifactorial neurodegenerative disorder caused primarily due to the accumulation of amyloid-β (Aβ) and tau protein hyperphosphorylation, which induce oxidative stress that affects a wide range of the cerebral cortex and hippocampus. Furthermore, various risk factors like increasing ageing, head injuries, infections, and environmental factors also contribute to the occurrence of the disease. Globally more than 57.4 million people are affected with AD and the cases are increasing day by day. Still, only two classes of drugs i.e. cholinesterase inhibitors and N-methyl d-aspartate (NMDA) antagonists, are available to treat symptoms of AD, however there is no cure or prevention of the disease. Phytochemicals isolated from medicinal plants are proven to be effective in various diseases. Here, we aimed to discuss the effects of three native medicinal plants (*Curcuma longa*, *Withania somnifera* & *Coriandrum sativum*) in AD. A potent phytochemical curcumin found in *Curcuma longa* has anti-inflammatory and antioxidant properties, reducing oxidative stress and preventing the formation of amyloid-β plaque. Bioactive components such as Witanopherin, witanolides A-Y etc. of *Withania somnifera* are found to be effective in decreasing the level of inflammatory mediators like IL-1β, Il-6, TNF-α, MCP-1. Moreover, these phytochemicals inhibit amyloidβ and tau protein accumulation, thereby preventing AD. *Coriandrum sativum* contains active phenolic components which have antioxidant property. Volatile oil from *C. sativum* proven to be effective for the prevention and reversal of the conditions of AD. Therefore, using these indigenous medicinal plants for the treatment of patients with Alzheimer's disease is a better alternative as these natural products are very effective with no side effects.

## Introduction:

Extremely frequent entities of neurogenetic disorders and Alzheimer's disease (AD) clearly demonstrate the range of neurological diseases that lead to unfathomable problems among people and their families worldwide. These terms refer to neurogenetic disorders as they cover

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a spectrum of disorders due to genetic mutations that alleviate the nervous system's structure and function. These pathologies commonly come with extremely diverse symptoms like cognitive impairments, motor dysfunctions and sensory dysfunctions, which present complicated diagnostic and management choices for healthcare providers (Dey & Guha, 2020; Haloi et al., 2023).

Alzheimer's disease (AD), being a neurodegenerative disorder, affects the aged people most. The name of the disease comes after Alois Alzheimer, a German neuropathologist who discovered it in 1906. The disease appears with memory loss, impaired performance, and deterioration in thinking ability as its main symptoms. Externally, AD resembles severe depression. Patient affected with AD exhibit emotional impairment like irritability, frustration and hostility (Ballard et al., 2011; Alzheimer's disease facts and figures, 2010). Due to amyloid-beta peptide's (Aβ) accumulation in the brain, neuritic plaques and neurofibrillary tangles are formed, resulting in Alzheimer's disease (De-Paula et al., 2012). AD is one of the most common modes of dementia and it contributes around 75% of all dementia reports. The effect of the disease is most prevalent in people above 65 years whether. Around 2-5% of cases are found at early ages. According to the latest reports, around 57.4 million people will be affected by it, which evokes global concern (Ray et al., 2023). Only some treatments are there to improve the quality of life of AD victims, but no cure is available right now (Yiannopoulou & Papageorgiou, 2020; Livingston et al., 2020). Herbal medicines contribute to the prevention of the progress of the disease and now-a-days, these are very much trending using medicinal plants for the production of drugs (Abascal & Yarnell, 2004; Perry et al., 1999). Medicinal plants (nervines) have the properties to improve the function of the nervous system and memory (Manyam, 1999; Mishra et al., 2000). According to phytochemical studies, various plant compounds effectively reduce inflammation. They exhibit anti-amyloidogenic, antioxidant, anti-cholinesterase and hypolipidemic effects (Howes et al., 2003; Kennedy & Wightman, 2011; Kumar, 2006; Manyam, 1999).

## Neuropathy of Alzheimer's disease:

The neuropathology of AD exhibit two types of lesions:

i. Positive lesions- In this case, neurofibrillary tangles, dystrophic neurites and amyloid plaques are found in the brain. All of these are due to accumulation.
ii. Negative lessons- These are exhibited by atrophy caused by synaptic, neural and neuropil loss. In addition, injury of cholinergic neurons, neuroinflammation and oxidative stress also results in neurodegeneration (Serrano-Pozo, 2011; Spires-Jones, 2014; Singh, 2016).

## Molecular mechanism of AD:

Aβ pathology and neurofibrillary tau pathology are the two main characteristics of Alzheimer's. A lot of studies have been conducted on the Aβ pathology (Pimplikar, 2009). As a therapeutic target to manage the disease, tau came to light after the failure of Aβ based clinical

trials. A lot of analysis reveals that, though Tau pathologies are exhibited in various neurodegenerative issues, the proteins are structurally different in each case (Avila et al., 2004). Cell-to-cell transmission of tau and conversion of normal tau to abnormal forms may be important points in administering AD treatment (Hasegawa, 2016). An unusual deposition of β-amyloid protein in the brain is shown in the cases of AD. In the fibrillar form of the protein, it has a neurotoxic effect as it provokes free radical formation and interrupts glucose transportation to neurons. Due to the accumulation of senile plaques, microglial cells produce toxins that destroy diseased and healthy neurons, enhancing the brain's inflammatory response (Tiwari et al., 2019).

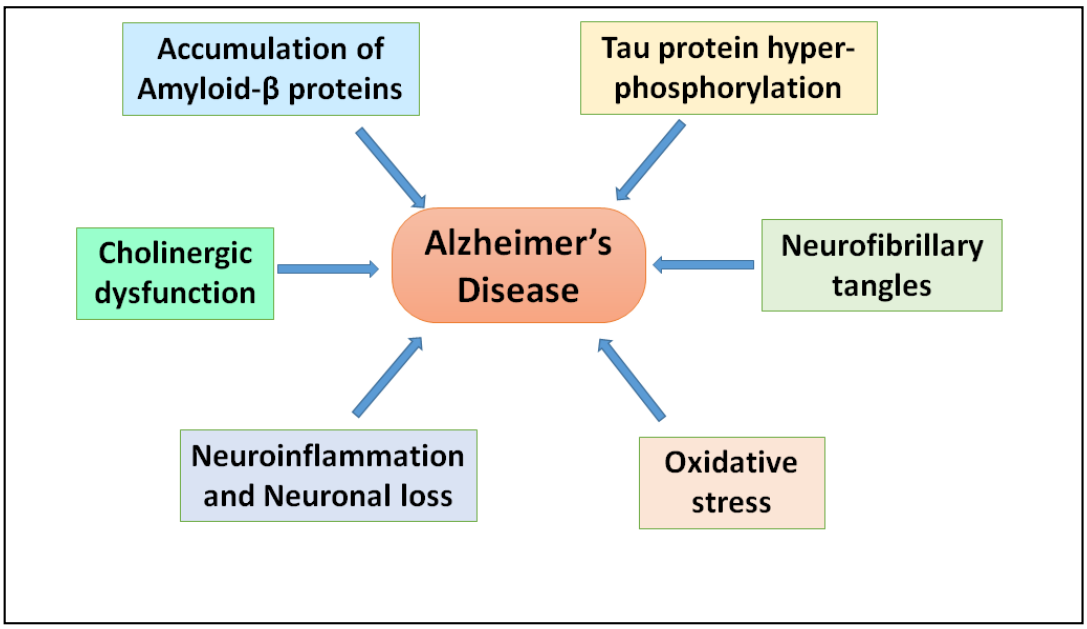


**Figure 1. Pathophysiology of Alzheimer's disease**

## Effects of Plant products on AD:

In this review, three very popular indigenous medicinal plants (*Curcuma longa, Withania somnifera & Coriandrum sativum*) will be discussed from the perspective of therapeutics against AD.

### *Curcuma longa:*

*Curcuma longa*, commonly known as Turmeric, is very well known in Ayurveda (Indian system of Medicine) for its anti-inflammatory activity. It also exhibits anti-cancer properties (Shishodia, 2005; Ammon & Wahl, 1991). *Curcuma longa* belongs to the family Zingiberaceae, the ginger family. It is used as a spice in India. Main active compounds of turmeric are curcumin, curcuminoids and turmerone oil (Agarwal et al., 2007). The epidemiological study found that AD cases are 4.4-fold lower in Southeast Asia because of using turmeric in their daily life as a spice (Ganguli et al., 2000). The anti-inflammatory

property of *Curcuma longa* is also responsible for controlling AD (Breitner et al., 1995). Curcumin decreases plaque deposition when they are given turmeric for feeding (Begum et al., 2008). It also checks the oxidative damage and reverses the Aβ pathology (Lim et al., 2001). Curcumin prevents plaque development, including the reduction of plaque levels, if injected into the brains of the mice. The strong antioxidant and anti-inflammatory properties of curcumin decrease the symptoms of Alzheimer's (Yang et al., 2005). In vitro, curcumin is more potent than Vitamin E in preventing lipid peroxidation and neutralizing the reactive oxygen species (Butterfield et al., 2002). No acute toxicity was observed after receiving 2000, 10,000 or 50,000 ppm of turmeric oleoresin to groups of male and female rats and mice for 13 weeks and 2 years in a Technical Report Series, National Toxicology Program CAS NO. 8024-37-1.

A randomized, placebo-controlled, double-blind clinical trial of curcumin in 27 patients having Alzheimer consuming 4g per day was found safe (Baum et al., 2008). If administered orally, more clinical trials are required to determine curcumin's efficacy (Belkacemi et al., 2011).

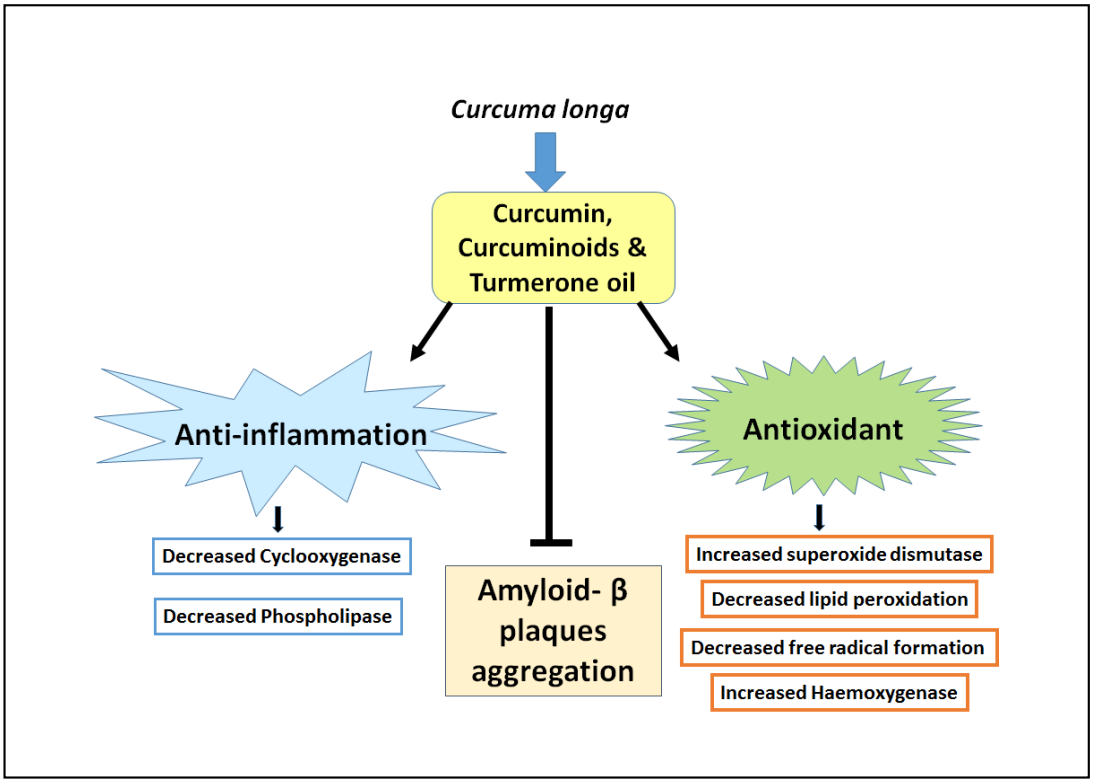


**Figure 2. Schematic representation of the effects of bioactive components from *Curcuma longa* in Alzheimer's disease**

### *Withania somnifera:*

In Ayurveda, the uses of *Withania somnifera* (Ashwagandha) are extensive. It belongs to Solanaceae family. It is a nervine tonic that helps relieve stress (adaptogens), prevent free

radicals and boost immunity (Mishra et al., 2000; Russo et al., 2001; Bhattacharjee, 2020). It is reported in a monograph of Alternative Medicine Review in 2004 that, Ashwagandha is different from the other adaptogens, it exhibits a calming effect rather stimulating, so it may be helpful for peoples with AD. Witanolides and alkaloids are two main active substances present in this plant. Witanopherin A, witanolides A-Y, witanone, witadomniferin A, and witasomniferols are the witanolides and witanin, somniferin, somnin, tropin, somniferinin, pseudowitanin, pseudotropin, choline, kuskohigrin, isopeletierin, and anaferin are the alkaloids (John, 2014). The study revealed that ashwagandha is potent to neutralize the β- amyloid, the leading cause of AD (Kurapati et al., 2013). A study exhibited inhibition of amyloid β-42, and decreased the level of IL-1 β, Il-6, TNF-α, MCP-1 and lipid peroxidation after oral administration of vitanon (a compound isolated from ashwagandha) in rat. Vitanon also reduced the activity of β and γ-secretase (the main cause of the formation of neurotoxic aggregates of β-amyloid (Pandey et al.,2018). Withaferin A, a witanolides of this plant, inhibits tau protein accumulation and β-amyloid aggregation and, thus, has a promising effect to prevent AD. The compound also regulates the heat shock proteins (HSPs), which express more with cell exposure towards stress (Das et al., 2021).

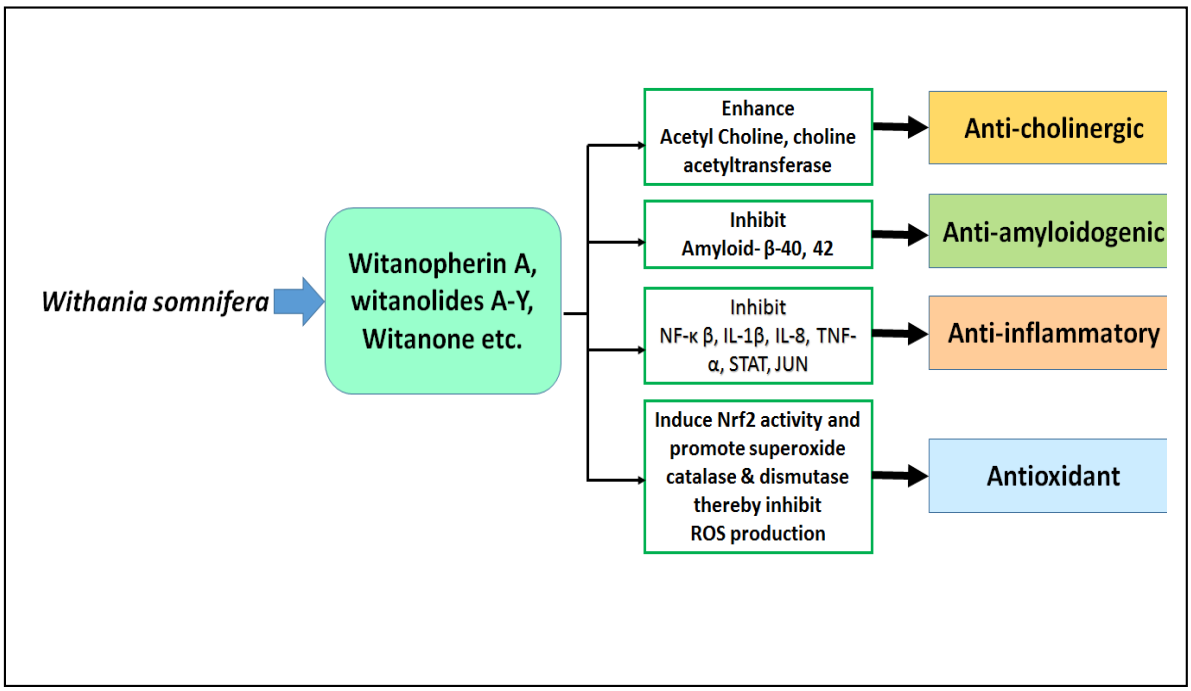


**Figure 3. Schematic representation of the effects of bioactive components from *Withania somnifera* in Alzheimer's disease (Abbreviations: NF-κβ: nuclear factor kappa B IL-1β: interleukin-1β; IL-8: interleukin-8; TNFα: tumor necrosis factor-α, STAT: signal transducers and activators of transcription; Nrf 2: nuclear factor erythroid 2–related factor; ROS: reactive oxygen species)**

### *Coriandrum sativum*:

*Coriandrum sativum* is an herb originating in Mediterranean areas (Yeung and Bowra,2011). It is generally used to treat digestive problems, diarrhea, colic, and other gastrointestinal medicine in Iranian traditional medicine (Zargari, 1991). Due to having phenolic compounds the plant shows hepatoprotective properties (Pandey et al., 2011). *C. sativum* also exhibit antioxidant activity in different organs (Kansal et al., 2011). Studies show that leaves of plants have the potential to improve memory and prevent aging in mice dose-dependently (Mani et al., 2011). The plant's hydroalcoholic extract (50,100 &200 mg/kg) prevents pentylenetetrazole-induced neuronal damage (Pourzaki et al., 2017). The efficacy of an active ingredient, volatile oil from *C. sativum*, after daily inhalation (1-3%) for 21 days was evaluated, which exhibited an improved deleterious effect of AD and reversed the condition of AD. It is reported that animals treated with volatile oil have a very low chance of amyloid deposition, In addition the oil from *C. sativum* also contributes to the improvement of hippocampal tissues, reduction of sodium dis-mutase, and MDA depending upon dose (Cioanca et al., 2013).

## Conclusion:

Alzheimer's disease is a problem of global concern. The number of victims is increasing vigorously. Aged people (>65 years) are more prone to this disease, but the disease can be started at a very early age. No drastic changes will occur, so can't be marked at early levels always. No cure has been invented against this culprit till today. The treatments available in the market prevent further development and maintenance of quality of life. Medicinal plants may be a lantern to the darkness in this difficult situation (Sarkar et al., 2016, 2021, 2022). As various study depicts the efficiency of various plant products against AD is hopeful, more studies should be done in this area. The studies show that plant products are comparatively safe and effective. With the advancement of science, plant products may be a breakthrough treatment procedure against Alzheimer's disease.

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Chapter- 5

# Exploring the Ethnobotanical Resources of Indian Sundarbans: An Insight into Medicinal Plants

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**Keywords:** Sundarban, traditional, medicine, bioactive compounds, healing, plant.

**Abstract:**

The Indian Sundarbans, a unique ecosystem comprising mangrove forests and diverse habitats, harbors an extensive array of medicinal plants with profound healing properties. This chapter navigates through the rich source of indigenous medicinal plants of the Sundarbans like Hogla, Hetal, Goran, Bain, Sundari, etc. outlining their traditional uses and potential therapeutic applications. Focusing on the roles of these plants in local healthcare practices, we tried to combine traditional wisdom with current scientific insights that hold great potential for pharmaceutical advancements. Different bioactive compounds (alkaloids, flavonoids, tannins, terpenoids) produced by medicinal mangroves have antioxidant, anti-inflammatory, antibacterial, and anticancer activities and other health-care potentials. Threats of habitat degradation, climate change, and anthropogenic activities pose grave risks to the existence of these invaluable plants, warranting immediate attention to safeguard their biodiversity. In a world where consumers are increasingly seeking natural and sustainable alternatives to promote their health, using plants as a medicinal source is commercially and environmentally feasible.

## Introduction:

The use of medicinal plants in India has a deep-rooted history dating back to ancient times, forming the basis of traditional systems of medicine like Ayurveda (Maiti et al., 2010, 2013;

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Erfani, 2021; Sarkar et al., 2021, 2022; Kar et al., 2022; Dhakar and Tare, 2023). Different regions of the Indian subcontinent possess unique medicinal flora with diverse traditional practices (Banerjee et al., 2014; Bose, 2018; Bhattacharjee, 2021; Basu et al., 2022; Bhowmik et al., 2022; Darro & Khan, 2023; De & Sharma, 2023; De et al., 2023). These practices reflect regional variation and highlight the cultural significance of traditional medicine in different parts of India (Shakya, 2016; Sarkar et al., 2016).

The Indian Sundarbans, a vast mangrove forest between India and Bangladesh shaped by the confluence of freshwater and saline tidal waters, constitute a rich and diversified ecoregion (Madhu et al., 2021; Das et al., 2022; Biswas et al., 2023). This unique mangrove, harbors a rich plant diversity, with numerous plant species known for their therapeutic properties (Neogi et al., 2016). Ethnobotanical practices in the Sundarbans are intrinsic to local communities, shaping their healthcare and cultural traditions. The indigenous people rely on the wealth of traditional knowledge, leveraging medicinal plants for various health issues like —treating skin conditions, digestive disorders, and injuries (Acharya et al., 2021, 2022, 2023). Beyond medicinal uses, these plants are interwoven into daily life, rituals, and economic activities. They hold cultural significance and serve as sources of livelihood, utilized in crafts, construction, and sustenance (Mondal & Das, 2023).

The extensive use of medicinal plants in these communities signifies the intimate relationship between humans and nature, emphasizing the reliance on natural resources for healthcare needs (Smith-Hall et al., 2012). This traditional wisdom, coupled with these medicinal mangrove plants' scientific validation and therapeutic properties, presents a promising avenue for integrating traditional medicine into modern healthcare practices (Mondal et al., 2012; Biswas, 2022). As modern-day consumers prioritize their health, there is a growing recognition of the potency and efficacy of plant-based remedies. Harnessing the healing properties of these plants offers a lucrative avenue in industries such as pharmaceuticals, wellness products, and herbal supplements. Thus, a combination of traditional wisdom and scientific exploration makes the study of medicinal plants in the Sundarbans an area of great interest (Patra et al., 2019).

## Medicinal Plant Diversity and Traditional Uses:

Various medicinal plants are found within the Indian Sundarbans, and their traditional usage is for therapeutic purposes (Madhu & Sarkar, 2015; Ghosh et al., 2022; Mandal, 2022; Pal et al., 2022; Jyotirmayee et al., 2023). These indigenous trees, shrubs, herbs, and climbers revealed their potential for health-related issues (Pyne & Santra, 2017; Raha et al., 2022; Saha et al., 2022; Pimple et al., 2023). From bark to fruit, roots to leaves, each preparation serves a distinct medicinal purpose, addressing a spectrum of healing benefits that sheds light on the invaluable ethnobotanical wealth of the Sundarbans. Table 1 represents different medicinal plants along with their ethnobotanical practice (Bandaranayake, 1998; Chowdhury et al., 2014; Sanyal, 2022; Mukhopadhyay, 2018; Islam et al., 2022).

**Table 1. List of various medicinal plants of the Sundarbans and their traditional uses**

| Sl. | Common Name | Scientific Name | Family | Parts Used | Traditional Usage | Types of Plants |
|---|---|---|---|---|---|---|
| 1 | Hogla | *Typha elephantina* | Typhaceae | Roots | Treats gastrointestinal issues and skin ailments, notably dysentery. Roots are anecdotally effective. | Herb |
| 2 | Goran | *Ceriops decandra* | Rhizophoraceae | Bark, Leaves | Alleviates skin diseases and digestive disorders. | Tree / Shrub |
| 3 | Hental | *Phoenix paludosa* | Arecaceae | Fruit Pulp | Treatment of skin maladies. | Palm |
| 4 | Sundari | *Heritiera fomes* | Malvaceae | Bark | Remedies ulcers, skin afflictions, and possesses astringent properties. | Tree |
| 5 | Kankra | *Bruguiera gymnorrhiza* | Rhizophoraceae | Bark | Addresses diarrhea and dysentery. | Tree |
| 6 | Bain | *Avicennia officinalis* | Acanthaceae | Bark, Leaves | Manages rheumatic conditions and skin disorders. | Tree / Shrub |
| 7 | Ketaki | *Pandanus odoratissimus* | Pandanaceae | Flowers | Helps in diabetes management and exhibits anti-inflammatory properties. | Shrub |
| 8 | Golpata | *Nypa fruticans* | Arecaceae | Roots, Leaves | Utilized in traditional medicine for treating fever and potentially broader therapeutic benefits. | Shrub |
| 9 | Gewa | *Excoecaria agallocha* | Euphorbiaceae | Latex | Latex is applied externally to alleviate pain and swelling caused by various conditions. | Shrub / Tree |
| 10 | Garjan | *Rhizophora mucronata* | Rhizophoraceae | Bark, Leaves | Treats skin disorders like eczema and dermatitis, believed to aid gastrointestinal issues. | Tree |

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| 11 | Khalsi | *Aegiceras corniculatum* | Primulaceae | Leaves, Bark | Used in traditional remedies for treating diarrhea, dysentery, and fever management. | Shrub / Tree |
| 12 | Keora | *Sonneratia apetala* | Lythraceae | Bark, Leaves | Reputed to have antimicrobial and anti-inflammatory properties; applied for wounds and skin infections. | Tree |
| 13 | Chak Keora | *Sonneratia caseolaris* | Lythraceae | Fruit | Edible fruit for local cuisine, fruit extract as an anthelmintic | Tree |
| 14 | Guava | *Psidium guajava* | Myrtaceae | Leaves | Leaves manage gastrointestinal issues, coughs, and colds. | Tree / Shrub |
| 15 | Hargoza | *Acanthus ilicifolius* | Acanthaceae | Root, Stem, Leaf | It is applied in treating conditions like leucorrhoea, paralysis, osteoblastic activity, asthma, and colds. | Herb |
| 16 | Kala Bain | *Avicennia officinalis* | Acanthaceae | Root, Stem, Leaf | Used as an anticancer, gastroprotective, astringent, diuretic, antiulcer, and for various conditions. | Tree / Shrub |
| 17 | Dhundul | *Xylocarpus granatum* | Meliaceae | Leaves, Fruits, Barks | Employed to treat viral infections, fever, cholera, dysentery, and fever. | Tree |
| 18 | Bawani lata | *Sarcolobus globosus* | Apocynaceae | Stem, Seed | Used as an antiseptic, to prevent bleeding, wound healing, and skin injuries. | Climber / Shrub |
| 19 | Pasur | *Xylocarpus mekongensis* | Meliaceae | Bark | Treats dysentery, suitable for making furniture | Tree |
| 20 | Peyara Bain | *Avicennia marina* | Acanthaceae | Fruit | Used in a concoction for abortion | Tree |

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| 21 | Akash Bel | *Casytha filiformis* | Lauraceae | Fruit | Treats sexually transmitted diseases and erectile dysfunction | Parasite |
| 22 | Mat-Garan | *Ceriops tagal* | Rhizophoraceae | Bark | Stops hemorrhages, useful for ailments resembling peptic ulcers | Shrub |
| 23 | Hudo | *Acrostichum aurium* | Pteridaceae | Rhizome | Treats boils and carbuncles | Shrub/Understory |
| 24 | Bon-Jui | *Clerodendrum inerme* | Lamiaceae | Leaves | Contains bitter extract used as a febrifuge | shrub |
| 25 | Chuliakanta | *Derris trifoliate* | Fabaceae | Root | Treats chronic alcoholism, useful as a stimulant and antispasmodic | .Climber |
| 26 | Gorshingiah | *Dolichandrone spathaceae* | Bignoniaceae | Seed | Antiseptic properties, used in enteric spasms | Shrub |
| 27 | Panlota | *Finlaysonia obovata* | Rubiaceae | Leaf | Remedy for dysentery | Climber |
| 28 | Nona Hatisur | *Heliotropium curassavicum* | Boraginaceae | Root | Dried root powder used for treating wounds, cuts, and external ulcers | Herb |
| 29 | Bhola | *Hibiscus tiliaceous* | Malvaceae | Leaf, Bark, | Leaf extract used as a laxative, Bark mucilage for dysentery-like symptoms | Herb |
| 30 | Goria | *Kandelia candel* | Rhizophoraceae | Leaf | Treats problems related to frequent urination | Shrub |
| 31 | Kripal | *Lumnitzera racemosa* | Combretaceae | Stem | Stem fluid is used to treat skin rashes and itches | Shrub |
| 32 | Dudhilata | *Pentatropis capensis* | Apocynaceae | Latex | Latex is used to heal minor burns | Climber |
| 33 | Tagri Bani | *Scyphiphora hydrophyllaceae* | Rubiaceae | Shoot | Shoot extract used for enteric diseases and liver problems | Shrub |

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| 34 | Ora | *Sonneretia griffithii* | Lythraceae | Fruit | Fruit is used as spice and for adding flavor in cooking | Tree |
| 35 | Antomul | *Tylophora tenuis* | Apocynaceae | Stem, Leaves | Decoction is used for bile/liver problems and perspiration | Herb |
| 36 | Sultan Champa | *Calophyllum inophyllum* | Calophyllaceae | Seed | Skin problems, rheumatism, swellings, ulcers, scabies, ringworm | Tree |
| 37 | Nagchampa | *Mesua ferrea* | Clusiaceae | Leaves, flowers | Used as an antiseptic and blood purifier, it treats skin problems, colds, fever and rheumatism. | Tree |

## Bioactive Compounds of the Medicinal Plants and their functions:

Investigating the botanical wealth of the Indian Sundarbans reveals a wide variety of bioactive compounds in various plant species responsible for healing properties. These substances, such as alkaloids, flavonoids, glycosides, phenolic compounds, and tannins, have anti-inflammatory, antioxidant, antimicrobial, and therapeutic potentials (Das, 2021). Thus offering significant medicinal implications for potential drug development and other health benefits.

## Antioxidant Properties:

Mangrove species like *Rhizophora* spp. and *Avicennia* spp. are recognized for their rich content of diverse bioactive compounds with potent antioxidant properties. These compounds encompass tannins, flavonoids, phenolic compounds, carotenoids, xanthones, and quinones, collectively contributing to their anti-oxidative potential. Tannins, widely present in these species, possess robust antioxidant capabilities, neutralizing free radicals and preventing cellular damage caused by oxidative stress (Dahibhate et al., 2020). Flavonoids, another prevalent compound, offer similar protective effects, aiding in the body's defense against oxidative damage and reducing inflammation. Phenolic compounds such as gallic acid, caffeic acid, and ferulic acid act as strong antioxidants, playing a crucial role in protecting cells from oxidative stress-induced damage. Carotenoids, renowned for their pigment qualities, also act as antioxidants, contributing to the body's overall scavenging of free radicals (Saranraj et al., 2016; Eswaraiah et al., 2020).

## Antimicrobial Potential:

*Rhizophora mucronata*, *Sonneratia alba*, and *Avicennia marina* are recognized for their antimicrobial qualities and contain a wide range of bioactive substances, such as flavonoids,

alkaloids, saponins, and phenolic compounds. These compounds have been studied for their potential to combat a wide spectrum of pathogens, showcasing promising abilities to fight microbial infections (Mitra et al., 2021). Flavonoids, prevalent in these mangroves, possess antimicrobial properties, effectively inhibiting the growth and spread of various bacteria, fungi, and viruses. Alkaloids, another significant group of compounds, contribute to their antimicrobial efficacy by displaying inhibitory effects against pathogenic microorganisms (Dahibhate et al., 2019). Saponins in these mangroves exhibit detergent-like properties, disrupting microbial cell membranes and inhibiting their growth. Phenolic compounds, known for their antioxidative abilities, also demonstrate antimicrobial effects, aiding in combating microbial infections (Nabeelah Bibi et al., 2019).

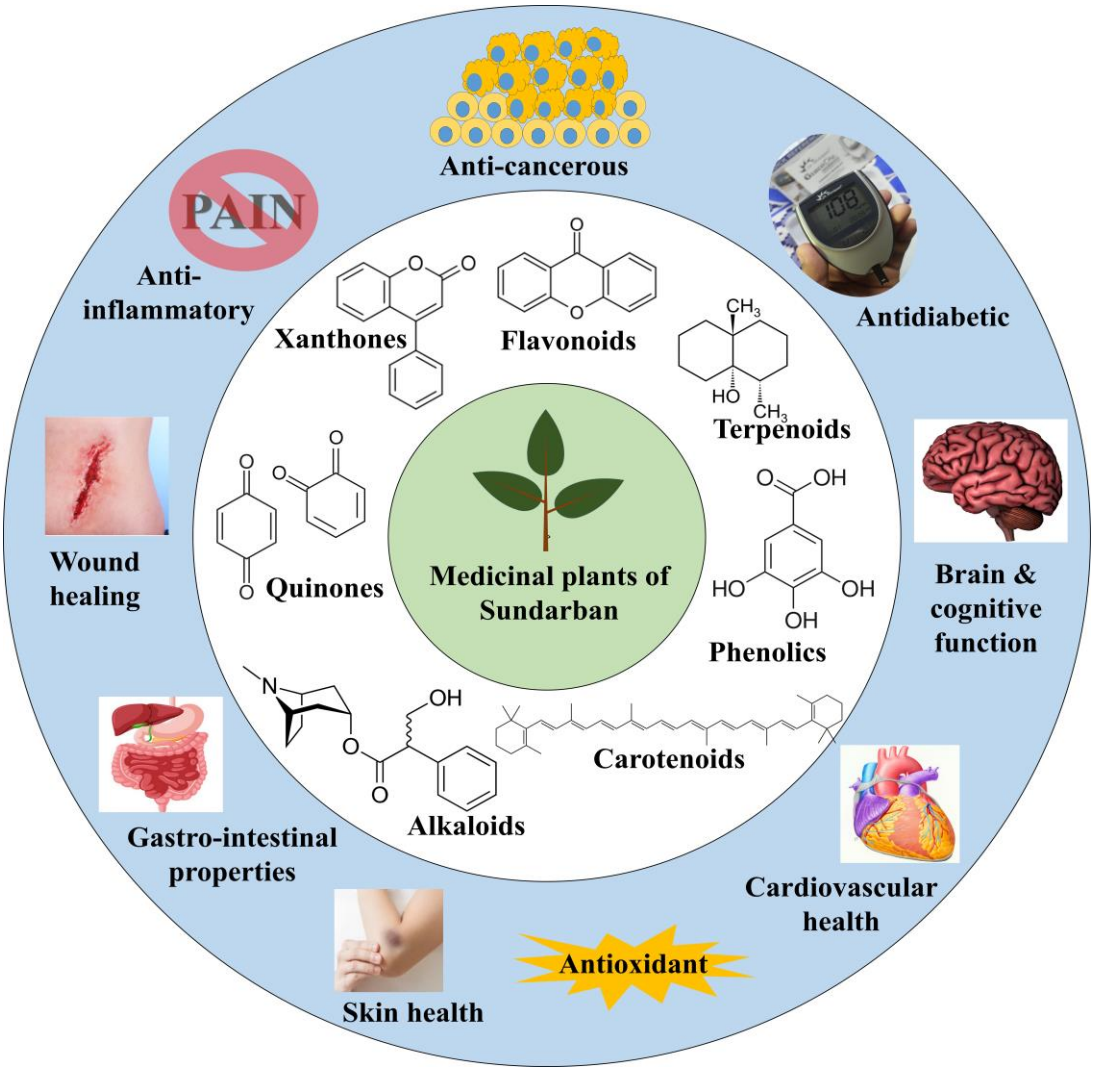


**Figure 1. Some bioactive compounds and their health implications (Figure concept adapted from Wani et al., 2020)**

**Anti-inflammatory Effects**:

*Avicennia* spp., *Ceriops decandra*, and *Avicennia officinalis* contain an impressive combination of flavonoids, terpenoids, and phenolic compounds. These compounds exhibited the potential to alleviate inflammation by modulating key pathways involved in the inflammatory process. Flavonoids, well-known for their antioxidative and anti-inflammatory effects, work synergistically with terpenoids, which display robust anti-inflammatory actions. Phenolic compounds further contribute by suppressing inflammatory mediators. The collective presence of these bioactive compounds in these mangrove species signifies their promising therapeutic potential in managing inflammatory conditions (Sithranga Boopathy & Kathiresan, 2010; Sohaib et al., 2022).

**Wound Healing Abilities**:

Tannins and phenolic compounds found in *Rhizophora* spp., *Ceriops zippeliana*, and *Avicennia integra* play pivotal roles in fostering wound healing. These compounds are believed to expedite wound closure, facilitate tissue repair, and potentially exhibit antimicrobial properties, thereby promoting accelerated healing processes. Known for their astringent qualities, tannins assist in contracting tissues, reducing bleeding, and aiding in wound closure. With their antioxidative and antimicrobial attributes, Phenolic compounds contribute to tissue regeneration and may prevent infection, collectively fostering a conducive environment for faster and more efficient wound healing in these mangrove species (Vinoth et al., 2019; Fernandez et al., 2002).

**Cardiovascular and Gastrointestinal Health**:

The phenolic compounds in *Sonneratia apetala* and *Acanthus ebracteatus*, along with the xanthones in *Mesua ferrea*, have potential cardiovascular and gastrointestinal wellness advantages. These compounds likely possess antioxidant properties, shielding cells from oxidative stress, and may exhibit anti-inflammatory effects, potentially alleviating inflammation within these systems. Their combined antioxidative and anti-inflammatory attributes suggest promising implications for promoting cardiovascular and gastrointestinal health within these mangrove species (Lalitha et al., 2019; Sasidhar, 2020; Kshirsagar et al., 2020).

**Skin Health and Diabetes Management**:

Carotenoids and xanthones present in *Avicennia lanata*, *Calophyllum inophyllum* signify potential advantages for skin health. Carotenoids, known for their antioxidant properties, may support skin integrity (Sumadri et al., 2018). Glycosides in *Lumnitzera racemosa* and *Aegiceras corniculatum* suggest potential antidiabetic effects. These compounds could assist in managing diabetes, potentially regulating blood sugar levels. Together, these bioactive compounds in these mangroves hint at beneficial prospects for skin wellness and diabetes management, promising natural support for these health aspects (Kumar & Pola, 2023).

## Potential for Antitumor Activity and Cancer Treatment:

*Excoecaria agallocha* and *Xylocarpus* spp. contains flavonoids and alkaloids, demonstrating promising potential in impeding tumor growth. These compounds exhibit cytotoxic effects specifically targeted at cancerous cells, suggesting a role in inhibiting tumor progression. Their identified bioactivity indicates a possible avenue for developing novel cancer treatments, leveraging these natural compounds' abilities to selectively combat and hinder tumor cell proliferation, fostering hope for future therapeutic interventions in oncology. *Xylocarpus granatum*, *Rhizophora stylosa* holds phenolic compounds, lignans, terpenoids, and xanthones, showing promising potential in fighting cancer. These bioactive compounds possess cytotoxic properties that may selectively target and inhibit the growth of cancerous cells. Recognized for their anticancer effects, these compounds suggest a potential avenue for developing treatments that aim to impede cancer cell proliferation within these mangrove species (Audah, 2018).

## Threats and Conservation:

The traditional use of these medicinal plants has been a cornerstone of local healthcare practices in the Sundarbans. While these plants have shown promising therapeutic potential, further scientific exploration and validation are imperative to ascertain their efficacy, safety, and mechanisms of action. However, these medicinal mangrove plants face severe threats like habitat destruction from logging and urbanization, climate change impacts like rising sea levels, cyclonic disruption, pollution from industrial waste, and unregulated commercial harvesting (Sharma et al., 2021).

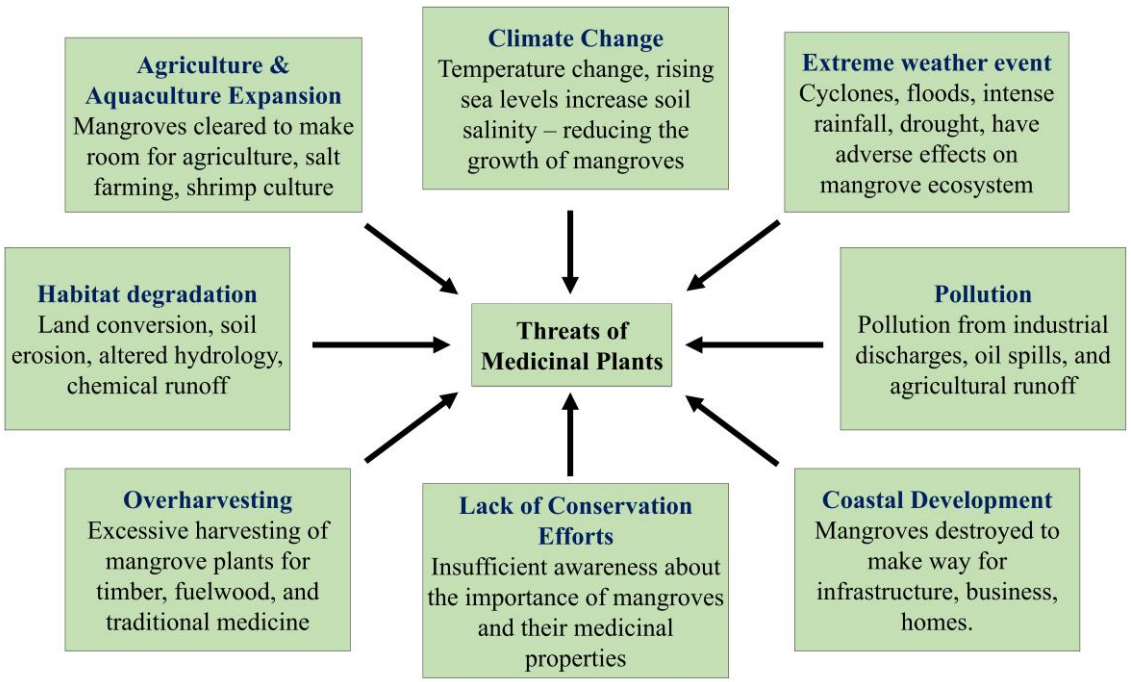


**Figure 2. Some potential threats to the medicinal plants.**

Urgent conservation efforts focusing on habitat protection, climate resilience, pollution control, and sustainable harvesting are necessary to safeguard these medicinal plants in the Sundarbans. Empowering local communities through education and eco-friendly practices can conserve this invaluable heritage, ensuring the preservation of the biodiversity of Sundarban and traditional knowledge. Efforts to protect these practices maintain cultural identity and offer insights into sustainable living and traditional healthcare systems. Conservation efforts should prioritize protecting habitats, engaging local communities, conducting research, enforcing policies against illegal harvesting, and fostering international collaboration to safeguard medicinal mangrove plants in the Sundarbans (Chowdhury et al., 2016).

## Conclusion:

In conclusion, the diverse array of medicinal plants thriving in the Indian Sundarbans represents an invaluable resource for the local communities and the broader field of medicine. The preservation and scientific exploration of this botanical wealth stand to offer significant contributions to humanity's quest for novel therapeutic interventions and holistic healthcare practices. Integrating traditional knowledge with modern scientific research holds the promise of uncovering novel medicinal compounds and treatments, potentially enriching the global pharmacopeia.

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Chapter- 6

# Traditional uses of some indigenous plants as medicine by Sundarbans' people in West Bengal

**Somnath Das* and Subhobrata Bondopadhyay**

**Keywords:** Traditional uses, indigenous plants, primitive people, Sundarban area.

**Abstract:**

Out of 45,000 plant species in India, more than 4,000 are known to be herbs. In Sundarbans, this number is more than a hundred. Trees, herbs and shrubs have been used for various ailments. In most cases, the long-term adverse reactions have forced the entire world today to look for ways to survive by searching for the herbal plants scattered in the forests and the knowledge accumulated over centuries of experience through application. In search of even though there is an advanced medical system available today, the people of Sundarbans have not lost their faith in the traditional herbs that have been passed down from generation to generation. People here lead their lives through hard struggles. They get benefits by using raw plant parts traditionally during illness. In many cases, plants are used as traditional medicine and are more effective than modern medicine, according to the local healer of Sundarbans. In this chapter, the scientific and vernacular names of some of the medicinal plants of Sunderbans, plants part, traditional uses & method of uses in particular disease for curing their daily health problems are elaborately described.

## Introduction:

Herbal medicine systems that have evolved over centuries of accumulated experience and it continue to evolve today have their own perspective (Ghosh, 1940; Banerjee, 1964; Banerjee et al., 1989; Sanyal et al., 1994; Acharya et al., 2020, 2021, 2022; Das, 2022; Das, 2023). However, these traditional medicines have no direct uses in our ancient scriptures (Banerjee et al., 2014; Bose, 2018; Bhattacharjee, 2021; Basu et al., 2022; Bhowmik et al., 2022; Darro & Khan, 2023). Atharvaveda is one of the shining examples of this context. World famous researcher Kenneth Zysk says that the concept of folk medicine evolved during the Indo-European civilization. This indigenous concept is a matter of pride for the entire Indian population at that time. According to McDonnell, Winternitz, Weber, etc., this Atharva Veda was composed around 3000 to 2000 BC. We will come up with the context of today's traditional herbal medicine in the lower Gangetic plains of West Bengal, where tribal peoples live, namely- Bhumij, Bedia, Munda, Orano, Mahali, Lohar, Santal and Chakma also (Parsard

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et al., 1987; Kenneth, 1993; Naskar, 1998; Naskar, 2000; Jana, 2020; Das et al., 2022; De & Sharma, 2023). Needless to say, all these people who belong to the tribal communities of the Sundarbans delta region live their lives with almost the same ritual and culture and also laid down their own traditional medical practices (Choudhuri & Chaudhury, 1994; Chaudhary, 2016; Erfani, 2021; Ghosh et al., 2022; De et al., 2023; Dhakar & Tare, 2023). People say 'Sundarban' has two concise terms 'forest' and 'basat'. The Sundarbans is the world's largest delta region at the Ganga-Brahmaputra estuary. India and present-day Bangladesh together have an area of 25,500 square km. This region is a collection of small isolated islands surrounded by salt water. Its water, soil, forest, environment, weather, etc. are all different in nature, taste, and character. Sundarban was named because of the forest of Sundari trees. Many people say that this region is full of beautiful deep forests called Sundarbans. But there is not much of an abundance of trees in Sundarbans. Heritiera (*Heritiera fomes* Buch-Hum) is only one species in this forest. In 1989, it was declared as 'Sundarban Biosphere Reserve'. Ecologists call mangrove forest. Here is a special type of ecosystem (Ecology). The annual average rainfall here is 1700-1900 ml and tidal water 04.5 m - 05.4 m every 6 hours, which is fluctuated. Of the part of Sundarbans that lies within India, 48 islands have protected forest areas and 54 islands are inhabited. Currently, the population here is about 45 lakhs. Ayurveda, Unani (Hechemy) and Siddha (South Indian system of medicine) were India's three main medical systems from ancient times until the Portuguese, Dutch and English arrived in India. All these medical methods were greatly developed (Madhu & Sarkar, 2015; *Maiti* et al., 2010, 2013; Mandal, 2022; Sanyal, 022; Kar et al., 2022; Jyotirmayee et al., 2023). All the herbs that have been tested on the hard stone for a long time and used to prevent and cure diseases are almost all proven correct by modern research (Pyne & Santra, 2017; Pal et al., 2022; Raha et al., 2022; Saha et al., 2022; Pimple et al., 2023; Sarkar, 2017; Sarkar et al., 2020, 2021, 2022, 2023). The Sundarbans region is a paradise for this herb. Not only that, but it is also the lungs of West Bengal and India. This unique, beautiful beach has been developed along the coast of the Bay of Bengal along the banks of the Ganges, Padma, Brahmaputra and their numerous tributaries and tributaries divided into many streams in West Bengal and the southern part of Bangladesh. Here is the ultimate monopoly of salt water in the vast aquifer. The ecosystem here is always in the constant movement of tides. A special type of mangrove plant has been born in this salty water. The word mangrove is derived from the Portuguese word 'mangu' and the English word 'grove.' Our discussion will take place in the natural environment of this Sundarbans region, the traditional aspect of herbal treatment based on its unique plantation.

**Arjun (*Terminalia arjuna* Bedd, family Combretaceae)**

**Common Features:** Large tree, usually bark, is shed twice a year.

**Active ingredients:** tannins and tannic acid.

**Parts used:** Bark and leaves.

**Medicinal/Traditional Uses :**

1. To relieve heart palpitations and heart ailments.
2. Used for relief of scabies, scabies, bone fractures, diarrhoea.
3. To relieve hoof ulcers in cattle.

**Method of use:**

1) Daily, 2-5 grams of bark powder is used to remove chest palpitations and heart disease.
2) Bark powder taken with warm milk relieves the pain of injury.
3) Paste of raw bark is applied to the rash,' mecheti'.
4) Bark juice relief from 'amasha'
5) Bark poultice to remove from hoof wounds of animals.
6) Raw bark is used for jabs (plaster) on broken bones.

**Anantamul (Common name *Hemidesmus indicus R.Br.*, Family- Asclepiadaceae )**

**Common features:** It is long-lived and creeping plant. It has white latex.

**Active ingredients:** Active ingredients are sterols and glycosides.

**Parts used:** Root, pulp.

**Medicinal/ traditional use:**

1. It has blood purifying activity.
2. Used to normalize the paralyzed limbs.
3. To relieve intestinal disorders, to remove facial acne and 'mecheta'.
4. Young twigs and roots increase the milk of cows and goats.

**Method of use:**

In each case, it is applied to the ointment for external uses or given to eat for internal uses.

**Antamul (*Tylophora indica* (Burm.f.) Merrill. Belongs to the family Asclepiadaceae)**

**Common features:** This plant is a long-lived vine. The creeper has white pulp.

**Active Ingredients:** Tylocorin and Tylocorylin.

**Parts used:** Root, leaves

**Medicinal\Traditional Uses:**

1. Used to reduce fevers, colds, asthma
2. Relieve dysentery in cattle diarrhoea and flatulence.

**Methods of use :**

1) Smoke of dried leaves reduces asthma.
2) Decoction of leaves (one part leaves boiled in 10 parts water) 10-12 ml. Used twice a day for colds and fevers.
3) Root decoction is used for white and bloody dysentery.
4) Chewing raw leaves in the morning relieves asthma.

5) 20-25 grams of root pulp is used twice a day to cure cattle dysentery and flatulence due to the emetic properties of the roots.

**Aparajita (*Clitoria ternatea* L., family Fabaceae)**

**Common features:** Plant is a long-lived creeping plant. Blue, pink and white colored flowers can be seen here and there.

**Active ingredients:** resinous substances and tannins.

**Parts used:** roots, bark, leaves, flowers.

**Medicinal/ Traditional Uses:** Relief from Whooping Cough/Goitre/Swelling of Ears/ Child Cough. It also relieves swelling of cattle's throats.

**Method of use:**

1) In whooping cough, 4-5 ml of root juice is taken once a day with cold milk.
2) To treat the Goitre, warm the roots (white flowering plant) with ghee is prescribed to eat with rice every day.
3) Applying the leaves' juice warmed with salt is claimed to remove swelling around the ears.
4) Flower juice mixed with mother's milk and honey is used to cure children's cough.

**Ashwagandha (*Withania somnifera,* Dunal belongs to the family Solanaceae)**

**Common features:** It usually looks like a small plant.

**Active ingredients:** Multiple alkaloids.

**Parts used:** Root, leaves

**Medicinal/Traditional Uses:**

1. To increase male fertility.
2. To remove adult weakness.
3. To relieve asthma in children, induce sleep, and bring healthy sleep.
4. Remove the shoulder sore for drawing bull.

**Method of use :**

1) Root powder with 5-7 grams of warm milk increases male fertility.
2) Elderly people are advised to take three grams of root powder once a day to remove senile weakness.
3) In children's asthma, the roots are boiled in mustard oil and massaged on the chest.
4) Root decoction is said to induce sleep.
5) The juice of the leaves of this plant is used to relieve the shoulder pains caused by drawing oxen.
6) To remove the gynaecological obstruction, the root paste is warmed with ghee and is prescribed orally after menstrual cycle.

**Akanda (*Calotropis gigantea* R. Br., Family: Asclepiadaceae)**

**Common features:** A shrub with purple and white flowers. Latex is present Plants with white flowers are relatively rare.

**Active Ingredients:** Akundrin and Calotropin.

**Parts Used:** Roots, leaves, bark, seeds.

**Medicinal/Traditional Uses:**

1. Relieves rheumatism/syphilis/relief of lice/spondylitis/toothache and removes lice (parasites),
2. Relieves to cattle from lice and hooves.

**Method of use:**

1) To relieve the pain of rheumatism, the raw leaves are said to be heated and given as a decoction.
2) Root powder is given twice a week in quantity of one gram to cure syphilis.
3) 'Mecheta' is removed to be mixed with raw turmeric.
4) Powder is used to kill head lice.
5) A pillow of seed cotton heated in the sun is used to cure spondylitis.
6) It is applied as toothache pills.
7) Dried leaf dust is used to remove lice (parasites), lice and mites

**Apang (*Achyranthes aspera* L.), Family- Amaranthaceae**

**General features:** Commonly known as Apang. It is small in size.

**Active ingredient:** Emitin

**Parts used:** Root, stem, leaves.

**Medicinal/Traditional Uses :** Used to remove water retention from the body/menstrual fits is removed/remove dental caries/ remove jaundice etc. and to stop bleeding and also make it easy to deliver a child of cattle.

**Methods of use:**

1) Drinking 10-12 ml of boiled water of tree bark twice a day removes sokha (water accumulation in the body).
2) Root paste prevents menstrual cramps.
3) To remove the pains of insect biting are prescribed to chew the root.
4) Jaundice is cured if a garland of tree trunk is put on around the neck.
5) The roots are tied to the leg of the pregnant woman for smooth delivery.
6) The juice of this plant is used to stop bleeding from broken horns of cattle.

**Asamlata/Baranlata/Ayublata ( *Mikania cordata* (Burm.f.) Robinson, Family- Asteraceae)**

**General features:** It is a long-lived creeping plant.

**Active ingredients:** Vitamin A, B and C of leaves.

**Medicinal / Traditional Uses:** It relieves gastric ulcers in freshly cut wounds and even after leg amputations in cattle.

**Method of use:**

1) 8-10 ml of raw leaf juice is said to be taken twice a day for stomach ulcers.
2) Juice of raw leaves applied to freshly cut wounds stops bleeding and acts as an antiseptic.
3) 10-12 ml of raw leaf juice is prescribed for gas and antacids.
4) If the leg of a cow/buffalo is injured by the plough blade during cultivation, applying the juice of this leaf is beneficial.

**Amrul (*Oxalis corniculata* L. belongs to the family Oxalidaceae)**

**General features:** it is a long-lived herb. Yellow-colored flowers can be seen on this plant.

**Active Ingredients:** Vitamin C and Carotene.

**Part used:** the whole tree.

**Medicinal/Traditional Uses:** Used to remove blood dysentery/relieve fever and cold/relieve pain from insect bites/remove opium and alcohol intoxication/relieve heartburn activity.

**Methods of use :**

1) 12-14 ml raw leaf juice is given with salt in blood dysentery.
2) This juice is taken with black pepper to get rid of colds, fever and influenza.
3) The application of leaf juice to stings of poisonous insects relieves pain.
4) The juice of raw leaves helps to remove the intoxication of opium and alcohol.
5) Eating the juice of the leaves with beet salt relieves heartburn.

**Alaraka/lata begun(Vine Eggplant): ( *Solanum trilobatum* L, family- Solanaceae)**

**General features:** this plant is also a long-lived creeper. Its flower color is purple.

**Active ingredient:** Solasodin in leaves and fruit.

**Parts used :** Roots, leaves, fruits.

**Medicinal/Traditional Uses:** Cure coughs, colds, fevers, hay fever, and skin diseases.

**Method of use:**

1) Leaf and fruit decoction of 8-10 ml of leaf and fruits once a day is used for cough and cold fever.
2) If the leaves and roots are boiled in juice and the oil is applied to the 'haja', the 'haja' is cured.
3) To cure the vaginal infection and inflectional disease of the outer genital part, the leaf paste and fruit paste are prescribed externally with mustard oil.

**Ayapan (*Eupatorium triplinerve* L., belonging to the family Asteraceae)**

**General features:** It is a climbing plant and a wild plant.

**Active Ingredients:** Ayapnin and Iodine.

**Part Used:** The whole part

**Medicinal/Traditional Uses:** This plant is used to remove blood vomiting/ cure the, heal stomach ulcers/relieve physical weakness and cure nervous system weakness.

**Method of use:**

1) Raw leaf juice 10 ml to cure blood vomiting and stomach ulcers. It is prescribed to be eaten twice or thrice a days in a week.
2) Leaf juice is said to be taken with sugar to remove physical weakness.
3) This plant is used to remove nervous system weakness.

**Ulat combal (*Ambroma augusta* L., family Sterculiaceae)**

**General features:** It is a small tree. The flower color is purple.

**Active ingredient:** linoleic acid as alkaloids.

**Parts used:** Root, bark and leaves

**Medicinal/Traditional Uses:** Used to relieve boils/urinary irritation.

**Method of use:**

1) The juice of raw leaves is applied to the boils for better results.
2) Drinking water soaked in leaf stalk to relieve a burning sensation in urine.

**Ulat chandal (*Gloriosa superba* L. belonging to Liliaccae family)**

**General features:** It is a creeping plant. The front side of the leaves of this tree is attractive. The flowers of this plant are bright fire colored.

**Active ingredient:** Colchicine is present in roots and seeds.

**Medicinal/Traditional Uses:** Roots are used to reduce rheumatic swelling due to their acute toxicity.

**Method of use:**

1) Paste of root is applied to tooth swelling.
2) Root powder is used as its roots are highly poisonous.

**Ora ( *Sonneratia griftithi* Kar., family-** Lythraceae**)**

**General features:** The tree is large in size. Its flowers look like jam flowers.

**Active ingredient:** Archinine.

**Parts used :** bark, leaves, fruit.

**Medicinal/Traditional Uses :** Relieving flatulence in cattle.

**Method of uses :**

1) Fruit pulp is used to relieve flatulence in cattle.

**Ora (White) (*Sonneratia alba* Sim) family;** Lythraceae

**General features:** It is a medium-sized tree. Its flowers are generally similar to Jamrul flowers.

**Active ingredient:** Tannin.

**Parts used:** Bark, fruit.

**Folk/Traditional Uses:** To relieve from cold cough and indigestion

**Method of use:**

1) The unripe fruit is prescribed for common cold and cough.
2) The ripped fruit is used as raw or cooked to cure indigestion.
3) In the case of indigestion caused by consuming excess milk from the calf, it is reduced by eating this fruit.

**Kakmachi: (*Solanum nigrum*. It belongs to the Solanaceae family)**
**General features:** the plant looks like a small pepper plant.
**Active Ingredients:** Solanine, Saponin.
**Parts Used:** Time plant, fruit.
**Medicinal/Traditional Uses:** Treatment of varicose veins/relief of itching and allergies/relief of gout/fit in children.
**Method of use:**

1) The juice of raw leaves mixed with raw turmeric and applied on the skin can prevent itching and allergies in hot weather.
2) A poultice of the leaves is used to cure rheumatism.
3) There is a practice of giving the juice of the ripe fruit and powder of the root to prevent "Tadaka" (Fit in children.

**Kankra** (*Bruguiera gymnorhiza* family-Rhizophoraceae)
**General features:** It is not very big in shape.
**Active ingredients:** Bark contains 14-19 percent tannin.
Parts used bark, fruit.
**Medicinal/Traditional uses:** Used to cure ringworm/relief of ingrown toenails/ prevent cattle hoofs.
**Method of use:**

1) Bark poultice is used to treat boils.
2) Leaf and bark paste is used to treat eczema, scabies ringworm and another fungal disease of skin.
3) Cattle hooves (a type of sore) should be washed off the bark of this plant with boiled water.

**Kalabine (*Avicennia alba* Blume., Kalabine is a tree of Avicenniaceae family.**
**General features:** this plant is medium in shape
**Used parts:** bark
**Medicinal/ Traditional uses:** Used to treat birth control, ulcers, skin conditions, and even cancer.
**Method of use :**

1) The leaf extract is used orally to treat stomach ulcers.

2)The bark paste is used externally to treat any type of skin infection.

**Keora (*Sonneratia apetala* Buch. family Lythraceae.).**

This tall tree and fruit are sour in taste.

**Active ingredient:** Tannic acid.

**Parts used:** Leaves and fruits.

**Physiological/Interactive Uses :** To cure digestive or gastro-intestinal problems.

**Method of use:**

1) Fruit is used to treat digestive problems like acidity, stomach-ache.
2) Raw fruit extract is used to treat diarrhoea and loose motion.

**Kesraj: (*Eclipta prostrata* L., Asteraceae family)**

**General features:** It is a creeping plant. Its flower color is white.

**Active ingredient:** Ecliptin.

**Parts Used:** Roots, whole plant, leaves.

**Folk/Traditional Uses:** Used to blacken hair promotes hair growth/relieve headache/stop bleeding.

**Method of use:**

1) Regular use of Kesraj leaf juice results in black hair.
2) Kesraj leaf juice promotes the hair growth.
3) The headache is relieved by twisting some Kesraj leaves to make juice and applying on head.
4) The leaves are used to stop bleeding and healing the cuts and wounds of cattle .

**Keya (Common name *Pandanus odoratissimus* L., Pandanaceae- family,)**

**General feature:** The prop root is visible. The fruit of this tree looks like a pineapple. It is medium-sized plant.

**Active ingredients:** benzyl benzoate, benzyl and salicylate.

**Parts used:** Roots, leaves, flowers and fruits.

**Medicinal/ Traditional use:** It is to treat cataracts in cattle in water instead of camphor as a perfume.

**Method of use:**

1) The flower extract is used as a perfume.
2) Use of these flowers instead of camphor in drinking water gives a different aroma.
3) The juice of the roots is used to treat cataracts in cattle.

**Kripa (*Luminitzera racemosa* Willd., Combretaceae- family )**

**General features:** It is medium in height.

**Active ingredient:** 11% tannin.

**Part Used :** Bark.
**Medicinal/Traditional Uses :** Use in Naranga (Herpes) and itching.
**Method of use:**

1) Bark paste is used to cure Naranga (Herpes).
2) Bark sheath is applied to cure the itching.

**Kunch *(Abrus precatorius,*. Fabaceae family)**
**General features:** It is a long-lived creeping plant. The seeds of this plant are poisonous. The seeds are usually red, white and grey in color.
**Active ingredients:** Abrin, Arabin, Glucoside.
**Parts used:** Root, leaves and seeds.
**Medicinal/Traditional Uses :**Reasons: Stop hair loss/prevent pregnancy/damage poultry and cattle.
**Method of use :**

1) Mixing the seed powder with coconut oil and applying it to the head solves the problem of hair loss.
2) To prevent unwanted pregnancy, the warmed milk-soaked seed husk is orally prescribed with ripe banana.
3) The seeds are poisonous to poultry and cattle. Again, if these seeds are soaked in milk for 12 hours, it is believed that the toxicity of the seeds is destroyed.

**Kumarilata/Ramdatton (*Smilax zeylanica* R. Br., family -Smilacaceae.)**
**General features:** Common name This long-lived creeper is known as the leaves of the tree, which play the role of attraction. It belongs to the
The active ingredient is tannin.
**Parts used :** Root, leaves.
**Medicinal/Traditional Use:** Reason Prevents tooth decay.
**Method of use:**

1) On the Dasahara day of Durga Puja, if this tree is used as a toothpick, it prevents tooth decay.

**Kukurchita\kharajora: (*Litsea glutinosa* Roxb., Lauraceae -family)**
**General features:** This is a medium-sized tree. Its leaves have a pungent smell, and green flowers bloom on it.
**Active Ingredient:** Neurotitannin of the plant.
**Parts used:** leaves, stems, and leaves.
**Medicinal/Traditional Uses:** Used to repel mosquitoes, pain killer
**Method of use:**

1) The powder of the bark of this plant is used to repel mosquitoes.
2) Water soaked leaves are said to be consumed in the morning to reduce the body aches.

3) Plaster of the bark of this tree is given to fix broken bones.

**Gandhabhaduli (*Paederia foetidal,* Rubiaceae family)**
**General features:** It is a long-lived creeper. Its leaves are smelly.
**Active Ingredients:** Odorless volatile vel, alkaloids.
**Parts used :** Root, leaves.
**Medicinal/Traditional Uses:** Used to increase body strength/relieve rheumatic pain
**Method of use:**

1) Raw leaf juice helps to increase body strength.
2) Its leaves are washed in clean water to make juice and regular use relieves the pain of rheumatism.
3) Massaging paver kai is known to relieve arthritis swelling.

**Jele goran: (*Ceriops decandra* Dingo belongs to the family Rhizophoraceae.)**
**General features:** This plant has respiratory roots. Medium height.
**Active ingredients:** 30-40% tannins.
**Used parts:** bark.
**Medicinal/Traditional Uses :**

1. The bark extract is orally prescribed to stop excessive bleeding after delivery
2. The bark paste is externally used to cure skin diseases like herpes, ringworm etc.

**Methods of uses:**

1) A decoction of its bark is used to stop excessive bleeding after childbirth.
2) Applying the decoction of the bark of this plant as a poultice to skin diseases such as ringworm, ringworm etc. will bring benefits within a few days.

**Choto Gimashak (*Mollugo pentaphylla* Linn. belongs to Molluginaceae family)**
**General features:** White flowered herb.
**Active ingredient:** bitter ingredient.
**Parts Used :** Whole plant.
**Medicinal/Traditional Uses:** Used to relieve fever.
**How to use:** The plant is washed well, and the decoction is prepared and prescribed for fever.

**Gneoya (*Excoecaria agallocha,* belongs to Euphorbiaceae family)**
**General features:** The tree is not very large in size. There is grass in the tree.
**Active ingredient:** 10% tannin.
**Parts used:** Bark, leaves, bark.
**Medicinal/Traditional Uses:** Used to cure the wounds of cattle hooves in the treatment of epileptic disease.

**Method of use :**

1) The leaves cure epilepsy.

2) A poultice applied to sores on the shoulders and the hoofs of cattle, and which dries quickly.

**Gullancha (*Tinospora cordifolia* (Willd) Miers ex Hook belonging to the family Menispormaceae)**

**General features:** long-lived vine.

**Active ingredients:** basic ingredients are

**parts used:** The whole plant.

**Medicinal/Traditional Uses:**

1. Stem and bark extract is prescribed for diabetes.
2. Increasing physical strength
3. Prevention of cattle disease.

**How to use:**

1) Overnight soaked bark water is prescribed orally on an empty stomach to cure diabetes.
2) This plant is used to remove physical weakness and increase strength.
3) The juice of this plant and raw turmeric are mixed together and applied to the area to relieve itching.
4) To treat the scabies of cattle, the tree bark (with jaggery) is given to eat and prescribed the bark paste is externally to the affected area. The disease is cured within a short time.

**Golpata (*Nypa fruticans* Wurmb, family- Arecaceae)**

**General features:** leaves look like coconut leaves.

**Active ingredients:** Raw fruit contains 5 percent protein.

**Parts used:** leaves, fruits.

**Medicinal/Traditional Uses:** Treatment of intestinal ulcers/ eye diseases.

**Methods of use:**

1) Burn the young leaves of this plant and apply the ash on the intestinal tract to heal the wound.
2) The juice of this fruit is used for eye diseases.

## Conclusion:

Over the centuries, each medical system has developed and accumulated through experience and has its own perspective. That perspective and herbal research have become more and more necessary in today's globalization day. There is a need to eliminate effective aspects of old medical systems and incorporate modern thinking to develop a comprehensive and robust health system for all. Modern medical science has not really discovered any curative medicine for diseases such as weight loss, immune deficiency, mental fatigue, memory enhancement etc. due to viral diseases. Nowadays, the demand for herbal plants is increasing in Western countries as they are much safer than chemical medicines and have no side effects. And along with that demand, people still have faith in the traditional treatment methods that have been used for generation after generation. The people of a certain region, the people living in the same geographical area, rely on that belief and carry on their livelihood. This mundane

traditional treatment has become their culture. Despite being one of the eight richest countries in the world, our country, India, has faith in this rural folk medicine system. So, the time has come to preserve and properly care for all these trees, shrubs and herbs in the Sundarbans delta.

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Chapter- 7

# A synoptic review on the traditional uses of gastropods and bivalves (Mollusca) as food and medicines in India

**Bulganin Mitra and Joyjit Ghosh***

**Keywords:** Indigenous Traditional Knowledge (ITK), India, tribes, animals, food, medicine.

**Abstract:**

Indigenous Traditional Knowledge (ITK) is deeply ingrained in numerous places worldwide. This knowledge system is essential for their overall well-being, promoting sustainable development, and monitoring their cultural vitality. In India, the literature on ITK, specifically about animals or fauna, is severely lacking and widely dispersed in contrast to the literature on flora. Traditional Knowledge is a multidisciplinary area of study that has attracted the interest of several experts, including zoologists, chemists, taxonomists, and others. This communication aims to compile all scientific works on the utilisation of Mollusca as food and medicine by indigenous communities in India. Present communication reports 38 species (identified & unidentified) under 14 families, 9 orders of 2 classes of molluscan currently used as food and medicines in India.

## Introduction:

The relationship between humans and animals dates back to ancient times, displaying a long-standing history of interaction. Animals played a significant role in anthropogenic culture and religion and served as materials for food and medicine. During the shift from a 'hunter and gatherer' lifestyle to a more structured civilization, some animals played crucial roles in humans' cultural and societal advancement. Throughout history, animals have been revered as sacred beings, embodiments of divine or evil forces, maintained as friends, consumed as food, used for pleasure hunting, or employed as substitutes for human labour.

The emergence of animal husbandry and the utilisation of animals as a food source in India may be traced back to the Indus Valley Civilization, which flourished in the fourth millennium BC. Their primary sustenance consisted of cultivated grains, supplemented by a diverse array

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of protein sources including fish, beef, hog, chicken, and mutton. Throughout history, animals from diverse phylogenetic backgrounds have played significant roles in our culture, religion, and food. The religious and cultural practises have been transmitted from one generation to another and are now integral to the indigenous traditional Knowledge among aboriginal, local, and tribal communities worldwide (Maity et al., 2010, 2013).

Throughout history, plants (Sarkar et al., 2022) and animals (Madhu & Jana, 2014), or their many components, have been utilised, and even in modern times, these resources remain crucial in global food supplies and healthcare. While plant and plant-derived materials have garnered significant scientific attention and are frequently utilised in traditional diets and medicine, it is vital to note that animal-derived products also play a crucial and indispensable role in nutrition.

Molluscs exhibit both ancient origins and a wide range of variation. This animal group constitutes the second most populous category of organisms, following insects, throughout the entirety of the animal kingdom (Mukhopadhyay et al., 2017). They exhibit a remarkable ability to adapt and can be found in all habitats except for those in the air. Originally inhabiting marine environments, these organisms have successfully colonised freshwater habitats and subsequently adapted to terrestrial environments. As a result, they currently exhibit a species diversity that is nearly equivalent to that of their marine counterparts (Ramakrishna & Dey, 2007). The group in the animal kingdom that is most distinctly characterised is the one that possesses at least two unique traits, namely the mantle and radula, which are not present in any other group. Molluscs are soft-bodied organisms with a bilaterally symmetrical and unsegmented body. They have a protective exterior coat called a shell and a broad, muscular fold of the body wall called a mantle (Mukhopadhyay et al., 2017).

This endeavour aims to consolidate nearly all the investigative studies conducted on molluscan species that are utilised by indigenous communities in India for food and medicinal purposes. Additionally, the scientific names of the animals utilised for food and medicinal purposes are verified and kept up to date, along with new classifications, followed by Mukhopadhyay et al. (2017).

## Methodology:

This synoptic review collates and compiles the existing research on some traditionally used molluscs as food and medicines by the indigenous people in India.

## Result:

A total of 38 species (identified & unidentified) are reported belonging to 14 families, 9 orders and 2 class. Out of these, 23 species are reported that are identified up to species level, and the rest are up to generic level.

**Table 1. List of Bivalves & Gastropods used as food & medicines by the indigenous people of India**

| Local Name | Scientific Name | Used by tribes | Used for | Reference |
|---|---|---|---|---|
| **Class Gastropoda** | | | | |
| **Order: Architaenioglossa** | | | | |
| | *Filopaludina bengalensis* Lamarck, 1822 | Tribe of Kosi River (Bihar) | Medicine | Prabhakar and Roy , 2009 |
| | *Filopaludina bengalensis* Lamarck, 1822 | Tribes of Northeast India | Food & medicine | Jadhav et al., 2023 |
| | | Birhors tribe (West Bengal) | Food & medicine | Chanda & Mukherjee, 2012 |
| | *Angulyagra* sp. | Tribes of Northeast India | Food | Jadhav *et al*., 2020 |
| | *Cipangopaludina lecythis* (Benson 1836) | Tribes of Northeast India | Food | Jadhav et al., 2020 |
| | *Bellamya* spp. | Tribes of Singbhum | Medicine | Kumari and Mahata , 2014 |
| | *Bellamya bengalensis* (Lamarck, 1822) | Tribes of Northeast India | Food | Jadav et al., 2020 |
| | *Bellamya bengalensis* (Lamarck, 1822) | Birhors tribe (West Bengal) | Medicine | Chanda & Mukherjee, 2012 |
| **Family: Ampullariidae** | | | | |
| | *Pila globosa* (Swainson, 1822) | Tribes of Palakkad and Malappuram | Food | Padmanavan, 2007 |
| | *Pila globosa* (Swainson, 1822) | Irular, Mudugar and Kurumbar | Medicine | Padmanabhan & Sujana, 2007 |
| | *Pila globosa* (Swainson, 1822) | Naga tribe | Medicine | Jamir and Lal, 2005 |
| Samu ladai | *Pila globosa* (Swainson, 1822) | Mech | Food | Sarkar et al., 2014 |
| | *Pila globosa* (Swainson, 1822) | Tribes of Northeast India | Food | Jadhav et al., 2020, Jadhav et al., 2023 |
| | *Pila* sp. | Karbi tribe (Assam) | Medicine | Hanse and Teron, 2012 |
| | *Pila* sp. | Matya, Kolha, Gond, Munda, Kawar, Kolha, Kharia (Odisha) | Medicine | Azami and Sinha, 2012 |

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|---|---|---|---|---|
| | *Pila* sp. | Tribe of Kosi River (Bihar) | Medicine | Prabhakar & Roy, 2009 |
| | *Pila* sp. | Saharia tribe (Rajasthan) | Medicine | Mahawar and Jaroli, 2007 |
| | *Pila olea* (Reeve, 1856) | Tribes of Northeast India | Food & medicine | Jadhav et al., 2020, Jadhav et al., 2023 |
| | *Pila theobaldi* (Hanley, 1876) | Tribes of Northeast India | Food | Jadhav et al., 2023 |
| | *Pila scutata* (Mousson, 1848) | Tribes of Northeast India | Food | Jadhav et al., 2023 |
| | *Pila virens* Lamarck, 1822 | Tribes of Northeast India | Food | Jadhav et al., 2023 |
| **Family: Pachychilidae** | | | | |
| | *Brotia costula* (Rafinesque, 1833) | Tribes of Northeast India | Food | Jadhav et al., 2020 |
| **Family: Lymnaeidae** | | | | |
| | *Paludomus crassa* (Busch, 1842) | Adi (Arunachal Pradesh) | Food | Jadhav et al., 2023 |
| Ghonga | *Paludomus conica* (Gray, 1833) | Adi (Arunachal Pradesh) | Medicine | Chinlampianga et al., 2013 |
| | *Paludomus sp.* | Tribes of North east India | Food | Jadhav *et al*., 2020 |
| Water snail | *Lymnaea* sp. | Tribe of Bhadrak | Medicine | Panda et al., 2013 |
| | *Lymnaea* sp. | Biate Tribe (Assam) | Medicine | Betlu, 2013 |
| Water snail | *Lymnaea* sp. | Zomi-Paite tribes (Mizoram) | Medicine | Chinlampianga et al., 2013 |
| | *Lymneaea acuminata* Lamarck, 1822 | Tribe of Theni (Tamilnadu) | Medicine | Chellappandian et al., 2014 |
| JinaiKhong | *Lymneaea acuminata* Lamarck, 1822 | Mech tribe (West Bengal) | Medicine | Sarkar et al., 2014 |
| | | | | |
| **Order: Stylommatophora** | | | | |
| **Family**: **Ariophantidae** | | | | |
| Khonjelekuwa | *Cryptozona bistrialis* (Beck, 1837) | Gibbon Wildlife Sanctuary, Assam | Medicine | Borah & Prasad, 2017 |
| | *Cryptozona sp.* | Biate tribes ( Assam) | Medicine | Betlu, 2113 |
| **Family: Helicidae** | | | | |
| Mollusks | *Helix aspersa* (Müller, 1774) | Mech tribe (West Bengal) | Food & medicine | Sarkar et al., 2014 |

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|---|---|---|---|---|
| Chupi | *Helix pomatia* Linnaeus, 1758 | Karbi tribe (Assam) | Food & medicine | Hanse and Teron, 2012 |
| **Family: Achatinellidae** | | | | |
| Kapkong | *Pulmonata* spp. | Tangsa tribe (Arunachal Pradesh) | Medicine | Jugli et al., 2019 |
| **Class Bivalvia** | | | | |
| **Order Unionoida** | | | | |
| **Family Unionidae** | | | | |
| | *Lamellidens* sp. | Tribe of Kosi River | Medicine | Prabhakar and Roy, 2009 |
| | *Lamellidens marginalis* (Lamarck, 1819) | Tribes of Northeast India | Food & medicine | Jadhav et al., 2020 |
| | *Lamellidens corrianus* (Lea). | Tribes of Singbhum | Medicine | Kumari and Mahata, 2014 |
| | *Anodonta anatine* Linnaeus, 1758 | Tribes of Northeast India | Food | Jadhav *et al*., 2023 |
| **Order: Ostreoida** | | | | |
| **Family: Ostreidae** | | | | |
| Gugli | *Crassostrea madrasensis* (Preston, 1916) | Birhors tribe (West Bengal) | Food | Chanda & Mukherjee, 2012 |
| **Order: Mytiloida** | | | | |
| **Family: Mytilidae** | | | | |
| Jhinuk | *Perna viridis* Linnaeus, 1758 | Birhors tribe (West Bengal) | Medicine | Chanda & Mukherjee, 2012 |
| | | Birhors tribe (West Bengal) | Food | Chaudhury et al, 2016 |
| | | | | |
| | *Unio* sp. | Munda, Gond, Matya, Bhuiza (Odisha) | Medicine | Azami and Sinha , 2012 |
| | *Unio* sp. | Tribe of Kosi River | Medicine | Prabhakar and Roy, 2009 |
| **Family: Viviparidae** | | | | |
| | *Cipangopaludina lecythis* (Benson, 1836) | Tribes of Northeast India | Food | Jadhav et al., 2020 |

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|---|---|---|---|---|
| **Order: Veneroida** | | | | |
| **Family: Mactridae** | | | | |
| Seepi | *Mactra* sp. | Bawaria, Mogya & Meena (Rajasthan) | Medicine | Mahawar and Jaroli, 2006 |
| Seepi | *Mactra* sp. | Saharia tribe (Rajasthan) | | Mahawar and Jaroli, 2007 |
| **Order: Unionida** | | | | |
| **Family**: **Unionidae** | | | | |
| Ghonga | *Parreysia* (*Parreysia*) *sikkimensis* Lea, 1859 | Adi tribe (Arunachal Pradesh), Zomi-Paite tribes (Mizoram) | Medicine | Chinlampianga et al., 2013 |
| | *Parreysia sp.* | Tribes of Kosi River (Bihar) | Medicine | Prabhakar & Roy, 2009 |
| **Order: Littorinimorpha** | | | | |
| **Family: Cypraeidae** | | | | |
| Shankh | *Cypraea sp./Angulus sp.* | Tribes of Rajsthan | Medicine | Jain et al., 2007 |
| Cowrie | *Cypraea spp.* | Tribes of Madhya Pradesh, Jharkhand, Odisha | Medicine | Joseph, 1988 |

## Discussion:

The utilisation of animals for sustenance and medical applications is an essential component of traditional knowledge systems worldwide, particularly in India. This practise is becoming pertinent to discussions on animal relationships and phylogeny, conservation biology, bioprospecting, and patenting. India's abundant biodiversity and the country's wealth of traditional Knowledge, particularly in the field of medicine, contribute to its richness. However, it is crucial to safeguard and encourage the preservation of this information. India has faced numerous challenges in preserving its traditional wisdom.

According to reports, almost 50% of the world's contemporary medications and most food resources are derived from animals. India possesses a wealth of traditional Knowledge, encompassing areas such as food inventory and medicinal practises. Our ancient books extensively detailed the consumption of food and beverages obtained from living organisms and the wide range of medicinal and therapeutic uses of plants and animals. Indigenous people have made use of a wide range of faunal resources, spanning from earthworms to higher animals and from broad to very particular applications.

Hence, it is imperative to investigate and record this ancient traditional Knowledge as fundamental information for future generations. Given the aforementioned, it is necessary to extensively document molluscan species and further study their culinary and medicinal applications in India. Furthermore, further research in this domain may yield other gastropods or bivalves that can potentially serve as food and pharmaceutical resources in India in the future.

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Chapter- 8

# Beauty with Boon- Dendrobium spp.

**Dr. Sujata Roy Moulik**

**Keywords:**Boon- *Dendrobium*,Orchids, Orchidaceae, Herbs.

**Abstract:**

Orchids are well known for their aesthetic qualities and are often used as decorative items in homes, offices, and public places. They are admired for their good looks and practical uses of them. *Dendrobium* is the second-largest genus in the family Orchidaceae. It exhibits a vast diversity in vegetative and floral characteristics and is of considerable interest due to its broad geographic distribution and the high value of hybrids as a floricultural commodity. In China, the "immortality herb" or "gold in medicine" or the No. 1 of the 9 "Chinese immortality herbs"- all refer to *Dendrobium*. Besides innumerable health benefits and medicinal properties, Dendrobium has been used for cosmetics and fragrance products. Here, some of the aspects of the multifarious *Dendrobium* are discussed.

## Introduction:

The medicinal orchids belong mainly to the genera namely *Calanthe, Coelogyne, Cymbidium, Cypipedium, Dendrobium, Ephemerantha, Eria, Galeola, Gastrodia, Gymnadenia, Habenaria, Ludisia, Luisia, Nevilia, Orchis, Thunia, Vanda* and *Vanilla*. In the Ayurvedic system of medicine, there is one rejuvenating herbal formulation, 'Astavarga' that is prepared from orchid species i.e., Jivak (*Microstylis wallichii*), Rishbhaka (*Malaxismuscifera),* Riddhi (*Habenaria intermedia*) and Vriddhi (*H. edgeworthii*) are orchids. Orchids are enriched with phytochemicals such as stilbenoids, anthraquinones, pyrenes, coumarins, flavonoids, anthocyanins and anthocyanidins, chroman derivatives, lignans, simple benzenoid compounds, terpenoids, steroids, alkamines, amino acids, mono- and dipeptides, Alkaloids and higher fatty acids which play a vital role for immunity development and curing other critical diseases of individuals.

The most prominent medicinal plants (Sarkar et al., 2022;Ghosh et al., 2022; Kar et al., 2022; Darro & Khan, 2023) and orchids used in traditional Chinese medicines are various *Dendrobium* spp used to make the drug Shihu [particularly *D. catenatum* Lindl., *D. loddigesii* Rolfe, *D. moniliforme* (L.) Sw. and *D. nobile* Lindl.)] (Teoh 2016; Leon and Lin, 2016). Fresh or dried stems, blossoms and canes are eaten. *Dendrobium* is a type of orchid that is generally yellow, white or pink in color. The plant has a long, thin stem that is used for various herbal

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and medicinal treatments. The Chinese believe that the tonic extracted from the *Dendrobium* plant is 'yin' in nature and can be used to treat ailments ranging from stomach pain, heatstroke, dry mouth and sores in the mouth. *Dendrobium* is considered a safe herb when consumed in the recommended dosages. Too much of Dendrobium in any form can cause convulsions and may even affect the heart and lungs. Research is still being conducted on the interactions of *Dendrobium* with other drugs or medications.

## *Dendrobium* – Multidimensional Uses:

### As Food:

In US, *Dendrobium* is famous as a food orchid. In Japan and Singapore, mature canes of many soft-cane *Dendrobium* are used for making sauces. Besides these, many preparations and food decorations are done using *Dendrobium* (Singh et al., 2016).

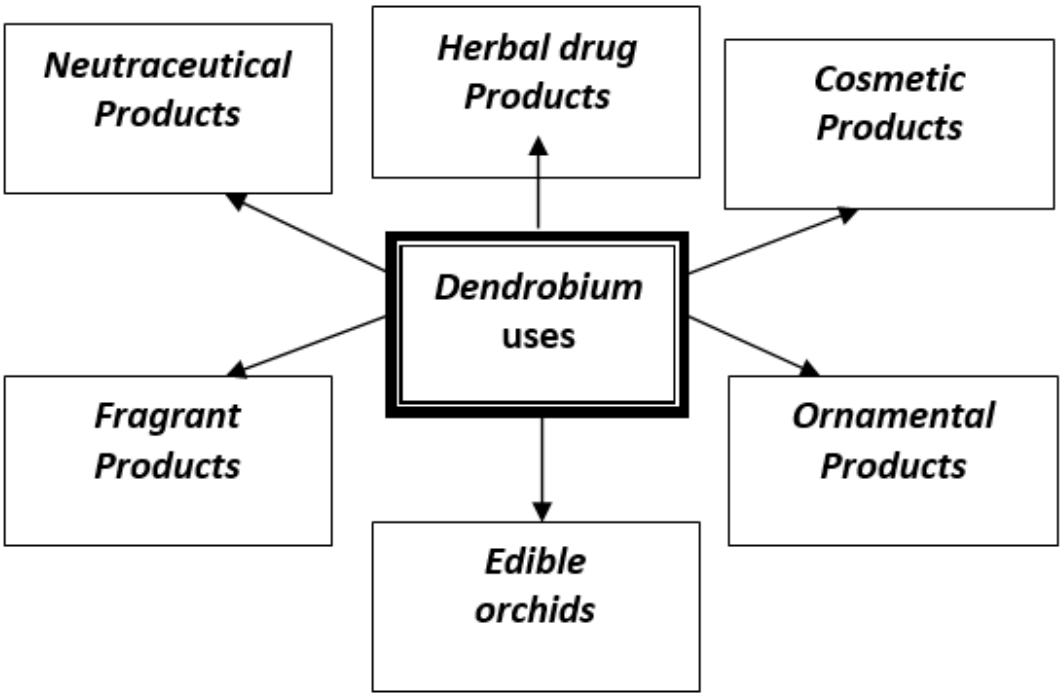


**Figure 1. *Dendrobium* uses**

**Table 1. *Dendrobium*spp used as food**

| Name and part | Country | Uses |
|---|---|---|
| *D. kingianum* pseudo-stem | Australia | Food |
| *Dendrobium* flowers | Thailand | Deep fry |
| *D. longicornu* flowers | Nepal | pickle |
| *Dendrobium* | Hawaii | salad |
| *D. salaccense* fragrant leaves | Malaysia | Condiment for rice |
| *D. cathenatum* canes | China | Healing tea |

## As Cosmetics and Fragrance ingredients:

The mucilaginous content of orchids makes them ideal for moisturizing and emollient agents due to the many links formed by hydrogen bonding, which maintains optimum water balance in the dermal tissues. These orchids are used to fight free radicals, increase skin immunity, and reduce aging. Orchid flowers are widely valued for their ornamental and fragrant properties and are used for decorations. Fragrance of the orchid flowers is due to aromatic volatile oils in floral parts. The release of fragrance is diurnal in nature. Aromatic oils from orchids are extracted by hydro- and steam-distillation, Maceration and Supercritical fluid extraction & Headspace technology (Kanlayavattanakul and Lourith, 2022).

**Table 2. *Dendrobium* spp. used as cosmetics and fragrances**

| Name | Part used | Type of Product |
|---|---|---|
| *Dendrobium moniliforme, D. amoneum, D. bellatum, D. candidum, D. cariniferum, D. chrysotoxum, D. cretaceum, D. crystallinum, D. densiflorum, D. falconeri, D. gibsonii, D. hookerianum, D. nobile, D. williamsoni, D. fimbriatum, D. transparens* | Flowers, seeds, leaves and root | Perfume, Essential oils |
| *D. phalaenopsis* | Flower extract | Skin conditioning agents in cosmetic products |
| *D. chrystotoxum* | Stem extract | Anti-aging component in lip and eye cream |
| *D. nobile* | Whole plant extract | Skin Conditioning Component in Toner |

## As Neutraceuticals and Herbal Drugs:

The term “Neutraceutical” was coined by Stephen L. De Felice (1995) by combining two words- Nutrition and pharmaceutical. A Neutraceutical is any substance that may be food or part of a food and it provides medical or health benefits, disease-prevention or treatment. These include any dietary supplements, herbal products, isolated nutrients, and processed food (Prasad and Achari, 1996). The root of the concept is deeply connected to the Indian system of medicine, ‘Ayurveda’. Some components called ‘AajasrikRasayana’ in Ayurveda tell about the food products that can be consumed daily to improve health quality and help prevent stress and diseases.

One such preparation is Shi-hu, which is an ancient Chinese medicine derived from *Dendrobium*. The most widely used one is D. nobile for treating kidney and lung diseases, stomach disease, red tongue, dry mouth, swelling, hyperglycemia, atrophic gastritis, diabetes etc. (Bulpitt et al., 2007). Besides, it is also used for longevity, as an antipyretic, as an aphrodisiac, for treatment of weakness due to thirst, impotence, leucorrhea, entropion, menstrual pain, as an anti-cancer agent (Miyazawa et al., 1997).

Stem extracts from *D. chrysotoxum* are used in herbal supplements for cataracts, conjunctivitis, glaucoma, and hypertension. Also, these extracts are used in products to resolve phlegm and alleviate cough, ling heat, dryness and chronic cough.

## As source of Phytochemicals:

Orchids are reported to produce phytochemicals, including alkaloids, flavonoids, carotenoids, anthocyanins and sterols. Alkaloids and flavonoids are most important for their biological roles. The first alkaloid to be isolated from orchids was dendrobinefrom Dendrobium nobile (Bose et al., 2017). The leading genus for phytochemical production is Dendrobium (Zhang et al., 2007). Secondary metabolites and phytochemicals are known to be used in various medicines (Singh et al., 2016; De, 2022).

**Table 3. Medicinal uses of some *Dendrobium* spp.**

| Name | Component | Used for |
|---|---|---|
| *Dendrobium amoneum* | Isoamoenylin | Antioxidative & antibacterial activity |
| *D. densiflorum* | Homoeriodictyol | Anti-platelet aggregation activity |
| *D. chrysotoxum* | Erianin, Dendrochrysanene | Antiangiogenic activity, Anti-inflammatory activity |
| *D. nobile* | Dendrobine, Dendrosides, Nobilin | Immunomodulator and antioxidative activity |
| *D. moniliforme* | Dendromonilisides, Alkyl ferulates, Dendrobine | Stimulation of proliferation B cells and inhibition of T cell proliferation, Antioxidative activity, Antipyretic activity |
| *D. loddigesii* | Shihudine, Shihunine, Moscatilin | Inhibits $Na^+$-$K^+$ ATPase activity in rat kidney, Anti-cancer agent |

## As Ornamental plants:

*Dendrobium* makes ideal houseplants. Along with their pretty colors and decorative qualities, growing *Dendrobium* at home can eradicate pollutants and toxins from the air and create a clean environment (Ramesh et al., 2019).

***D. nobile*** ***D. Chrysotoxum*** ***D.densiflorum*** ***D. candidum***

**Figure 2. Photographs of some *Dendrobium* spp. (Reproduced from the internet)**

## Conclusions:

Apart from its beauty, *Dendrobium*spp are full of medicinal and other qualities that benefit human society. Economic contribution of these *Dendrobium*spp is also very high. These orchids are generally inhabitants of high altitudes. Proper knowledge of their habit, habitat, and applicability can be useful for their cultivation and conservation.

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Chapter- 9

# Green Pharmacy: Unveiling the Healing Potential of Medicinal Plants

**Rupa Sanyal**

**Keywords:** Medicinal Plant, Ethno-botanical significance Active Compound, Disease treatment, Conservation.

**Abstract:**

In the heart of dense, lush jungles where sunlight filters through the emerald canopy, a profound connection between humans and nature unfolds like a sacred dance. Herbal medicines can contribute to creating a new era in healthcare by standardizing and assessing the health of chemical substances originating from plants, which can be used to treat human ailments in the future. Within the tribe, nature is not merely a backdrop but an esteemed teacher. Through generations, indigenous communities have cultivated an intimate knowledge of the flora and fauna around them, learning from the jungle's wisdom. Most of the naturally occurring sources whose active chemicals are used today have an ethnomedical application. As a result, many pharmaceutical companies have recently updated their approaches to natural product research to find new compounds and possible sources for medication development. Thus, the purpose of this review is to explain the practice of treating a variety of diseases with medicinal plants and knowledge of the Conservation of these nature-gifted pharmacies.

## Introduction:

Since the beginning of human civilisation, medicinal herbs have been recognised as providers of life-saving medications. Throughout countless centuries and numerous generations of humans, the usage of medical substances has been passed down. Plant research benefits greatly from using ethno-botany and indigenous medicines (Banerjee et al., 2014; Bhattacharjee, 2021; Acharya et al., 2021, 2022, 2023; Mandal, 2022; Basu et al., 2022; Surendran et al., 2023). Tribal communities across the globe have, for centuries, relied on the biodiversity of their surroundings to address a myriad of health concerns (Bose, 2018; Bhowmik et al., 2022; Das et al., 2022; Darro & Khan, 2023; De & Sharma, 2023). This research seeks to explore and document the traditional knowledge surrounding medicinal plants within select tribal groups, emphasizing the holistic nature of their healing practices and the sustainable use of natural resources.

All facets of an individual's health, including clinical and non-clinical practices that reflect their particular needs, are called "ethnomedicine" (Madhu & Sarkar, 2015; Maiti et al., 2010, 2013; Erfani, 2021; Ghosh et al., 2022; Das & Sarkar et al., 2023; De et al., 2023; Dhakar & Tare, 2023). The adverse effects of synthetic and contemporary medicine have led to

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considerable growth in the use of medicinal plants in recent decades. In addition, the high expense of contemporary medicine has prompted impoverished nations to turn to traditional herbal therapy, which is less expensive, more effective, and safer (Sanyal, 2022; Saha et al., 2022; Kar et al., 2022; Tamang et al., 2023; Jyotirmayee et al., 2023).

## Medicinal Uses:

Tribes often possess traditional knowledge of medicinal plants, using them to treat various ailments and injuries. Knowledge is typically passed down orally through generations, and specific individuals within the community may be designated as healers or herbalists. Tribes rely on local plants for their dietary needs, including fruits, vegetables, nuts, seeds, and roots. Traditional agricultural practices, such as shifting cultivation, showcase an intimate understanding of local ecosystems and plant life (Pyne & Santra, 2017; Raha et al., 2022).

*Aloe vera* has been used to treat wounds for over 5000 years by the Egyptians, Romans, and native populations of Africa, Asia, and the Americas. It is still the first choice for treating burns, ulcers, and surgical wounds. Numerous naturally occurring bioactive substances, such as simple and complex water-soluble polysaccharides, pyrocatechol, saponins, acemannan, anthraquinones, glycosides, oleic acid, and phytol, are found in aloe vera. *Aloe vera* leaf acetone extracts had greater antibacterial properties than alcohol and aqueous extracts (Shedoeva et al., 2019; Sarkar et al., 2016; Sarlar et al., 2017; Sarkarkar et al., 2021; 2022).

*Ampelopsis japonica* has been shown to contain various pharmacological properties, such as antibacterial, neuroprotective, and anticancer properties. In China, India, and other Southeast Asian nations, *Aandrographis paniculata*, popularly known as green chiretta, is used as a traditional remedy for fever, snake bites, diarrhoea, infections, wounds, and itching by the tribal communities (Chen et al., 2014; Pal et al., 2022; Pimple et al., 2023). In TCM prescriptions, dried *Angelica sinensis* root is frequently used to treat feminine ailments, inflammation, headaches, moderate anaemia, exhaustion, and hypertension. In human skin fibroblasts, extracts from *Angelica sinensis* have been demonstrated to increase cell proliferation, collagen secretion, and cell motility while also activating an antiapoptotic mechanism (Hsiao et al., 2012). *Calendula officinalis*, popularly referred to as pot marigold, is a relatively common herb that is used to treat a wide range of skin ailments, including burns, wounds, and dermatitis. *Calendula officinalis* is said to possess various pharmacological properties, such as anti-inflammatory, antioxidant, antibacterial, antiviral, antifungal, and anticancer properties. The tribal people frequently utilised Asia hold great regard for green tea, an aqueous extract derived from *Camellia sinensis* leaves, due to its purported health advantages. Experimental validation of *Camellia sinensis's* antioxidant, anti-inflammatory, antibacterial, anticarcinogenic, anti-ageing, anti-obesity, cardioprotective, and neuroprotective properties has confirmed centuries of anecdotal data (Shedoeva et al., 2019). In many nations, safflower, or *Carthamus tinctorius*, seeds are a common source of cooking oil. Numerous biological activities, such as vasodilation, immune modulation, anticoagulation and thromboprophylaxis, antioxidation, antihypoxic, antiaging, antifatigue, anti-inflammation, antihepatic fibrosis, anticancer, and analgesia, have

been linked to it by recent experiments according to Yao et al. (2016). In bronchitis, asthma, and whooping cough cases, children are given a mixture of young leaf juice of *Nyctanthes arbor-tristis* L., honey, and warmed cow milk twice a day for two weeks. Young branches and leaves are used to treat gastrointestinal disorders (Debbarma et al., 2017). Indian tribal people have a long history of using medicinal plants to treat a variety of medical conditions. Many times, their traditional understanding of medicinal plants is the result of centuries of observation and research.

## Some Harbal Plants Profiles:

### Neem (*Azadirachta indica*): (Sakib et al., 2023)

**Traditional Uses:** Used for treating skin infections, wounds, boils, and as a general antiseptic.
**Active Compounds:** Nimbin, nimbidin, azadirachtin.
**Modern Research:** Antimicrobial, anti-inflammatory, and antifungal properties; potential applications in skin care and wound healing.

*Azadirachta indica* (Creative Commons Attribution-Share Alike 2.0)

### Tulsi (*Ocimum sanctum*): (Rao et al., 2023)

**Traditional Uses:** Used for respiratory infections, fever, and as a general health tonic.
**Active Compounds:** Eugenol, ursolic acid, rosmarinic acid.
**Modern Research:** Antioxidant, anti-inflammatory, and antimicrobial properties; potential use in respiratory and cardiovascular health.

***Ocimum sanctum*** (Creative Commons Attribution-Share Alike 3.0)

### Turmeric (*Curcuma longa*): (Iweala et al., 2023)

**Traditional Uses:** Applied topically for wound healing; used internally for anti-inflammatory purposes.

**Active Compounds:** Curcumin.

**Modern Research:** Anti-inflammatory, antioxidant, and anticancer properties; studied for its potential in treating various chronic diseases.

***Curcuma longa*** (Creative Commons Attribution-Share Alike4.0)

### Ashwagandha (*Withania somnifera*): (Kumar & Kumar, 2019)

**Traditional Uses:** Used for pain management and as an adaptogen to manage stress.

**Active Compounds:** Withanolides.

**Modern Research:** Adaptogenic and anti-stress properties; studied for its potential in managing anxiety and depression and improving overall well-being.

*Withania somnifera* (Creative Commons Attribution-Share Alike 4.0)

### Giloy (*Tinospora cordifolia*): (Devi, 2020)

**Traditional Uses:** Used as an antipyretic for reducing fever and for its immunomodulatory effects.

**Active Compounds:** Tinosporin, berberine, palmarin.

**Modern Research:** Immunomodulatory and anti-inflammatory properties; potential use in boosting the immune system.

*Tinospora cordifolia* (Creative Commons Attribution-Share Alike 4.0)

### Aloe Vera (*Aloe barbadensis*): (Tiwari & Upadhaya, 2018)

**Traditional Uses:** Used for constipation, stomach ulcers, and indigestion.

**Active Compounds:** Polysaccharides, anthraquinones.

**Modern Research:** Wound healing, anti-inflammatory, and potential applications in skin care and gastrointestinal health.

***Aloe barbadensis*** (Creative Commons Attribution-Share Alike4.0)

### Cinchona (*Cinchona officinalis*): (Aslam et al., 2023)

**Traditional Uses:** Used for the treatment of malaria.

**Active Compounds:** Quinine.

**Modern Research:** Antimalarial properties; historically used in developing antimalarial drugs.

***Cinchona officinalis*** (Creative Commons Attribution-Share Alike 3.0)

### Shatavari (*Asparagus racemosus*): (Bharati & Kumar, 2019)

**Traditional Uses:** Used for women's health, including menstrual problems and postpartum recovery.

**Active Compounds:** Saponins, alkaloids.

**Modern Research:** Potential benefits for women's reproductive health, including hormonal balance and lactation support.

***Asparagus racemosus*** (Creative Commons Attribution-Share Alike 4.0)

### Conservation technique:

Over 50,000 plant species are utilised in pharmaceuticals and other health products, accounting for more than 10 percent of all plant species. However, there are differences in the global distribution of therapeutic plants. Due to misuse for trade and treatment, some plant families contain a higher percentage of threatened species than others and have a higher number of therapeutic plants (Chen et al., 2016). Extinct (EX), extinct in the wild (EW), critically endangered (CR), endangered (EN), vulnerable (VU), near threatened (NT), least concern (LC), and data deficient (DD) are some of the threat categories that each species is assigned according to the IUCN categorisation. Now, the status of these valuable plants is going towards extinction day by day. Some strategies for addressing the issue of eradication in order to preserve the gifted plants include raising knowledge in rural communities about cultivation, harvesting, grading, packaging, and marketing and implementing capacity-building programmes that involve on-site training (Gowthami et al., 2021). Another type of conservation is In-situ and Ex-situ conservation, which are mostly used. In-situ conservation is the method where plants are cultivated and preserved in their natural habitat. Ex-situ conservation, such as seed banks, gene banks, and cryopreservation, is mostly used. The genes, seeds, and fruits are

preserved in the artificial environment (Zegeye, 2017). Numerous species, like the California condor (*Gymnogyps californianus*), Arabian oryx (*Oryx leucoryx*), whooping crane (*Grus americana*), and black-footed ferret (*Mustela nigripes*), to mention a few, have benefited greatly from ex-situ programmes. Largely, the species that need cryopreservation for long-term preservation are those that are short-lived at the standard seed banking temperature of -20°C but can withstand significant desiccation [Pence et al., 2020]. Hoffman et al. (2010) discovered that captive breeding was a significant contributing factor to improved conservation status for 16 of the 68 vertebrate species that showed improvement in status across the time period studied. Numerous ex-situ initiatives, such as captive breeding and release plans, initiative launches, and focused research, can prevent extinction and assist in bringing populations or species closer to sustainability and recovery (McGowan et al., 2017).

## Conclusion:

It has been widely accepted to believe that plants can heal since ancient times. People have utilised herbs as a traditional kind of medicine. It has been demonstrated that natural products made from medicinal plants are an abundant source of physiologically active compounds, many of which have served as the foundation for creating novel pharmaceutical compounds. Most developing nations' healthcare systems heavily rely on traditional medicine and medicinal plants. Most medicinal plants used in traditional medicine are gathered from the wild. For the benefit of human and animal health, we must promote and undertake the conservation, management, and sustainable use of medicinal plants.

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Chapter- 10

# Quercetin: A Promising Bioflavonoid for Health and Healing

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**Keywords:** Quercetin, Bioactive molecule, Therapeutic potential, Herbal drug.

**Abstract:**

Quercetin, a vital natural polyphenolic flavonoid, has diverse pharmacological activities and therapeutic potential. Flavonoids have emerged as a fundamental component in various cosmetic, pharmaceutical, and medicinal formulations. Quercetin is widely recognized for its numerous health benefits, encompassing antioxidant, anti-inflammatory, antiviral, and anticancer properties and due to its wide spectrum of health-promoting effects, quercetin has attracted much attention from dietitians and medicinal chemists. Despite its promising benefits, quercetin faces challenges such as poor solubility, limited water solubility, chemical instability, and low oral bioavailability significantly restrict its potential applications. Strategies such as formulation optimization and nanoparticle-based delivery systems are being explored to enhance its pharmacokinetic profile. Understanding the pharmacology, biochemistry, and pharmacokinetics of quercetin is crucial for optimizing its therapeutic potential and designing precise drug for clinical use. Further scientific research is necessary to elucidate its mechanisms and enhance clinical utilization.

## Introduction:

Since ancient times, plants have played a crucial role in the treatment of infectious diseases. In recent years, the popularity of natural products has surged both in developing and developed nations, leading to the widespread availability of herbal medicines not only in drug stores but also in supermarkets and food stores. Additionally, extensive research has explored the biological and pharmacological activities of various phytoconstituents and chemical compounds extracted from medicinal herbs (Sarkar et al., 2016; Bansal and Priyadarsini, 2021; Das et al., 2022; Pawar et al., 2023). Through isolating and characterizing these phytochemicals, the scientists aim to explain their mechanisms of action, pharmaco-kinetics and possible applications in the treatment of different diseases (Acharya et al., 2022a; 2022b; Ghosh et al., 2022). The activities thus not only enrich our knowledge of traditional herbal remedies but also, at the same time, create a way in which the development of new pharmaceuticals with better efficacy and fewer side effects will take place, thus bridging the gap between traditional wisdom and modern medicine (Maiti et al., 2010, 2013; Banerjee et al.,

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2014; Sarkar et al., 2021). Among these compounds, Quercetin (Qct), a polyphenolic flavonoid, has garnered significant attention due to its diverse pharmacological activities, which include antioxidant, antiviral, immune-modulatory, and anticancer properties, coupled with a low toxicity profile. Chemically composed of three benzene rings and five hydroxyl groups, Qct (3,5,7,3',4'-pentahydroxyflavone) is the principal polyphenolic flavonoid found in a variety of vegetables and fruits, such as berries, lovage, capers, cilantro, dill, apples, and onions, as well as in flowers, bark, stems, and roots, and even in wine (Aghababaei et al., 2023). This book chapter aims to explore the pharmacological effects of Qct, its clinical applications, and important safety considerations

## Structure, bioavailability, dose, metabolism and excretion of Qct

### Structure

Qct, presents a yellow hue and demonstrates high solubility in lipids and alcohol. However, it exhibits limited solubility in cold water and remains insoluble in hot water. The name "Quercetin" finds its roots in the Latin term "Quercetum," which denotes Oak Forest. Belonging to the flavonol category, Quercetin is not naturally produced within the human body. According to the International Union of Pure and Applied Chemistry (IUPAC) nomenclature, Quercetin is designated as 2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one, with a chemical formula represented by $C_{15}H_{10}O_7$. Quercetin, categorized as a flavonol flavonoid, exhibits a molecular structure typical of polyphenolic compounds. With its chemical composition of $C_{15}H_{10}O_7$, it comprises two benzene rings (A and B) connected to a heterocyclic pyrene (C). A notable feature of Quercetin is the presence of five hydroxyl groups (OH) situated at positions 3, 5, 7, 3', and 4'. These hydroxyl groups exert a significant influence on the biological activities of the compound and contribute to the potential diversity of derivative compounds that can be synthesized from it.

Qct exhibits a wide range of pharmacological activities, including anticancer, antiviral, anti-allergic, metabolic, and anti-inflammatory effects. It also shows promise in treating eye and cardiovascular diseases, as well as arthritis. Additionally, Qct has demonstrated potential as a cancer-preventive agent and possesses psychostimulant properties. It notably inhibits platelet aggregation, reduces capillary permeability, mitigates lipid peroxidation, and enhances mitochondrial biogenesis.

### Bioavailability

Bioavailability refers to the proportion of a chemical that effectively reaches its intended site of action. Qct is initially consumed in the form of glycosides, with glycosyl groups being liberated during mastication, digestion, and absorption. Subsequently, Qct glycosides undergo conversion into aglycone within the intestine, facilitated by the action of β-glycosidase enzymes, before being absorbed into enterocytes. However, various factors such as poor water solubility, extensive hepatic and intestinal epithelial metabolism leading to the formation of

metabolites with reduced biological activity, and interactions with the intestinal microbiota can significantly impact the absorption and metabolism of Qct (Degroote et al., 2019).

Given its lipophilic nature, Qct can traverse intestinal membranes via simple diffusion. It is generally presumed that absorption is more efficient in its aglycone form compared to its glycosidic counterparts, which may reach the intestines without degradation (Nemeth et al., 2007). Studies involving patients with ileostomies have indicated a higher absorption rate of Qct glycosides from onions compared to the pure aglycone form (Hollman et al., 1995). Furthermore, research aimed at identifying food sources that optimize Qct absorption has demonstrated that Qct present in onions exhibits superior absorption compared to that in tea (De Vries et al., 1998).

On the contrary, Scholz and Williamson have documented significant levels of aglycone in ileostomy fluid samples obtained from patients who had consumed meals containing onions. Interestingly, they noted a high concentration of Qct glycosides alongside a minor presence of Qct aglycone, with the absence of Qct glycosides in the fluid. One plausible explanation is the enzymatic hydrolysis of Qct glycosides, facilitated by β-glycosidase enzymes, leading to the formation of aglycone. These enzymes are predominantly located in the small intestine, where they catalyze this conversion, after which most of them are absorbed.

## Daily recommended dose of Qct

It has been estimated that daily Qct intake typically falls within the range of 5 to 100 mg, primarily based on fruit and vegetable consumption. However, heavy consumption of Qct-rich foods can elevate daily intake to as high as 500 mg (Harwood et al., 2007; Bischoff et al., 2008; Russo et al., 2012). Studies have revealed that the effectiveness of the dose increases notably when Qct is consumed alongside a fatty meal or in conjunction with apple pectin, oligosaccharides, and lecithin (Harwood et al., 2007; Russo et al., 2012). In clinical settings, Qct is commonly administered at doses ranging from 500 to 1000 mg per day, divided into multiple doses (Lee et al., 2012; Edwards et al., 2007). Research shows that when Qct is taken as a dietary supplement, there is a significant increase in serum levels, although the extent of this increase varies greatly among individuals (Kressler et al., 2011).

## Metabolism and excretion of Qct

Immediately after absorption, Qct is transported to the liver, where it undergoes metabolism and the derived metabolites subsequently enter the bloodstream for distribution throughout the body's tissues (Hollman, 2004). Mullen et al. (2006) identified the primary metabolites of Qct in plasma as Qct-3-O-sulfate, Qct-3-O-glucuronide, and Qct-3-O-sulfate, while Qct-3-O-glucuronide, Qct diglucuronide, isorhamnetin-O-glucuronide-sulfate, isorhamnetin-methyl-Qct, and diglucuronideisorhamnetin-glucuronide were detected in urine samples from healthy individuals following onion ingestion.

The short half-life and rapid clearance of Qct metabolites from the bloodstream result in their rapid detection in plasma within just 30 minutes of ingestion, with substantial excretion

occurring over a 24-hour period (Moon et al., 2008). Moon et al. (2000) also indicated the aggregation of Qct conjugates in human plasma following repeated consumption of Qct-rich foods.

## Biological activities of Qct

### Neuroprotective effect:

Qct increases toxicity-induced neuronal cell damage and stabilizes intracellular calcium concentration. It has been found that an unnecessary increase in intracellular calcium causes neuronal cell death, which in turn leads to ischemic stroke. It is demonstrated that the calcium-binding protein is modulated to reduce calcium excess in Qct's neuroprotective activity against cerebral ischemia (Park et al., 2020). It has been reported that a number of metabolic syndromes linked to prenatal and early postnatal stress are diminished with treatment by Qct and kaempferol. Qct and kaempferol modulate leptin and ghrelin levels along with antioxidant pathways to prevent alterations in metabolism and brain functioning brought on by prenatal and early postnatal dietary shortages (Anachuna et al., 2020). Oxidative stress, mitochondrial dysfunction, neuroinflammation, and apoptosis associated with neurodegenerative diseases (Alzheimer's, Parkinson's, Huntington's diseases) have been shown to be affected by Qct. Studies conducted on rat models with intracerebral hemorrhage, transgenic mouse models of Alzheimer's Disease (AD), and streptozotocin-induced diabetic rat models have found that Qct improves neurological abnormalities. Qct has been advertised as having the ability to reduce oxidative stress and neurotoxicity when administered in vivo along with a variety of metals, pesticides, and neurotoxins. It is also proven that Qct exposure alone has negative effects on fish (*Channa punctata*), although it has protective effects on fish with oxidative stress (Wu et al., 2021)

### Cardioprotective effect:

Studies indicate that hypoxic environments are responsible for oxidative stress, leading to the loss of heart function as cardiomyocytes undergo apoptosis. An effective preventive or therapeutic approach for CVD is to halt the progression of apoptosis due to the critical role that cardiomyocyte loss plays in morbidity and death (Guo et al., 2019). Qct has been found to be a wonderful potential cardioprotective agent. Its antioxidative and antiplatelet properties significantly impact muscle function. These properties include inhibiting smooth muscle cell migration and proliferation, improving mitochondrial function of cardiac cells, and inhibiting nuclear factor-kappa light chain-enhancer of activated B cells (NF-B) (64). Qct is believed to regulate blood pressure by affecting the renin-angiotensin-aldosterone system (RAAS) and enhancing vascular function. A significant antihypertensive effect has been revealed as Qct is taken by people with hypertension or prehypertension at doses of 500 mg/day and above. Qct has also been found to improve vascular function by increasing the bioavailability of nitric oxide produced in endothelial cells. Several studies show that it lowers blood triglyceride levels while affecting no other plasma lipids. Qct plays a pivotal role in Atherosclerosis (AS) and

Atherosclerotic Cardiovascular Disease (ASCVD), chronic inflammatory diseases characterized by endothelial dysfunction, abnormalities in lipid metabolism, and oxidative stress (Deng et al., 2020). Qct's anti-inflammatory effects can reduce cardiovascular risk factors such as fibrinogen and C-reactive protein (Bhat et al., 2021). With its anti-inflammatory, antioxidative, regulation of lipid metabolism abnormalities, and other properties, Qct inhibits AS plaque formation in the treatment of ASCVD.

Recent research establishes a potential association between depression and cardiovascular illness and brain-derived neurotrophic factor (BDNF). Qct is known to reduce behavioral dysfunction by lowering hippocampus oxidative stress (Wang et al., 2021). Besides its cardiovascular effects, Qct also provides strong protection against various cardiac injuries, such as ischemia-reperfusion (I/R) injury, doxorubicin-induced cardiotoxicity, diabetic cardiomyopathy, and others, by regulating a variety of signaling pathways and proteins. It acts by decreasing oxidative stress and inhibiting apoptosis, as well as affecting inflammatory proteins in the heart (Ferenczyova et al., 2020).

## Osteoprotective effect

Having strong osteo-inductive and angiogenic properties, Qct and its derivatives might support the differentiation of bone marrow stem cells (BMSCs) into osteoblasts (Ren et al., 2022). Studies have shown Qct's positive interactions with bone cells, promoting osteoblast growth while slowing or halting osteoclast activity. Research has also indicated Qct's critical role in regulating bone tissue renewal and inflammation (Huang et al., 2021). It has been demonstrated that both Qct and kaempferol significantly enhance bone mineralization, bone microstructure, and osteoblast activity in estrogen deficiency-induced bone loss and ovariectomized rats (Wong et al., 2020). A significant increase in the levels of tumor necrosis factor-alpha (TNF-a), heightened oxidative stress, interleukin (IL)-6, and IL-1beta impact bone metabolism. Additionally, osteoclast differentiation and bone resorption occur via reactive oxygen species (ROS), while oxidative stress and inflammatory cytokines stimulate osteoclast development. Osteoclasts, specialized bone-resorbing cells, are regulated by nuclear factor kappa-B ligand and macrophage colony-stimulating factor (M-CSF) (RANKL). Qct plays a crucial role in treating Rheumatoid Arthritis (RA), a chronic inflammatory disease characterized by synovial inflammation and joint destruction. Thus, it can be inferred that Qct controls osteoclast genesis in RA in various ways, including reducing the level of RANKL in RAFLS, inhibiting osteoclast differentiation of monocytes from RANKL and IL-17, and regulating the development of Th17 cells (Anachuna et al., 2020).

## Antioxidant activity

Qct is widely known as a potent natural flavonoid with antioxidant properties that protect our body from free radicals by reducing or inhibiting damage and oxidative stress in both in vitro and in vivo studies. According to Lesjak et al. (2018), Qct-derived metabolites (e.g., isorhamnetin and tamarixetin) showed higher antioxidant activity than Qct by inhibiting lipid

peroxidation. In vivo studies indicated antioxidant and hepatoprotective effects against acute liver damage induced by tertiary butyl hydrogen peroxide. Qct has also been found to have a protective function against radiation-induced damage and genetic toxicity (Kalantari et al., 2018).

Age-related macular degeneration (AMD) is characterized by vision loss in older people. Reactive oxygen intermediates are responsible for damaging retinal pigment epithelial cells (RPEs). With its cytoprotective property, Qct is considered a good agent in reducing the risk of developing AMD. Several studies have also demonstrated the role of Qct in inhibiting oxidative stress-mediated neuronal damage. Its radical-scavenging and metal-chelating activities reduce a number of neurodegenerative disorders and vascular pathologies in the brain.

## Anti-inflammatory activity

Quercetin exhibits potent anti-inflammatory effects and has a long half-life. In a mouse model, where Qct and galangin were administered either alone or in combination, both substances were found to reduce interleukin-6 (IL-6), NF-kB, and nitric oxide production in lipopolysaccharide (LPS)-stimulated RAW264.7 macrophages. Additionally, histological analysis and measurements of ear thickness revealed a significant reduction in IgE levels and inflammation. This suggests that the combination of Qct and galangin offers novel strategies for preventing atopic dermatitis (AD) (Lee, H.N. et al; 2018).

In various in vitro studies, Qct has been shown to inhibit the growth of IL-8-induced LPS in lung A549 cells and the production of lipopolysaccharide (LPS)-mediated tumor necrosis factor (TNF-α) in macrophages. Furthermore, Qct can decrease the amounts of TNF-α and interleukin (IL)-1α produced by LPS, thus reducing apoptotic neuronal cell death driven by activated microglia (Saeedi-Boroujeni et al.,2021). Studies have demonstrated that Qct effectively inhibits the NLRP3 inflammasome, which activates multiple inflammatory mediators, including NRF2, TXNIP, and SIRT1. This suggests that Qct may be a potential therapy for severe inflammation, such as that seen in COVID-19 (Saeedi-Boroujeni et al.,2021).

In peripheral blood mononuclear cells (PBMC) under normal conditions, Qct significantly upregulates the gene expression and production of interferon-γ (IFN-γ) from T helper cell 1 (Th1) and downregulates IL-4 from Th2. Additionally, Qct is known to decrease the production of inflammatory molecules such as COX-2, nuclear factor-kappa B (NF-κB), activator protein 1 (AP-1), mitogen-activated protein kinase (MAPK), reactive nitric oxide synthase (NOS), and reactive C-protein (CRP) (Lee, H.N. et al; 2018).

## Anti-diabetic activity

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by increased cellular resistance to insulin or a deficiency in insulin secretion, leading to disturbances in protein, carbohydrate, and lipid metabolism (Poznyak et al., 2020; Sarkar et al., 2023). Several studies have suggested that Qct shows anti-diabetic properties by promoting insulin secretion and

modulating carbohydrate metabolic enzymes (Sur et al., 2023; Biswas et al., 2023; Roy et al., 2023; Acharya et al., 2023). Research indicates that Qct may play a protective role against streptozotocin (STZ)-induced toxicity, alleviating oxidative stress in the pancreas and promoting insulin secretion, thereby restoring pancreatic islet function in STZ-induced diabetes (Jaishree et al., 2020). Hemmati et al. (2018) investigated the effect of Qct as a dietary supplement and found it to be critical in regulating the expression of key enzymes involved in glucose metabolism, including glucokinase and glucose-6-phosphatase. Additionally, Qct has been shown to mitigate gestational diabetes by modulating adiponectin signaling and its receptors, thereby restoring the expression of these enzymes (Mahabadi et al., 2021). Furthermore, studies have demonstrated that Qct exerts significant inhibitory effects on the activities of alpha-amylase and alpha-glucosidase in a concentration-dependent manner, while also protecting against lipid oxidation in pancreatic tissue homogenates (Oboh et al., 2015). Higher Qct consumption has been associated with a reduced risk of type 2 diabetes mellitus (T2DM) in the Chinese adult population (Yao et al., 2019). In the context of diabetic osteopenia, Qct has been shown to play a role in rebuilding bone architecture damaged by diabetes (Hemmati et al., 2018). Moreover, Qct has been found to prevent the increase in acetylcholinesterase (AChE) activity induced by diabetes in the cerebral cortex and hippocampus. Additionally, it reduces cholinergic signaling and aids in the restoration of lost memory in diabetic rats by enhancing acetylcholine (ACh) function (Maciel et al., 2016).

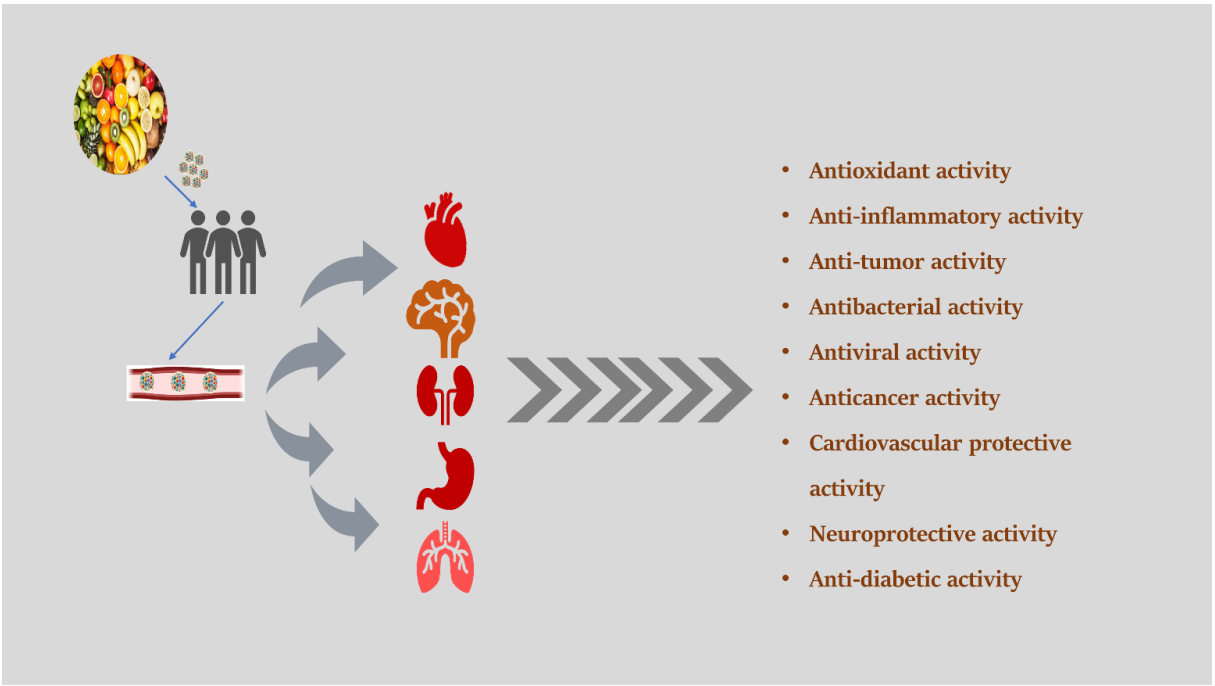


**Figure 1. Diverse biological role and therapeutic applications of quercetin, a potent flavonoid found in various plant-based foods. From antioxidant and anti-inflammatory properties to potential benefits in cardiovascular health, and cancer prevention, quercetin emerges as a versatile molecule with promising implications for human health and disease management.**

## Anti-hyperuricemic activity

Recently, hyperuricemia has gained increased attention among people not only because of its primary association with gout but also due to its significant threat in developing associated illnesses such as cardiovascular disease (CVD) and chronic kidney disease (CKD). Essentially, hyperuricemia denotes an elevated level of serum urate, resulting in the accumulation of monosodium urate crystals in joint tissue interstitial spaces, leading to gout (Tumova et al., 2021).Qct plays a significant role in preventing hyperuricemia by inhibiting a number of enzymes related to urate production, supporting the activity of urate excretion transporters, and controlling the activity of urate reabsorption transporters. Additionally, it reduces the risk of hyperuricemia by enhancing the antioxidant defense system to remove free radicals and by mitigating comorbid conditions associated with gout and hyperuricemia, such as hypertension, diabetes, obesity, dyslipidemia, CVD, and kidney disease. Therefore, it may be utilized as an alternative to traditional medications or in combination with them to minimize their negative effects as much as possible (Nutmakul et al., 2022).

## Anti-cancer activity

The global cancer burden is growing due to population ageing and growth, as well as changes to people's exposure to risk factors. Various chemical families and bioactive substances from plants demonstrate promising anticancer effects. Numerous studies show Qct's anti-proliferative activity against various cancers, along with its mechanisms of action, including modulation of cellular signalling, binding to cellular receptors and proteins, and inhibition of carcinogen-activating enzymes (Rauf et al., 2018; Madhu et al., 2023).

Langner et al. demonstrated the effects of naturally occurring phytochemical combinations in reducing colon cancer cell growth without adverse effects on healthy colon epithelial cells, suggesting their potential for the prevention and treatment of colon cancer (Langner et al., 2019). Qct-2,3-dioxygenase, present in *Bacillus* spp., is essential for Qct metabolism. Its metabolic products, 2,4,6-trihydroxybenzoic acid (2,4,6-THBA) and 3,4-dihydroxybenzoic acid (3,4-DHBA), possess antiproliferative properties in cancer cells (Sankaranarayanan et al., 2021).

Natural dietary components, such as Qct, are gaining popularity in cancer prevention and therapy. Qct's pro-oxidant properties control tumor growth and trigger apoptotic pathways or cell cycle arrest (Ezzati et al., 2020). With its catechol and OH groups, Qct scavenges free radicals and shows potential for combination therapy with chemoprotective medications. Qct emerges as a potential option for ovarian cancer treatment (Shafabakhsh et al., 2019).

## Anti-bacterial activity

Qct exhibits potent bacteriostatic action against a wide range of bacteria, particularly Gram-positive species (Wang et al., 2018). Qct derivatives, including Qct 4’,5-diphosphate (QDP), Qct 3’,4’,3,5,7-pentaphosphate (QPP), and Qct 5’-sulfonic acid (QSA), show high

biocompatibility and potency as antibacterial agents, with 100% inhibition of *Listeria monocytogenes*, *Aeromonas hydrophila,* and *Pseudomonas aeruginosa* reported (Osonga et al., 2019).

## Antifungal activity

Qct exhibits inhibitory effects against various pathogenic fungi, inducing oxidative stress and altering fungal cell membrane composition, leading to cell death. It shows synergistic effects when combined with other antifungal agents. Rocha et al. (2019) demonstrated a significant reduction in biomass and metabolic activity of Candida strains when using kaempferol and Qct in combination.

## Anti-tuberculosis activity:

Lipids present on the cell wall of *Mycobacterium tuberculosis* are responsible for its intracellular survival and pathogenicity. The enzyme pantothenate synthetase (PS or PanC) produces pantothenate (vitamin B5), which is necessary for the biosynthesis of coenzyme A (CoA), an essential element for fatty acid production. Novel anti-TB drug discovery aims to block cell wall synthesis; the fatty acid synthesis of *M. tuberculosis* is greatly affected if PS or PanC is inhibited (Premalatha et al., 2020). The growth-inhibitory properties of Qct against M. *tuberculosis* H37Rv are now well established. Qct's ability to combat *tuberculosis* (TB) suggests its suitability as a prototype for future anti-TB drug delivery methods. Additionally, patients with destructive pulmonary *tuberculosis* (DPTB) who receive chemotherapy in combination with Qct-fixed polyvinylpyrrolidone (PVP) have shown an improved prognosis. Qct has been found to have antioxidant activity, act as a capillary stabilizer, and may also have immunomodulatory effects (Chaudhari et al., 2021).

Besides its role in the tricarboxylic acid (TCA) cycle functionality and cyclic cell development of M. *tuberculosis*, isocitrate lyase, an enzyme, is also required for attachment to host cells. Qct has been shown to improve the repressive effect on *M. tuberculosis* metabolism by reducing *M. tuberculosis* isocitrate lyase (Maiolini et al., 2020).

## Covid-19

Qct can lower blood cholesterol levels in macrophages by altering the expression of ABCA1, a key regulator of reverse cholesterol transport. During the initial stages of atherosclerosis, Qct controls dysregulated cholesterol metabolism and persistent inflammation, resulting in a reduction in the production of foam cells (Pawar et al., 2021). Angiotensin-converting enzyme II (ACE2), required for SARS-CoV-2 entry into cells, has been identified as a human SARS-CoV-2 receptor, offering insights into developing new drugs to combat COVID-19. Qct can attach to the S-receptor-binding protein's domain (RBD), blocking receptors and rendering the SARS-CoV-2 virus ineffective (Roychoudhury et al., 2021; Mbikay et al., 2022). Network pharmacology and bioinformatics analysis support Qct's potential role in host immunomodulation, making it a candidate for COVID-19 treatment (Pan et al., 2020).

## Toxic side effects of Qct

Although the ames test showed Qct as a mutagenic agent, most in vivo animal studies have indicated that Qct is safe, with no carcinogenic effects. In 1999, the International Agency for Research on Cancer (IARC) recommended that Qct should not be classified as a human carcinogen (Utesch et al., 2008; Okamoto, 2005). In vitro studies have suggested that Qct may have a mild negative impact on fetal growth, requiring protective measures, but there is no evidence of teratogenic activity on embryonic growth (Pérez-Pastén et al., 2010). In vivo, experiments also indicated a slight increase in the frequency of malignant tumors in the young offspring of mice lacking DNA repair mechanisms (Vanhees et al., 2011). However, experiments conducted on laboratory rats found that Qct administration significantly increased the liver-to-kidney weight ratio in rats given doses exceeding 314 mg and 157 mg of Qct per kilogram of body weight per day, respectively. Additionally, doses higher than 157 mg Qct/kg body weight/day exhibited pro-oxidant effects (Batiha et al., 2020). Clinical trials in humans have confirmed its tolerance and suitability for use. It is noteworthy that prolonged administration of Qct for several months did not induce any adverse effects on serum electrolytes, kidney and liver function, blood parameters, or hematology. Studies have cautioned against co-administering Qct with digoxin in patients, as it may lead to toxicity (Wang et al., 2004). When orally ingested, dietary Qct undergoes first-pass metabolism in the intestine and liver, resulting in almost complete metabolization, thus minimizing the potential for toxicity. However, the use of high-dose intravenous (IV). Qct in patients with compromised health has been associated with nephrotoxicity (Russo et al., 2012).

## Conclusion

Quercetin, a natural bioactive compound found in foods like apples, onions, and berries, is gaining attention for its medicinal potential. It shows promise in treating ailments such as diabetes, heart disease, and osteoporosis. Consumption of flavonoids like quercetin is linked to a reduced risk of cardiovascular disease. Its antioxidant, anti-inflammatory, and anti-tumor properties suggest potential clinical applications. Quercetin also exhibits antibacterial activity, though this aspect requires further investigation. Nevertheless, its broad-spectrum antibacterial nature could offer alternatives to antibiotics for treating infectious bacterial diseases. Further research is required to explore its biological as well as therapeutic applications.

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Chapter- 11

# DNA barcoding and medicinal plants

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**Keywords:**DNA barcoding, medicinal plants, metabarcoding, gene sequence.

**Abstract:**

Medicinal plants are used in several societies. It has been practiced worldwide for centuries to use herbs for maintaining a healthy life, especially for chronic diseases. Now a days, people from developed countries are also increasingly using traditional medicine as an alternative or alongside modern medicines. The medicinal plants to be used must be correctly identified for our safety. For a long time, expert botanists have identified medicinal plants based on morphological characteristics, and analytical techniques have been used to determine their quality. But neither morphological features nor previous analytical methods can easily identify closely related species and in cases involving powders or processed products obtained from plants, it is difficult to identify adulteration. DNA barcoding is an emerging molecular identification and classification technology that has been applied to medicinal plants since 2008. The application of this technique has greatly ensured the safety and effectiveness of medicinal materials. From single locus-based DNA barcodes to combined markers to genome-scale levels, DNA barcodes contribute more and more genetic information. At the same time, other technologies, such as high-resolution melting (HRM), have been combined with DNA barcoding. With the development of next-generation sequencing (NGS), metabarcoding technology has also been shown to successfully identify species in mixed samples. As a widely used and effective tool, DNA barcoding will become more useful over time in the field of medicinal plants.

## Introduction:

Medicinal plants and herbal supplements have played an important role in the health of human populations for thousands of years (Maiti et al., 2010, 2013; Banerjee et al., 2014; Ghosh et al., 2022; Acharya et al., 2022a,b; 2023; Dey-Ray et al., 2024). Even today, the global market for these plant species and their products continues to grow. Globally the authentication and verification of correct plant products has become increasingly important issue over time. DNA barcode technologies have evolved from single genes to combined genes, to genomes, and most recently, metabarcoding. All these techniques are now routinely applied to track medicinal plants' use, commercialization, and authentication globally. DNA Barcode technologies have been especially useful in the ethnobotany of herbal medicines which is crucial for human health.

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## *Medicinal Plants*

The term "medicinal plants" refers to all the plants that can be used as medicines or food supplements, playing important roles in human health (Sarkar et al., 2016; Sarkar et al., 2021; Biswas et al., 2023; Pawar et al., 2023; Rai & Sharma, 2023; Roy et al., 2023; Sarkar et al., 2023; Sarkar et al., 2024). The definitions of "medicinal plants" in different countries are different. According to Yu et al. (2021) the types of medicinal plants are grouped into five pharmacopoeias worldwide. Information for a total of 1133 medicinal plant species had been collected, covering 184 families and 656 genera. The Pharmacopoeia of China (2015) contains 610 species, belonging to 381 genera and 136 families, and Pharmacopoeia of India contains 396 species, belonging to 325 genera and 119 families (Sur et al., 2023; Swaminathan, 2024; Sarkar et al., 2024). The Japanese Pharmacopoeia contains 222 species, belonging to 151 genera and 74 families. Korean Pharmacopoeia contains 219 species belonging to 141 genera and 72 families; United States Pharmacopoeia contains 141 species belonging to 103 genera and 47 families. Only 4 species (*Curcuma longa*, *Glycyrrhiza glabra*, *Illicium verum*, *Zingiber officinale*) are common to all five Pharmacopoeias. Further analysis showed that among 1133 medicinal plants, the top 10 families were Asteraceae, Fabaceae, Lamiaceae, Ranunculaceae, Rosaceae, Apiaceae, Apocynaceae, Euphorbiaceae, Rutaceae and Solanaceae, while the top 10 genera were *Prunus*, *Clematis*, *Euphorbia*, *Solanum*, *Artemisia*, *Dioscorea*, *Acacia*, *Citrus*, *Ficus*, *Aconitum*.

## *DNA barcoding*

A DNA barcode is a relatively short gene sequence in the genome that is unique to a species (Jian, 2014). DNA barcoding is a helpful tool for taxonomic classification and species identification by sequencing a concise, standardized DNA sequence in a well-defined gene. The species are identified by amplifying highly variable regions (DNA barcode region of the nuclear, chloroplast or mitochondrial genome) using Polymerase Chain Reaction (PCR). Regions widely used for DNA barcoding include nuclear DNA (e.g., ITS), chloroplast DNA (e.g. rbcL, trnL-F, matK, psbA, trnH, psbK) and mitochondrial DNA (e.g., COI). DNA barcoding is used for a wide range of purposes, such as the authenticity of labelling by confirming identity or purity to support ownership or intellectual property rights to reveal cryptic species, in forensics to link biological samples to crime scenes, to support food safety and in ecological and environmental genomic studies. Paul Herbert and colleagues in 2003 first proposed the use of short DNA sequences as a method of identifying species, with the aim of rapid species-level identifications across all life forms. Hebert et al. (2003), proposed to use the mitochondrial gene Cytochrome c oxidase subunit l gene (CO1) as the standard barcode for all animals. The scientific community readily adopted this and CO1 can be used to distinguish over 90% of species in most animal groups. In recent years, the barcoding movement has grown substantially, and worldwide efforts coordinated by CBOL (the Consortium for the Barcode of Life) are now being put into retrieving barcode sequences from all organisms

(CBOL, 2009). The power of DNA barcoding to identify species has been demonstrated in several studies. Research shows that DNA barcoding can rapidly identify poisonous plant materials. Mati et al. (2011) have demonstrated that a DNA barcoding approach can identify species in processed plant materials of commercial kitchen spices. DNA barcoding has been used to identify ingredients in commercial plant mixtures. studies such as Newmaster et al. 2013, showed the successful approach of DNA barcoding for species adulteration of natural health products and medicinal plant raw drugs.

## DNA barcoding for identification of medicinal plants

A gene region must satisfy three criteria to be practical as a DNA barcode (Yu et al., 2021). The gene region should contain a sufficient variation to discriminate between species, consist of conserved flanks to develop universal PCR primers and have a short sequence length to facilitate current DNA extraction and amplification capabilities. A single barcoding locus combining these traits has not been found, and a combination of two or more is required to approach the level of species discrimination and universality for plants (Jian, 2014). The reliable candidates for plant DNA barcodes are several chloroplast gene regions nucleotide coding loci or noncoding spacers and coding genes. The Chloroplast genome is appropriate due to the high copy number, conserved structure, and diversity of substitution rates across genes, introns, and intergenic spacers. Examples of them are the arc ribosomal RNA maturase K (matK) coding gene and Ribulose 1, 5- bisphosphate carboxylase/oxygenase large subunit coding region (rbcL) considered core barcodes.

The CBOL recently recommended the two-locus combination of matK+rbcL as the best plant barcode with a discriminatory efficiency of only 72% (CBOL, 2009). Taxonomists have suggested that a multi-locus method may be necessary to discriminate plant species. The combination of the spacer region tRNA-His and photosystem II protein D1 (psbA-trnH spacer) and ITS is also used as a plant barcode for the majority of plant families in addition to core barcode markers (Chen et al., 2010). According to CBOL, matK and rbcL genes need to be supplemented by additional loci to discriminate among closely related species. The other plastid loci sequenced in plant systematics for phylogenetic purposes are trnL-F, rpoCl, rpoB2, 911, etc., with different success degrees (Kress et al., 2005).

## Types of DNA barcode markers used for identification of medicinal plants

### *Single-locus DNA barcode markers*

It was announced in 2009 at the 3rd World DNA Barcode Conference that the matK and rbcL markers are the core sequences of plant DNA barcodes, with ITS and trnH-psbA as complementary sequences (Group, 2009). After extensive experiments and verification, Chen and colleagues proposed the ITS2 region as the primary DNA barcode and trnH-psbA as a complementary sequence for identifying medicinal plant species (Chen et al., 2010). Since then, many plant scientists have used other several markers to evaluate the efficiency of ITS2 and trnH-psbA by identifying the species in different families or genera: atpF-atpH (Ran et al.,

2010), rpoB (Al-Qurainy et al., 2011), atpB-rbcL, trnH-psbA, trnL-F, trnS-G, atpF-H, rbcL, matK, rpoB, rpoC1, nad1 (Quan and Zhou, 2011), rbcL, matK, psbA-trnH, ITS2, ITS, trnL intron, and trnL-F (Sun et al., 2011), trnL and rpoC1 (Madesis et al., 2012), rpoC1 (L-Qurainy et al., 2014), ndhJ (He et al., 2014), matK, rbcL, atpH-atpI, rpl32-trnL (UAG), rps18-clpp, trnL-trnF, trnL-ndhJ, trnS-trnfM (Mao et al., 2014), rbcL and trnL (Buddhachat et al., 2015), rbcL, psbA-trnH and petA-psbJ (Deng et al., 2015), matK, rbcL, trnH-psbA, ITS, trnL-F, 5S-rRNA and 18S-rRNA(Mishra et al., 2016), rps16, and trnT-F (Mishra et al., 2016), trnL (Suesatpanit et al., 2017). The ITS2 secondary structures have also been used to identify the species in different genera, such as Akebia (Zhang et al., 2015), Glehnia (Zhu et al., 2015), Physalis (Feng et al., 2016), and Smithia (Umdale et al., 2017).

### *Multiple-locus DNA barcode markers*

As single-locus marker sequence cannot always provide enough information for low level identification, some scientists used a combination of markers to identify medicinal plants. The most common combinations of DNA markers exist between matK, rbcL, trnH-psbA, and ITS sequences (Newmaster et al., 2013; Fu et al., 2011; Purushothaman et al., 2014). Some other combinations, such as atpB-rbcL+trnL-F and atpB-rbcL+ -atpF-H, have been used in identifying the species of Prunus L., which can resolve all five species (Quan and Zhou, 2011). Parveen compared the combinations of rbcL, rpoB, rpoC1, matK, and ITS in Orchidaceae, with the maximum species resolution provided by ITS+matK (Parveen et al., 2017).

### *Genome-based DNA barcode markers*

The chloroplast genome contains all the DNA sequences in a plastid, which contains more genetic information for species identification than any commonly used single-locus marker. By 27 October 2019, 3452 plants' chloroplast genome was published on NCBI. Govindaraghavan and Li proposed that the entire plastid genome be used in the field of DNA barcoding (Govindaraghavan et al., 2012; Li et al., 2015). Sucher suggested that genomic fingerprinting can differentiate between individuals, species and populations and is useful for the detection of the homogeneity of the samples and presence of adulterants in herbal supplements (Sucher and Carles, 2008). Yang used the chloroplast genome to identify the species of *Datura stramonium* (Yang et al., 2014). He sequenced and analyzed the complete chloroplast genome of Lonicera japonica. Zhou et al. analyzed the complete chloroplast genomes of Papaver rhoeas and Papaver orientale. They concluded that the chloroplast genome could be used as a powerful tool to resolve medicinal plants' phylogenetic positions and relationships (Zhou et al., 2018).

## Most popular marker sequences for plant DNA barcoding

### *The matK region*

Ribosomal RNA maturase K (matk) is a rapidly evolving coding gene. Such a region with 800-1500 base pairs (bp) is located within the intron of the chloroplast gene trnK (Figure). According to Windelspecht (2007), MatK has a high evolutionary rate, suitable length, obvious

interspecific divergence, and a low transition/ transversion rate. But matK is difficult to amplify universally using currently available primer sets. The CBOL Plant Working Group (2009) revealed a nearly 90% success rate in amplifying angiosperm DNA using a single primer pair. However, the success was limited in gymnosperms (83%) and much worse in cryptogams (10%) even with multiple primer sets. Different primer pairs were necessary for different taxonomic groups (Chase et al., 2007). Lahaye et al. (2008) used specific primers to amplify the matK gene of 1667 angiosperm plant samples and achieved a success rate of 100%. Matk could discriminate more than 90% of species in the Orchidaceae (Kress & Erickson, 2007) but less than 49% in the nutmeg family. Many research findings suggests that the matK barcode alone is not a suitable universal barcode.

### *The rbcL region*

Ribulose 1, 5- bisphosphate carboxylase/ oxygenase large subunit coding region (rbcL) which is located in the plastid genome, has a length of 600-750 bp. The rbcl region is a candidate for plant barcoding as it can detect generic-level evolutionary relationships (Windelspecht 2007).

The rbcL can be easy to amplify and sequenced and aligned in most land plants. Thus, it is a good DNA barcoding region for plants at both the family and genus levels. Kress et al., (2005) showed that since rbcL sequences evolve slowly, it has a low divergence of plastid genes in flowering plants. Hence it is not very suitable for discriminating at the species level. Moreover, the length is also a drawback where four primers are required for its double-stranded sequencing. However, despite its limitation, rbcL is still being wildly used for plant barcoding due to a large amount of easily accessible data and straightforward recovery of the entire gene sequence.

### *The trnH-psbA region*

The trnH-psbA non-coding spacer, located between tRNA-His and photosystem II protein D 1, shows many features considered as desirable in a barcode. The trnH-psbA gene with 800-1500 base pairs (bp) is located within the intron of the chloroplast DNA. Since the region has a highly conserved coding sequence, it enables the designing feasible universal primers, where a single primer can amplify almost all the angiosperms. The noncoding intergenic region has a high rate of insertion and deletion, making trnHpsbA a suitable candidate for plant barcoding (Shaw et al., 2007).

However, trnH-psbA may undergo frequent inversion in certain plant linkages that may cause incorrect phylogenetic assignment. It some cases where taxon-specific internal primers are not available, the mononucleotide repeats can have premature termination of sequencing (Lee, 2016).

### *The ITS region*

ITS (Internal transcribed spacer) region is located between the 16S and 23S rRNA genes. It is recommended only as a supplementary locus by CBOL. ITS region is not permitted to being

a core barcode marker. Firstly the ITS region is different to amplify and sequence. Secondly, it has an incomplete concerted evolution. Thirdly, the ITS region is not specific for plants as it is also present in fungus (fungal contamination), thus, ITS sequence amplification can be confused with fungi sequence (Mishra et al., 2015).

## Metabarcoding

With the development of DNA high-throughput sequencing technology, DNA barcodes have been transformed into DNA metabarcoding, which can simultaneously acquire DNA barcode sequences for mixed multi-species samples. This technology uses high-throughput sequencing technology to obtain the barcoded amplicon sequences and uses bioinformatic methods to identify species diversity and composition within a sample. This technology has now been applied to the field of medicinal plants. Dietary analysis by metabarcoding was proposed at the 6th International Barcode of Life Conference (Adamowicz, 2015). De Boer used nrITS1 and nrITS2 DNA metabarcoding to identify orchids and other plant species present in 55 commercial products (De Boer et al., 2017). Arulanhu developed a multi-locus DNA metabarcoding method to identify endangered plant (including *Echinocactus*, *Euphorbia*, *Aloe variegate*, *Dendrobium*, *Cycas revolute*, *Lactuca sativa*) and animal species in complex samples (Arulandhu et al., 2017). Omelchenko improved protocols of ITS1-based metabarcoding and analyzed 39 plant-containing products (Omelchenko et al., 2019). Raclariu uses DNA metabarcoding coupled with chromatography technologies to authenticate 16 *Veronica officinalis* herbal products (Raclariu et al., 2017a), 78 *Hypericum perforatum* herbal products (Raclariu et al., 2017b), and 53 Echinacea herbal products (Raclariu et al., 2018a, 2018b). DNA metabarcoding combines other sequencing techniques can determine both prescribed and contaminated species in Traditional Chinese Medicine (TCM) preparations, such as Liuwei Dihuang Wan (Cheng et al., 2014), Jiuwei Qianghuo Wan (Xin et al., 2018).

Raclariu compared the benefits and limitations of DNA Barcoding versus Metabarcoding in herbal product authentication and concluded that both techniques have potential in the context of quality control of both well- and poorly-regulated supply systems (Raclariu et al., 2018a, 2018b). However, the accurate determination of species or herbal products by DNA metabarcoding is dependent on a comprehensive and accurate reference library of DNA sequences of a standard genetic marker.

## Conclusion

Universal PCR amplification has the highest relative rate of recovery of a barcode region (Erickson et al., 2008). There are several aspects of species differentiation. A fraction of species groups cannot be resolved with any suggested DNA barcode marker, but recovery can be improved through marker selection. The complementation of loci is useful for this purpose (Kress and Erickson, 2007). Combined barcodes are recommended for numerous beneficial outcomes but opposite arguments on its usage are also being raised. Chen et al. (2010) stated that the combined barcode causes increased analytical difficulty compared to the single-locus

marker. Moreover, CBOL also demonstrated in one study that the use of seven different candidate loci combinations did not improve species-level discriminatory ability compared to rbcl+ matK. Some authors stated inconsistency between the plastid gene tree and species boundaries, resulting failure of multiple-locus barcodes. Multiple-locus barcodes cannot eliminate the inherent deficiencies of the current DNA barcoding of plants (Dubey et al., 2016).

Globally, medicinal plants have been recorded in 219 different families (52.1%). Among them, 142 families, including 832 genera, have DNA barcodes revealed (64.8%). The remaining 77 families of medicinal plants have no published record of DNA barcode sequence data (Yu et al., 2021). After more than 10 years of development, DNA barcoding with standardized genetic markers has made tremendous progress. Today, barcode markers can be combined with other biotechnologies, such as molecular, chromatographic, and spectrum technologies to obtain better identification results. These other molecular technologies include SNP (Single Nucleotide Polymorphism), HRM (High Resolution Melting), and RFLP (Restriction Fragment Length Polymorphism). Chromatography technologies include LC-MS (Liquid Chromatography -Mass Spectrometry), HPLC (High Performance Liquid Chromatography), TLC (Thin Layer chromatography). Xiao demonstrated that the chemical profiles determined by LC-MS and DNA profiles in ITS spacer domains could serve as barcode markers for the quality control of Radix *Astragali* (Xiao et al., 2011). Zhang showed that DNA barcoding is more powerful than HPLC fingerprint for the identification of *Phellodendri* Cortex and its related species (Zhang et al., 2016).

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Chapter- 12

# Ethnomedicinal plants with antimicrobial activity

**Sutapa Maiti and Nilanjana Banerjee***

**Keywords:** Multidrug resistant bacteria, antimicrobial activity, phytochemicals, ethnomedicinal plant.

**Abstract:**

Despite the successful development of antibiotics, infectious diseases remain the world's second leading cause of death. At the same time, antibiotic resistance has emerged as a major challenge in the twenty-first century. The abundance of phytochemicals found in medicinal plants offers a promising avenue for the development of new drugs. Plants, which are known for synthesizing a wide range of secondary metabolites, have disease-prevention properties. Plant-derived products have distinct advantages for medical treatments, including potential efficacy and minimal to no side effects. However, developing new antimicrobial compounds from plant extracts appears to be difficult to overcome. Still, ongoing efforts are being made to improve the antimicrobial activity of phytochemical compounds. The information about few ethnomedicinally important plants studied for in vitro antimicrobial activity is provided in this chapter.

## Introduction:

Infectious diseases caused by bacteria and fungi have increased in recent years, posing significant health challenges. Children and adolescents are especially vulnerable to the serious health consequences associated with these infections. Pathogenic bacteria such as *Pseudomonas aeruginosa*, *Enterococcus faecium*, *Enterobacter species*, *Staphylococcus aureus*, *Acinetobacter baumannii*, and *Klebsiella pneumoniae*, have been identified as common culprits (Bhatia et al., 2021). The introduction of antibiotics in the twentieth century was a turning point moment in the fight against bacterial and fungal infections (Fauci, A. S., 2001). On the other hand, the indiscriminate and repeated use of anti-microbial drugs has resulted in the emergence of multiple drug resistances in human pathogenic microorganisms (Shariff, 2001). Plants provide all human necessities, including food, clothing and medicines. These are the treasure troves of phytochemicals that may yield medications of the future.

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Such as various secondary metabolites synthesized by plants act as anti-microbial Compounds and can be an important tool in human health Management. Plants, as natural sources of various anti-pathogen compounds, mostly secondary metabolites, have become an important tool in human health management. The use of phytochemicals for pharmaceutical purposes has gained attraction around the world, with an increasing number of reviews emphasizing the importance of natural compounds in the treatment of human diseases (Antony and Singh, 2011; Sultana, 2011). The World Health Organization (WHO) comprehends medicinal plants as an important source of various drugs, echoing a five-millennia-old tradition in India, China, and the Near East. Ethnobotanical knowledge, particularly from India and China, has significantly contributed to the discovering of medicinal compounds and has attracted pharmaceutical companies for R&D initiatives (Krishnaraju et al., 2005). Companies and governmental bodies, including the Government of India's Ministry of Chemicals, recognize the importance of traditional knowledge in research and development.

Regardless of the rich customs and knowledge foundation, there is still much to discover, with only a small percentage of the world's flowering plants being tested for biological activity. However, half of the drugs used in the pharmaceutical industry originate from plants (Harborne, 1998).

As the demand for traditional treatments grows, there is a growing desire for scientifically sound evidence to support their principles and effectiveness, addressing Western scientific community concerns about research, development, and quality of drugs (Fabricant and Farnsworth, 2001; Patwardhan et al., 2003;).Drug phytochemicals can be used singly or in combination (Bazzaz et al., 2018). Researchers are focusing more on finding out novel and efficient medicines from the plant origin.

## Ethnnomedicinal plants and their significance:

The broad knowledge of traditional medicinal herbs was obtained from Traditional Indian medicine (TIM) and Traditional Chinese Medicine (TCM) systems to heal body & mind. Different formulations of herbal products were utilized in both systems, playing a significant role in drug discovery *(Maiti* et al., 2010, 2013; Banerjee et al., 2014; Sarkar et al., 2016, 2021; Anand et al., 2019; Rai & Sharma, 2024). Ethnomedicinal plants have been utilized for generations by tribal communities as a source of medicine for both humans and animals (Sur et al., 2023; Sarkar et al., 2023; Roy et al., 2023; Sarkar et al., 2024). The medicinal plants have exhibited numerous biological activities, including anti-microbial, antioxidant and anti-inflammatory properties (Acharya et al., 2022a, b, 2023). These plants guide researchers in determining the bioactive components utilized for healing patients by validating the traditional use of Ethnomedicinal plants (Ghosh et al., 2022; Biswas et al., 2023; Pawar et al., 2023; Dey-Ray et al., 2024). Moreover, traditional medicines are more competent for living systems than chemically synthesized drugs. Ethnobotanical knowledge is important in drug discovery, and the addition of analytical and biological sciences like genomics and proteomics may provide the required validation for traditional therapies.

## Anti-microbial activity of some ethnomedicinal plants:

In developing countries, more than 80% of people depend on traditional medicine to cure primary health problems (WHO, 2013). Medicinal plants have been applied as folk medicine to prevent the growth of several microorganisms like bacteria, fungi, viruses and protozoa. Research has explored how plant extracts prevent the growth of multi-drug-resistant organisms (Bhatia, 2021). Moreover plant extracts can synergistically inhibit the growth of pathogens with special mechanism of action (wagner and ulrich-Merzenich, 2009). It is quite difficult to enumerate each plant that exhibits antimicrobial properties. Some of these are pointed out here. Propanolic leaf extracts of *Adhatoda vasika*, *Bacopa monnieri*, *Carica papaya*, *Cissampelos pareira*, and *Cynodon dactylon* were found to be a good source of antibiotics against various bacteria, reported by Hema et al. (2013). Carbohydrates, resins, and diterpenes were discovered in *Cynodon dactylon* with significant antimicrobial effects. Nitave and Patil conducted a study in 2014 to evaluate the antimicrobial abilities of an ethanolic extract derived from *Punica granatum* peels, which are typically considered waste. The extract outperformed ciprofloxacin in its antibacterial action against *Gram negative Pseudomonas aeruginosa*, *Proteus vulgaris*, *Escherichia coli*, and Gram-Positive *Staphylococcus aureus*. Furthermore, the extract demonstrated antifungal activity against *Aspergillus flavus* and *Candida albicans*, demonstrating that it was more potent than fluconazole. The abundance of active constituents such as alkaloids, flavonoids, steroids, tannins, terpenoids, and cardiac glycosides was revealed by phytochemical analysis. Kaur et al. published a study in 2015 that highlighted the efficacy of *Withania somnifera* (Ashwagandha) extract of root against *Candida albicans*. Panda et al. (2016) studied antimicrobial activity on 222 plant species of 82 families and 177 genera collected from the Mayurbhanj district. Six gram-negative and Two gram-positive bacteria were taken as test organism. Among these selected plants of 68 families are active. Mickymaray et al. (2016) evaluated that between five plant species [ *Aerva lanata* (L.) Juss. ex Schult, *Acalypha indica* L. *Pergularia daemia* (Forsk.) Chiov., *Clerodendrum inerme* (L.) Gaertn. and *Solanum surattense* Burm. f.], *A. lanata* and *A. indica* showed tremendous antibacterial activity against *Staphylococcus aureus* and *E. coli*. Mishra et al.,(2017) looked into the efficacy of nine tropical flowering plants, including *Terminalia chebula*, *Tinospora cordifolia*, *Azadirachta indica*, *Bauhinia variegata*, *Anogeissus acuminata*, *Boerhaavia diffusa*, *Tribulus terrestris* , *Soymida febrifuga*, and *Punica granatum*, as potential sources of antimicrobials against multidrug-resistant (MDR) urinary tract infections causing bacteria. Result revealed a significant zone of inhibition ranging from 25 to 29 mm, indicating promising antimicrobial activity. Arulmozhi et al. (2018) tested the antimicrobial potency of leaves from *Capparis zeylanica*,*Tribulus terrestris*, *Streblus asper*, and extracts against *Staphylococcus epidermidis*, *Salmonella paratyphi*, *Enterococcus faecallis*, *Mycobacterium tuberculosis*, *Shigella dysenteriae* and *Candida albicans*, using the agar well diffusion method, and the Minimum Inhibitory Concentration (MIC), The results showed that the ethyl acetate extract of *C. zeylanica* leaves has greater potential activity than the other extracts and standard drugs (Gentamycin and Ketocozole).

Manandhar et al. (2019) reported that the antimicrobial properties of methanolic extracts of *Artemisia vulgaris*, *Cinnamomum tamala*, *Ageratina adenophora* and *Oxalis corniculata*, were tested using the agar well diffusion method. Most extracts demonstrated significant antimicrobial activity,

with *O. corniculata* exceeding the others against *Salmonella typhi*, *E. coli*, MDR *Salmonella Typhi*, *Citrobacter koseri*, and *Klebsiella pneumoniae* with the zone of inhibition measurements ranging from 11 to 17 mm. Furthermore, extracts of *Artemisia vulgaris*, *Ageratina adenophora* and *Cinnamomum tamala* demonstrated antibacterial activity against *Staphylococcus aureus*. This study backs up the plant extracts' potential as natural antibacterials. Ibrahim et al. (2020) investigated the antibacterial activities of three medicinal plants, *Lepidium sativum*, *Moringa oleifera*, and *Azadirachta indica*, which have been shown to be effective in treating a variety of diseases, were studied against *Staphylococcus aureus*, *Streptococcus agalactiae, and Salmonella typhi*. Maceration was used to extract crudes using methanol and aqueous solvents. The disc diffusion method was applied for susceptibility testing, and the broth dilution method was used to determine the Minimum Inhibitory Concentration (MIC). According to Verma et al. (2020), an ethnomedicinal plant, *Leucas lanata* showed antimicrobial activity and ethanolic extract responded to the significant zone of inhibition against *S. aureus* as well as *Salmonella typhimurium*. Al-Nemari et al. (2020) evaluated that Methanolic leaf extract of *Annona squamosa* contains sesquiterpenes and showed tremendous antibacterial activity against gram-positive and gram-negative bacteria. It can be alternative source of antibiotics as well as a drug for colon cancer. Swain et al. (2021) investigated four medicinal plants—*Zingiber officinale*, *Curcuma longa*, *Piper longum* and *Piper nigrum*, commonly used as spice products in South Asia were studied for antioxidant properties and antibacterial effects. These plants' methanolic extracts showed significant inhibition zones, with *Curcuma longa* showing the most inhibition against a wide range of bacterial strains. *Zingiber officinale* was also found to be antibacterial against *K. pneumonia*, *S. aureus*, and *P. aeruginosa*. *Curcuma longa* has emerged as a potential co-therapeutic agent for the treatment of gastrointestinal infections due to its high antioxidant content and effective inhibition of a variety of bacterial strains. Rather et al. (2023) assessed MIC, MBC, and total antibacterial activity (TAA) of 20 ethnomedicinal plants from North East India against *Chromobacterium violaceum* and *P. aeruginosa*. The findings indicate that the ethnomedicinal plants studied are high in phytochemicals and have strong antibacterial and antibiofilm properties. This suggests that they can potentially be important sources of novel antibacterial agents.

## Plant metabolites as antimicrobial agent:

Exploring the plant kingdom appears promising in searching for new antimicrobial agents. Plant extracts or compounds frequently exhibit potent anti-pathogen activity by inactivating the mode of synthesis or functioning, often with minimal side effects. The diverse chemical structures of plant-derived compounds may reveal novel mechanisms of anti-microbial action and present new bacterial cell targets. Several secondary metabolites of plants and derivatives are being investigated as antimicrobial agents. It is reported that phytochemicals (alkaloids, coumarins, xanthones, ellagic acid derivatives, phenolics, terpenoids) isolated from traditional plants were potentially active as anti-microbial (Kuete, 2010). Among the secondary metabolites studied, alkaloids and polyphenols are recognized as key compounds with strong anti-microbial activity. Polyphenols, a diverse group of secondary metabolites, use their antioxidant properties as a foundation for exerting antimicrobial

effects. Alkaloids, on the other hand, serve as the structural foundation for developing a wide range of antibiotics with diverse efficacy (Othman, 2019). Flavonoids show promising antibacterial properties. They also effectively inhibit virulence factors and combat microbial threats, such as biofilm formation. Furthermore, some plant-derived flavonoids have been shown to reverse antibiotic resistance and improve the efficacy of existing antibiotics. As a result, the discovery and use of flavonoid-based drugs represent a potentially fruitful avenue in the fight against antibiotic-resistant infections (Górniak et al., 2019). Terpenes and their hydrocarbon derivatives, commonly found in essential oils (EOs), have been shown to have potent antimicrobial properties with powerful bacteriostatic and bactericidal effects against various pathogens (Mahizan et al., 2019). The ability of certain plant secondary metabolites to act as resistance-modifying agents is a particularly promising avenue for combating bacterial resistance.

## Future perspective:

Ethnnomedicinal plants remain less explored. So, natural resources like phytochemical pools still need to be investigated, and they can be therapeutic tools for drug discovery against multidrug-resistant microorganisms (Heinrich and Gibbons, 2001). Synergistic effects of different phytochemicals or plant extracts or between plant extracts and Antibiotics must be clearly established. Moreover, further study is required to develop a profile on the mechanism of action of isolated phytochemical or the plant extract mixture. Next, *in vitro*, research on Ethnnomedicinal plants must be conducted to study susceptibility for microorganisms as compared to standard drugs. The in vivo examination of phytochemical effects requires toxicity studies of plant extracts or mixtures of plant extracts. Quantitative data and standardized protocol preparation are needed to fulfil the rising demand for safe ethnomedicinal plant products. International cooperation can result in shared expertise that benefits communities, government and research (Vaou et al., 2021)

## Conclusion:

The growing threat of infectious diseases with specially Multi-Drug Resistant (MDR) pathogens creates a significant threat to public health emphasizes the critical importance of research efforts. These efforts are aimed at isolating and characterizing plant secondary metabolites and understanding the mechanisms underlying plants' natural defenses against microbial threats. However, the production of new anti-microbials from plant extracts faces a number of challenges and obstacles that must be overcome. Despite ongoing efforts to improve the antimicrobial activity of chemical compounds, several challenges remain in this effort (Vaou et al., 2021). Such insights reduce pathogenic infections and play a crucial role in defeating “superbugs”.

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Chapter- 13

# Phytoremediation of indoor air pollution using indoor plants

**Sujata Roy Moulik**

**Keywords:** Air pollution, Indoor pollution, Phytoremediation, medicinal plants.

**Abstract:**

Pollution is everywhere, within our homes. This has been a major concern as indoor air pollution is present globally, especially in developed countries and cities. There are different indoor air pollutants like CO, volatile organic compounds (VOCs) like formaldehyde, benzene, nitrous oxide, trichloro-ethylene, fluorine, ammonia, radon, aldehyde, hydrocarbons etc. These pollutants have serious hazardous effects on human health. Indoor plants have been used worldwide for decoration since ancient times. But this beautification may add some beneficial aspects to control of indoor pollution through a process called as Phytoremediation. Experiments are going on to evaluate the actual contribution of these ornamental plants in indoor air pollution control. This could be a sustainable approach towards the maintenance of indoor air quality.

## Introduction:

### *Indoor Air Pollutants*

Air pollutants are substances in the atmosphere that can potentially cause damage to the environment, the climate, and human health. These pollutants are typically divided into two main categories: Bare in mind to underscore the main and the secondary pollutants. The primary pollutants are the ones that are directly discharged by sources such as factories, vehicles and even natural events such as volcanic eruptions. Regular instances of carbon monoxide, sulphur dioxide, and nitrogen oxides are examples of pollutants. On the contrary, secondary pollutants are not emitted directly but form in the atmosphere as a result of chemical reactions involving the primary pollutants. Ozone, which is a prominent component of smog, is a prominent secondary pollutant (Das et al., 2016; Prasad et al., 2023).

Pollution of the air has now turned out to be a serious world problem due to its broad impact. The fact that it is responsible for respiratory and cardiovascular diseases, premature death and it aggravates conditions like asthma and bronchitis is the reason why it is dangerous. Besides, air pollutants are responsible for the destruction of ecosystems, that is, the decrease of biodiversity

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and the alteration of water and soil conditions. Besides that, some air pollutants, such asgreenhouse gases, are responsible for the majority of climate change as they trap the heat in the atmosphere and consequently cause global warming.

There are several air pollutants. Here, some of the major pollutants are discussed.

### *Organic Pollutants*

Volatile organic compounds (VOCs) like Formaldehyde, Toluene and ethylbenzene, Acetaldehyde, Acrolein, Naphthalene, Trichloroethylene, Tetrachloroethylene, Carbon dioxide and carbon monoxide- are organic pollutants. These chemicals are mostly vaporized easily at room temperature, and their concentration is higher than that of other pollutants in the indoor air. Aerosols, cleaning agents, varnishes, polishes, paints, pressed-wood products and pesticides are some of the VOC sources indoors (Aller, 1999; Mentese et al., 2015; De Gennaro et al., 2014).

Biomass fuels and coal are a source of energy for cooking and heating. Almost 3 billion people use biomass (wood, charcoal, crop residues, and animal dung) and coal worldwide as their primary and other household needs (Ezzati, 2008). From biomass and coal combustion $CO_2$ and $NO_2$, arsenic, fluorine and organic matter such as polycyclic aromatic hydrocarbons are emitted. Chronic obstructive pulmonary disease, respiratory infections, asthma, lung cancer and eye diseases are the hazardous effects of biomass and coal (Smith et al., 2004; Smith, 1987).

Tobacco smoke is the largest source of air pollutants in indoor environments. It has more than 4000 chemical compositions, which could lead to pneumonia and bronchitis, especially in childhood (Schwela, 2005; Jenkinset al., 1992; Bruce et al., 2000).

Carbon dioxide and carbon monoxide result from poorly ventilated kitchens, rooms over garages, and unvented combustion appliances (stoves, ovens, heaters, and the presence of tobacco smoke) (Schwela, 2014). Symptoms of exposure are sneezing, coughing, and minor eye irritation (Kaur and Misra, 2014).

Formaldehyde is a class of aldehydes that is a colorless gas. The sources of formaldehyde are different building materials, household products, or combustion processes. Indoor sources include pressed-wood products, including particleboard, panelling, fiberboard, resins, carpet backings, drapes, and upholstery fabrics, linens, and clothing; urea–formaldehyde foam insulation; adhesives; paints; coatings; and carpet shampoos plus tobacco smoke. Decreasing ventilation rate will increase the level of formaldehyde (De Gennaro et al., 2014; Nielsen et al., 2012; Nielsen et al., 2016). Formaldehyde exposure could cause respiratory symptoms, reductions in lung function, headaches, and asthma, and it can affect the nervous system (De Gennaro et al., 2014).

Toluene exists in many materials, such as gasoline, paints, and fingernail polish. Ethylbenzene is also present in paints, lacquers, and insecticides. These compounds are

hazardous to human health and have adverse effects on the nerves, liver, kidneys, and respiratory system (Schwela, 2005; Sriprapat et al., 2014).

Acetaldehyde is toxic to the cilia of respiratory epithelia and may interfere with respiratory clearance mechanisms. Acetaldehyde is also a central nervous system depressant and, a proven carcinogen in animals and a potential carcinogen in humans. The acetaldehyde source of indoors is construction materials, furnishing materials such as vinyl, polyvinyl chloride (PVC) and rubber floorings, nylon carpets, particleboard furniture, plywood, fiberboard, flooring adhesives, wood panelling, and other consumer products and emitted by printers and photocopiers (Schwela, 2005; Destaillats et al., 2007).

Acrolein is a very potent eye irritant, causing lacrimation at concentrations of approximately 2 mg/m3. At high concentrations, acrolein can cause significant lung injury, including dyspnea, asthma, congestion, edema, and persistent respiratory insufficiency with decreased lung function (Schwela, 2005).

Naphthalene is a volatile white solid. It is an aromatic hydrocarbon, including a fused pair of benzene rings (Schwela, 2005). Naphthalene is mostly used as a toilet deodorant and as a moth repellent. Extended exposure to a large amount of naphthalene may damage or destroy some of the red blood cells.

Trichloroethylene (TCE) is a clear, non-flammable liquid used mainly for vapour degreasing and cold cleaning of manufactured metal parts and, to a lesser degree as a solvent for a variety of organic materials. The primary sources of TCE in the indoor air include varnishes, finishes, lubricants, adhesives, wood stains, paint removers, cleaning liquids containing TCE, and contaminated food and water (Schwela, 2005). TCE is carcinogenic to humans (ATSDR, 2011) and can affect the central nervous system (CNS), eyes, kidneys, liver, lungs, mucous membranes, and skin (Bahr et al., 2011).

Tetrachloroethylene (PCE) is a colorless liquid mostly used for dry cleaning fabrics, as a solvent for organic materials, and to degrease metal parts in the automotive and other metalworking industries. Another source of PCE is dry-cleaned clothes. Exposure to PCE vapor could cause damage to the following organs: kidneys, the liver, the peripheral nervous system (Schwela, 2005), the upper respiratory tract, the skin, and the central nervous system (CNS) (ATSDR, 2008).

### *Inorganic Pollutants*

Nitrogen oxides are combustion by-products produced by the burning of natural gas or oil in oxygen-rich environments such as kitchen stoves and ovens, furnaces, and unventilated gas and kerosene heaters from a fireplace or wood stoves are used. Adverse effects of $NO_2$ exposure are breathing symptoms, bronchoconstriction, growth of bronchial reactivity, painfulness, and increased respiratory infection.

Trace elements are generally related to Particulate Matters (PM) and are Fe, Al, Mg, Zn, Co, As, Cr, Cd, Mn, Cu, Ni, and Pb. Trace elements such as Mg, Fe, and Al are greatly released

from crustal sources such as parent rocks, metallic minerals, seas, and oceans. Fossil fuel combustion, forest and biomass burning, and metal processing are also sources that release many trace elements (Ugranli et al., 2016). These toxic pollutants either ingress from outside of the buildings or are generated inside because of fossil fuel combustion.

Mercury (Hg) is a persistent, poisonous, and bio-accumulative heavy metal. It can discharge into the atmosphere from a diversity of anthropogenic and natural sources like burning process of fuels (36%) and biomass (33%) (Shen et al., 2017; Loupa et al., 2017).

Ozone can cause the muscles in the airways to constrict, trapping air in the alveoli leading to wheezing and shortness of breath. The source of ozone in a building is electrostatic copying devices, mercury-raised light bulbs, and electrostatic air cleaners (Aller, 1999; Darling et al., 2016; Fadeyi, 2015).

### *Particulate Matters*

Inhalable particulate matter is classified into three groups according to their sizes: coarse particles (2.5 <dp< 10 μm), fine particles (≤2.5 μm) and ultrafine particles (UFP,<0.1 μm) ( Heal et al., 2012; Irga et al., 2017). Fine particles are more potent when inhaled than coarse fractions since they can penetrate the lungs more. UFP can penetrate alveoli and enter the blood, which can be very harmful. Sources that can increase the PM concentration are Earth's crust elements from oil burning and human activities, and motor vehicles (Othman et al., 2009). An increase in exposure to PM leads to increased hospital admissions of the old and individuals with cardiopulmonary and respiratory illnesses. PM concentration inside a building is basically governed by indoor sources of fine particles, outside PM concentration, the rate of air circulation, and the particles' depositional speed (Buczy´nska et al., 2014). Studies show that indoor concentration of PM2.5 is usually higher than outdoor concentration (Buczy´nska et al., 2014).

Asbestos exposure for an extended period of time could lead to lung cancer, known as mesothelioma and asbestosis. Insulation and other building materials, such as floor tiles, drywall compounds, and reinforced plasters, are sources of asbestos (Kaur and Misra, 2014).

### *Phytoremediation of indoor air*

Indoor plants means the plants that can grow indoors i.e., their light, temperature and water requirements are low. They may be either flowering plants (Peace lily, Kalanchoe, Amaryllis, Hydrangeas, Poinsettia) or foliage plants (cactus, palm plants, fern and succulents). National Aeronautics and Space Administration (NASA) has found that common household plants work as natural air purifiers. Interestingly indoor plants can remove a notable amount of at least 87% of VOC's in 24 hours. Succulents and many indoor house plants are further advantageous as they are small in size and add a continuous flush of fresh oxygen day and night. Studies have shown that people in buildings with plants like Money plant, Mother- In- Law's Tongue and Areca palm have 34% fewer respiratory problems, 54% less eye irritation and 24% fewer headaches (Maiti et al., 2010, 2013; Anon., 2016; Banerjee et al., 2014; Ghosh et al., 2022).

Phytoremediation means using plants and their associated microorganisms to isolate or degrade toxic substances from the environment (Chaney et al., 1997; Ensley, 2000; Prasad and Freitas, 2003). Phytoremediation can utilize six different strategies. The plant itself can use several pathways. The phytoremediation methods are cheaper than other techniques available, although it may be lengthy (Schnoor et al., 1995; Mendez and Maier, 2007; Teiri et al., 2018; Gawro´nska and Bakera, 2014). Phytoremediation is the collection of the above mechanisms in which green plants capture and degrade indoor air pollutants (Wang et al., 2014). Phytoremediation of contaminated soils acts as pollutants that accumulate and are degraded by plants. However, in botanical air filters, applying microbial activity has an important role in removing indoor pollutants. Also, VOC biodegradation can occur due to the growth of bacteria and plants. Generally, plants and bacteria have the complexity and important interactions (Wang et al., 2014).

Experiments on light and dark spaces for formaldehyde elimination were also carried out using *Ficus benjamina* L. and *Ficus japonica* plants. The aerial parts of both species reduced formaldehyde concentrations during the day but only slightly removed at night. Meanwhile, the root is capable of removing large amounts of formaldehyde during the day and night. The effectiveness of roots in eliminating formaldehyde was mainly due to microorganisms and roots. The results of this study indicate that enhanced photodegradation was the main process of removing formaldehyde (Kwang et al., 2008; Aydogan& Montoya, 2011). Formaldehyde elimination was also studied in experiments using plants from the Liliaceae, Agavaceae and Araceae families that are effective in removing formaldehyde. However, *Philodendron selloum* is the least resistant to formaldehyde exposure (Zhou et al., 2011). The plant species tested have a high potential to improve the interior environment from exposure to formaldehyde (Teiri et al., 2018b).

Recent data shows the efficiency of toluene phytoremediation increased by an average of 156 $mg/m^3/hour/m^2$ leaves of *Pinus densilora* and *Salvia elegans* (Kwang Jin Kim et al., 2011). Efficient removal of toluene and xylene was achieved using indoor plants (*Schefflera actinophylla* and *Ficus benghalensis*). Experiments show that toluene and xylene was translocated from the air to the root zone through the stem, which indicates that the root zone plays an important role in this elimination process (Kim et al., 2016).

There is intensive research to filter out dozens of plant species that are capable of eliminating many VOCs gases. For exposure to each gas as much as 10 ppm within 6 hours, it was found that *Hemigraphisalternata*, *Hedera helix*, *Hoya carnosa*, and *Asparagus densivechlorus* had the highest removal efficiency for all pollutants (Yang et al., 2009). Other types of plants have different and lower removal efficiencies. The difference in efficiency between plant species indicates the need, importance and necessity of biodiversity in the processing of pollutants by plants (Samudro & Mangkoedihardjo, 2020; Samudro & Mangkoedihardjo, 2020; Ren et al., 2017).

The average benzene removal efficiency of 70% was achieved by four common ornamental plants, namely *Epipremnumaureum*, *Chlorophytum comosum*, *Hedera helix* and *Echinopsistubiflora*. *Echinopsistubiflora* is interesting for the high ability of removal efficiency due to its high ability to transpiration and high chlorophyll content (Gong et al., 2019). The high transpiration of plants indicates that they need a lot of watering while they are used for room remediation. Likewise, the high chlorophyll content of plants indicates the need for sufficient sunlight to utilize it. Therefore, planting conditioning and maintenance need to be considered (Mangkoedihardjo & Samudro, 2014; Ni et al., 2019) in order to support the maximum capacity of plants to eliminate polluting gases. Thus, the application of biodiversity, including the diversity of plant conditions and ways of maintaining them, is able to eliminate many pollutants maximally.

Thus, the potential of plants to improve Indoor Air Quality (IAQ) depends upon the capacity of leaves to exchange gases and pollutants from indoor air through stomata. The capacity is limited by physical constraints pertaining to stomatal and mesophyll resistance. The size of the stomatal pore varies with variations in environmental conditions viz., light, temperature, humidity -and cascades of signalling through plant hormones, especially abscisic acid. Besides stomatal absorption, pollutants can get adsorbed on the external surfaces of plants or soil-root interface. The process of absorbing lipophilic semi-volatile compounds is achieved through leaf surface adsorption, where atmospheric resistance serves as a major limiting factor (Wei et al., 2017). This type of removal depends upon the total surface area and anatomical, morphological and chemical features of the plant surface, along with the characteristics of the soil substrate (Irga et al., 2013). The adsorption of pollutants, especially lipophilic VOCs, such as benzene, on plant surfaces is dependent upon the type and density of trichomes (Li et al., 2018), cuticular wax deposition and lipid composition of the epidermal membrane (Gawronska and Bakera, 2015). Research revealed that the amount of pollutants absorbed through stomata is 30- 100 times more than adsorbed on the plant surface or non-stomatal deposition (Tani et al., 2009). After entering into plant leaf either through absorption or adsorption, pollutants are translocated to shoots and roots for metabolic degradation through oxidases or hydrolases and then conjugation with different metabolic compounds (sugars, amino acids, organic acids, and peptides) to form bioproducts. These products are either re-expelled (into the air or as root exudates into the soil) or used as carbon and energy sources (Oikawa and Lerdau, 2013).

In addition to air phytoremediation, another least explored aspect is phytoremediation i.e., remediation through habituated microbes either on leaf surface or endophytes by biodegrading or transforming pollutants into less or nontoxic molecules (Sandhu et al., 2007). Leaves are the primary photosynthetic organs with dorsiventral symmetry and play pivotal roles in supporting phyllosphere microbes (Bringel and Couee, 2015). Several reports documented that both plant leaves and leaf-associated microbes mitigated air pollutants, such as Azalea leaves and the leaf-associated *Pseudomonas putida*, in reducing VOCs (De Kempeneer et al., 2004) and Poplar

leaves and the leaf-associated *Methylobacterium* sp. decreased xenobiotic compounds (Van Aken et al., 2004). Thus, different mechanisms underlie the phytoremediation potential of plants for indoor pollutants.

**Table 1: Research results showing some pollutants and their regulation with indoor plants**

| Pollutant | Potted Plant species | Results |
|---|---|---|
| $O_3$ | Peace Lily (*Spathiphyllum*), Ficus species (*Ficus Decora Burgundy*), Calathia (*Calathia Species*), Dieffenbachia (*Dieffenbachia* Species), Golden Pothos (*Epipremnumaureum*) | The Golden Pothos had the highest ozone deposition velocity values among plants, and the lowest value was for Peace Lily [Abbass et al., 2017] |
| Toluene and Xylene | *Schefflera actinophylla* and *Ficus benghalensis* | Removal of toluene and xylene was 13.3 and 7.0 μg·m−3 ·m−2 leaf area over a 24-h period in *S. actinophylla* and was 13.0 and 7.3 μg·m−3 ·m−2 leaf area in *F. benghalensis*. It also showed that the root zone has a vital role in toluene and xylene removal. [Kim et al., 2016] |
| Benzene | *Syngonium podophyllum, Sansevieria trifasciata, Euphorbia milii, Chlorophytum comosum, Epipremnumaureum, Dracaena sanderiana, Hedera helix, Clitoriaternatea* | *Chlorophytum comosum* was the most efficient plant for removing benzene during the 96 h. [Sriprapat and Thiravetyan, 2016] |
| PM | Spider plants (*Chlorophytum comosum* L.) | The result shows the accumulation of PM at a high level on the surface of leaf [Gawro ´nska and Bakera, 2014] |
| Formaldehyde | Golden Pothos | Dynamic airflow through the root bed and microbes was essential for removing high efficiency; moisture of the bed root has a vital role in removing VOCs [Wang et al., 2014] |
| Toluene ethylbenzene | *Aloe vera, Sansevieria masoniana, Sansevieria trifasciata, Sansevieria hyacinthoides, Sansevieria ehrenbergii, Kalanchoe blossfeldiana,* | *S. trifasciata* had the highest value for removing toluene, *C. comosum* for removal of ethylbenzene, *S. trifasciata* and *S. hyacinthoides* had a high value in the absorption of toluene and ethylbenzene. [Sriprapat et al., 2014] |

| | | |
|---|---|---|
| | *Dracaenaderemensis, Codiaeum variegatum, Chlorophytum comosum, Dracaena sanderiana, Cordyline fruticosa, Aglaonema commutatum* | |
| Benzenen-hexane | Janet Craig S. Sweet Chico | The highest value for removing TVOCs (75%) by potted-plants is when indoor average TVOC concentrations are higher than 100 ppb [ Wood et al., 2006] |
| Benzene Trichloroethylne Formaldehyde | *Chamaedoreaseifritzii, Aglaonema modestum, Hedera helix, Ficus benjamina, Gerbera jamesonii, Dracaena deremensis, Dracaena marginata, Dracaena massangeana, Sansevieria laurentii, Spathiphyllum, Chrysanthemum morifolium, Dracaena deremensis* | These plants require low light and low metabolic rates. These plants are a suitable selection to decrease sick building syndrome, containing many new, energy-efficient buildings. The plant root-soil zone showed high efficiency for the removal of VOCs [Wolverton et al., 1989] |
| Benzene $CO_2$, CO | *Zamioculcas, Aglaonema, Dracaena* | CO2 concentration increases 10% in offices in the air-conditioned building. The CO level reduces with or without air-conditioning. Higher value removing of benzene appearance by these plants. [Tarran et al., 2007] |
| $CO_2$ | Peace lily, weeping fig, areca palm<br><br>Sweet Chico, Hahnii, *Chamaedoreaelegans, Dracaena marginata*, Florida Beauty, Lemon Lime, Janet Craig, *Ctenanthe oppenheimiana, Ficus repens, Hedera helix, Epipremnum, aureus, Philodendron, scandens, Dizygotheca, elegantissima* | The rate of photosynthesis change with the variation of $CO_2$ concentration in light indoor. The leaf area is effective to decrease $CO_2$ [Oh et al., 2011].<br><br>Woody plants species accumulate dry mass (and carbon) better than smaller, herbaceous species [Pennisi and van Iersel, 2012] |

## Conclusion

The basis for phytoremediation is the potent efficiency of some plants to assimilate, degrade, or modify toxic pollutants into non-toxic ones. Breathing walls, portable air filters for rooms or whole house filtration through heating, ventilation and air conditioning systems are some of the technologies to reduce indoor air pollution and improve indoor air quality, but all these are costly, resource consuming and, still there is a question on their efficiency. Phytoremediation seems to be the key solution to improve indoor air quality as it has many potential advantages (simple, potentially cheap and easily implemented) in comparison to other traditional or latest methods available.

One of the best tools for selecting indoor plants is the Air Pollution Tolerance Index (APTI). APTI considers biochemical properties of leaves such as ascorbic acid: relative water content, total chlorophyll and leaf extract pH. These properties affect the value of the plant's tolerance to air pollutants. For example, the high value of ascorbic acid is one of the strategies to prevent oxidative damage to the thylakoid membranes under water stress conditions (Bandehali et al., 2021). Therefore, the selection of plants for our indoor environment is also important. Costly and large resource-consuming technologies can be used for IAQ maintenance, but indoor plants are beautiful with boon and they are very easy to install and maintain.

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Chapter- 14

# A Survey of Medicinal Plants on Acharya Prafulla Chandra College Campus

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**Keywords:** Acharya Prafulla Chandra College, Medicinal garden, Conservation, Medicinal plants.

**Abstract:**

A survey of medicinal plants was undertaken on the campus of Acharya Prafulla Chandra College in New Barrackpore, Kolkata, West Bengal, India. The study included in-depth field visits and observations of the surrounding outdoor spaces as well as the medicinal plant garden. The well-organized recording of the plant species by the research work means that the traditional knowledge is conserved and the basis for further scientific research is laid. The medicinal garden is made by going to the field to find and categorize plant species, talking with the old aged Kaviraj all over West Bengal to get their opinions and a review of the existing literature to put the findings into perspective with the help of the Government of West Bengal, Department of Higher Education, Science & Technology and Biotechnology (Science & Technology Branch and Biotechnology Branch). The study is designed to list the different species of medicinal flora that are identified in the conventional knowledge, traditional application and pharmacological properties. One hundred fourteen (114) different species of medical plants were recorded in the designated medicinal plant garden. The medicinal properties of the plants that were recorded included anti-bacterial, anti-cancer, anti-diabetic, anti-viral, anti-fungal, antidote, anthelminthic, and anti-analgesic qualities. These properties were found to be efficacious in treating a variety of ailments, including colds, coughs, ulcers, diarrhea, skin conditions, and snakebite. This survey draws attention to the possibility that, in the ensuing decades, some species may become endangered on college campuses. Thus, the campus can be considered a great source for both education and medicinal aspects. The purpose of this survey's results is to offer Acharya Prafulla Chandra College students insightful information on the medicinal plants on campus. It also highlights the significance of conservation efforts in maintaining these bioresources for therapeutic purposes. Furthermore, the survey research also covers the conservation status of these plants and proposes methods for their sustainable use and protection.

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## Introduction:

In the current world, conventional medicine, particularly plant-based treatments, is still the most important way to combat the diseases resulting from fungi, bacteria and viruses. More than 80% of people in the world use these natural medicines deeply and widely as their main source of healthcare, especially in developed and developing countries (Maiti et al., *2010, 2013;* Banerjee et al., 2014; Bhattacharjee, 2021; Bhowmik et al., 2022; Darro and Khan, 2023). Even though the younger generations are starting to be interested in traditional medicine, their knowledge and comprehension of using medicinal plants are still limited, which greatly contrasts with the older generations, who are the carriers of profound wisdom (Sarkar, 2017; Bose, 2018; Sarkar et al., 2021; Ghosh et al., 2022; Mandal, 2022; Pal et al., 2022; Raha et al., 2022; Sanyal, 2022).

On the other hand, there is a possibility of losing valuable information on the application of therapeutic herbs to the ageing of older people. Besides, numerous therapeutic plant species have been extinct because of human recklessness (Saha et al., 2022; Sanyal, 2022; Prasad et al., 2023; Roy et al., 2023). Thus, biodiversity, which is the primary habitat necessary for whole families, communities, countries, and future generations, is threatened (Elizabeth and Dowdeswell, 1995; Sarkar et al., 2016; Pimple et al., 2023).

Plants are so important to human life since they provide building materials, numerous medical uses and crucial food crops (Sarkar et al., 2021; Sanyal, 2022; Sarkar et al., 2023; Sur et al., 2023). Very few plants have been studied for their medical and agricultural use. Thus, a huge number of undiscovered medicines and crops are just waiting to be found by researchers and scientists (Das et al., 2016; Das et al., 2022). The World Health Organization (WHO) recognizes the worth of traditional medicine and emphasizes that many people in underdeveloped countries use plant-based traditional remedies for their basic medical needs. Consequently, the demand for medicinal plants has risen in both developed and developing countries because they are natural, non-toxic and have no side effects (De and Sharma, 2023; De et al., 2023). Traditional medicine like Ayurveda, Siddha and Unani dates back thousands of years, and these medications are gaining popularity. Botanical cures, once used for cooking, are now widely used medicines. Most modern medicines have originated from natural compounds derived from first discovered plants. Preservation and survey of, on the other hand, such plants are quite important for future medicine investigation and novel therapy approaches. Medicinal plant's value is expressed in many ways, as a starting point of traditional medicine or widespread pharmacology and as part of biodiversity conservation (Basu et al., 2022; Acharya et al., 2021, 2023; De et al., 2023). The primary stage of the initiative was to ensure the comprehensive assessment and recording of the herbal plants on the college campus. The diagnosis for traditional medicines includes all the medications that are prepared by the ancient herbs and the diseases for which they are used. The design of this study is to discover the chemical compounds that are in these plants and which one of them is responsible for the medicinal properties of this plant is the aim of this study. The purpose of the study was to identify the management of the plants and use them to support the sustainable

management of these plants (Pyne and Santra, 2017; Dey and Guha, 2020; Erfani, 2021; Dhakar and Tare, 2023).

This background establishes the framework for investigating the diversity of medicinal plants on the vast campus of Acharya Prafulla Chandra College in New Barrackpore, Kolkata. The college campus, which covers an area of around nine acres, is a vibrant patchwork of open spaces, lawns, gardens, and academic buildings. This study project aims to significantly contribute to botanical studies and related fields by identifying the various plant species and their sustainable use on campus.

Allopathic drugs have become the standard of care in the modern period, but several negative side effects frequently accompany their effectiveness. This insight has accelerated the search for less harmful alternatives to current medicines, bringing us full circle to the supply of therapeutic plants. These plant resources, present in various plants' leaves, roots, and bark, are essential components of conventional and cutting-edge medical formulations.

That which dates back to the ancient medicinal plants, a practice that began in human history and is considered one of the sources of treatment for various ailments before modern drugs, is worthy of consideration. The questionnaire that was placed is about the types of medicinal plants found at APC College, not which medicinal plants are the most popular. The target is not just to document and study the botanical treasures surviving in this setting but to find uniformity in the basic building blocks of life itself. This research will focus on compiling and studying these species, investigating their traditional medical uses and determining the potential medical applications of these plants in a modern pharmacy. Through this questionnaire, we aim to expand the scientific knowledge involving local plants and their functions in health and wellness. This study not only enhances the college's reputation as a knowledge leader but also points out the role of natural diversity that should be saved for future generations to see. The research will aid in designing educational material for students, researchers and local community dwellers, where plants' importance will be the central subject. This study aims to illuminate the rich flora by examining the broad range of medicinal plants within the Acharya Prafulla Chandra College campus. The authors have done GCMS studies for further research and show important bioactive substances found in these plants. This will open new avenues for research and conservation in botany and allied sciences.

## Materials & Method:

### Study Location:

The medicinal garden covers approximately 8840 sq. ft. of the Acharya Prafulla Chandra College campus. The geographical coordinates of the college campus are 22.6975°N latitude and 88.4384°E longitude.

### Study Period:

From March 2023 to November 2023, nine months were used for conducting the survey.

## Medicinal Plant Garden:

The study's primary focus was the college campus's medicinal plant garden. One hundred fourteen (114) medicinal plant species were found in the garden.

## Data Collection:

The medicinal plant garden's One hundred fourteen (114) species had to be observed on the ground to gather data. Medicinal plants were identified using plant identification books, teachers from Botany Department and Dr. Prabir Ranjan Sur, Retd. Scientist, Botanical Survey of India. Every species was documented in detail, including its botanical traits and therapeutic qualities. The surrounding flora, including plants, shrubs and other vegetation, was also considered throughout the data collection procedure.

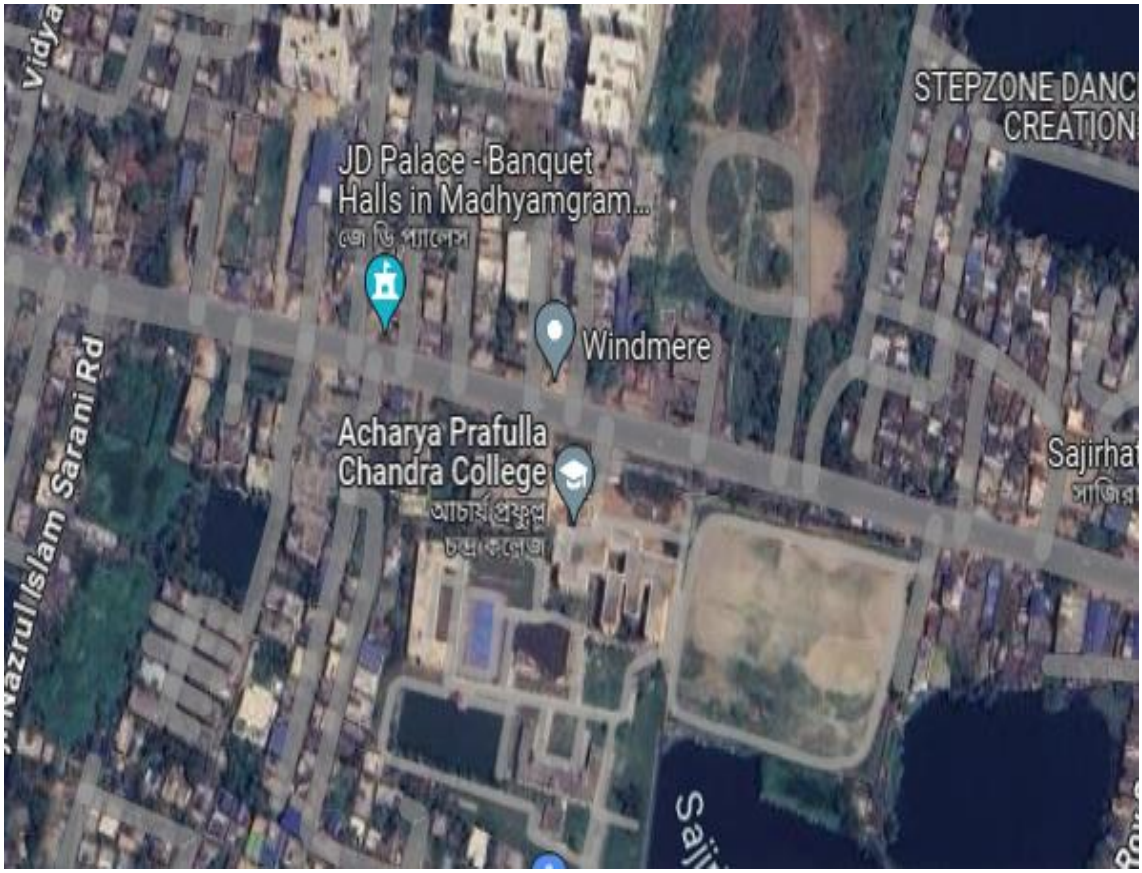


**Figure 1. College Campus in Google Maps.**

## Results:

The survey identified a total of 114 medicinal plant species belonging to 28 families. Below is a summary of key findings:

**Table 1: List of wild types of medicinal plants at Acharya Prafulla Chandra College campus**

| Sl. No | Description | Sl. No | Description |
|---|---|---|---|
| 1 | Binomial name: *Syzygium aromaticum* (L) Merril & Perry<br>Family: Mytraceae<br>Common name: Labanga<br>Habit: Tree<br>Parts used: Dried flower bud, leaves<br>Medicinal use: Clove oil is used as a painkiller, for dental problems, for treating hernia and stomach upset, and as an expectorant. | 2 | Binomial name: *Barleria prionitis* L.<br>Family: Acanthaceae<br>Common name: Bazradanti<br>Habit: Herb<br>Parts used: Leaves<br>Medicinal use: Leaf juice is used to prevent tissue maceration, stop gum bleeding, and as an expectorant. |
| 3 | Binomial name: *Glycosmis pentaphyla* (Retz) Correa<br>Family: Rutaceae<br>CommoMn name: Ash shaowra<br>Habit: Shrub<br>Parts used: Leaves and stem<br>Medicinal use: Leaves are used for fever liver complaints, and stem are used for ulcer. | 4 | Binomial name: *Trema orcientalis* (L) Blume<br>Family: Cannabaceae<br>Common name: Jibanti<br>Habit: Tree<br>Parts used: Leaves and bark<br>Medicinal use: Leaves & bark are used for cough, sore throat, asthma and yellow fever. |
| 5 | Binomial name: *Blumea lacera* ( Burm. F.) Dc.<br>Family: Asteraceae<br>Common name: Bara cooksina<br>Habit: Herb<br>Parts used: Whole plant<br>Medicinal use: Leaves are used for liver tonic, antipyretic, diuretic and ophthalmic. | 6 | Binomial name: *Clitoria ternatea* L.<br>Family: Fabaceae<br>Common name: Aporajita<br>Habit: Herb, Climber<br>Parts used: Leaves<br>Medicinal use: Leaves are used as memory enhancers, anti-depressants, and sedative agents. |
| 7 | Binomial name: *Aegel marmelos* (L) correa<br>Family: Rutaceae<br>Common name: Bel<br>Habit: Tree<br>Parts used: Whole plant, Leaves, Fruit<br>Medicinal use: Fruit pulp use for laxative, jaundice, constipation | 8 | Binomial name: *Elaeocarpus serratus* L.<br>Family: Elaeocarpaceae<br>Common name: Jalpai<br>Habit: Tree<br>Parts used: Leaves and Fruits<br>Medicinal use: Leaves are used for rheumatism and as an antitode for poison, and fruit is used for dysentery. |
| 9 | Binomial name :<br>*Pogostemon cablin* (Blanco) Benth<br>Family: Lamiaceae<br>Common name: Pachouri<br>Habit: Herb<br>Parts used: Leaves<br>Medicinal use: Used in insect repellants and antidepressants. | 10 | Binomial name: *Cympogon citrus* (L.) Spreng<br>Family: Poaceae<br>Common name: Lebu ghash<br>Habit: Herb<br>Parts used: Leaves |

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| | | | Medicinal use: Pesticide, insecticide & antifungal and antibacterial and also used as insect repellent. |
| 11 | Binomial name: *Ocimum tenuiflorum* L.<br>Family: Lamiaceae<br>Common name: Krishna Tulsi<br>Habit: Herb<br>Parts used: Whole plant.<br>Medicinal use: Reduce chest congestion, germicide and tuberculosis. | 12 | Binomial name: *Stephania japonica* (Thumb). Micrs<br>Family: Menispermaceae<br>Common name: Nimukha<br>Habit: Climber, Herb<br>Parts used: Whole plant and Leaves.<br>Medicinal use: The leaves are used to treat fever, diarrhoea, and dyspepsia, while the root is used to treat fever, diarrhoea and urinary disease. |
| 13 | Binomial name: *Mikania scandense* B. L. Rob.<br>Family: Asteraceae<br>Common name: Jarman lata<br>Habit: Climbing Herb<br>Parts used: Leaves<br>Medicinal use: Gastric ulcers and wound insect bites stop bleeding from cutting; it also has antimicrobial, antipyretic, and anti-inflammatory properties. | 14 | Binomial name: *Aerva lantana* L.<br>Family: Amaranthaceae<br>Common name: Chaya<br>Habit: Herb<br>Parts used: Whole plant<br>Medicinal use: Antioxidant activity, Kidney problems,urinary troubles, stop abnormal bleeding in menstruation. |
| 15 | Binomial name: *Desmodium gangeticum* (L.) Dc.<br>Family: Fabaceae<br>Common name: Shalparni<br>Habit: Herb<br>Parts used: Leaves and roots<br>Medicinal use: Heart disease, rejuvenation, anti dysenteric | 16 | Binomial name: *Costus specious* (J. Koning.) C. Specht.<br>Family: Zingiberaceae<br>Common name: Keu<br>Habit: Herb<br>Parts used: Rhizome<br>Medicinal use: Anti-diabetic to treat asthma, bronchitis and fever. |
| 17 | Binomial name: *Uraria picta* (Jack) Dc.<br>Family: Fabaceae<br>Common name: Prishiparni<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Medicinal use: Hear trouble, fractured bone, cough. | 18 | Binomial name: *Iresine herbstii* Hook. ex Lindl.<br>Family: Amaranthaceae<br>Common name: Lal vishyalikarani<br>Habit: Herb<br>Parts used: Leaves<br>Medicinal use: Healing property. |
| 19 | Binomial name: *Ruellia prostrata* L.<br>Family: Acanthaceae<br>Common name: Patpati<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Medicinal use: Anti-cancerous against the epidermis of naso-pharynx. | 20 | Binomial name: *Barringtonia acutangula* (L) Gaertn.<br>Family: Lecythidaceae<br>Common name: Hijol<br>Habit: Herb<br>Parts used: Whole plant, Leaves. |

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| | | | Medicinal use: Seed extract for anti tumor and anti-fungal. |
| 21 | Binomial name: *Madhuca longifollia* (J. Konig) J. F. Macbr<br>Family: Sapotaceae<br>Common name: Mahua<br>Habit: Tree<br>Parts used: Flower and Bark<br>Medicinal use: Bark is used for tonsillitis and gum trouble, and Flowers are used as stimulants, laxatives, antihelminthes, cough remedies, and respiratory disorders. | 22 | Binomial name: *Cephalandra indica* (W. and A.) Naud<br>Family: Cucurbitaceae<br>Common name: Talakuch<br>Habit: Herb, Climber<br>Parts used: Whole plant<br>Medicinal use: Flower- Jaundice, Fruits- Leprosy, bronchitis, asthma, Leaves- Cough, skin disease, Root- Diabetes, gonorrhea. |
| 23 | Scientific name: *Hemidesmus indicus* R. Br.<br>Family: Asclepedaceae<br>Common name: Ananta mul<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Oligo-spermia, skin disease, piles, leucorrhoea. | 24 | Scientific name: *Syzazium jambos* L. (Aloston)<br>Family: Mytraceae<br>Common name: Jam<br>Habit: Tree<br>Parts used: Seeds and young Leaves<br>Uses: Diabetes (seed), dysentery, anti-inflammatory effect. |
| 25 | Scientific name: *Artemisia vulguris* L.<br>Family: Asteraceae<br>Common name: Nagdola<br>Habit: Herb<br>Parts used: Whole plant,<br>Uses: Malaria fever, worm repellent. | 26 | Scientific name: *Ocimum gratissimum* L.<br>Family: Lamiaceae<br>Common name: Chandan tulsi<br>Habit: Herb<br>Parts used: Whole plant,<br>Uses: Antiseptic, anti-microbial property used in common cold and respiratory trouble. |
| 27 | Scientific name: *Morinda citrifolia* L.<br>Family: Rubiaceae<br>Common name: Noni<br>Habit: Shrub<br>Parts used: Fruit and Leaves<br>Uses: Leaf, fruit and bark are used to treat AIDS, liver disease, smallpox, and cancer. | 28 | Scientific name: *Saraca asoca* (Roxb.) Willd.<br>Family: Fabaceae<br>Common name: Ashok<br>Habit: Tree<br>Parts used: Bark, leaves and seed<br>Uses: Dysmenorrhoea, depression, leucorrhoea. |
| 29 | Scientific name: *Vitex negundo* Linn.<br>Family: Verbaneceae<br>Common name: Nishinda<br>Habit: Herb<br>Parts used: Whole plant, | 30 | Scientific name: *Murraya koenigii* (L.) Spreng.<br>Family: Rutaceae<br>Common name: Kari Pata<br>Habit: Shrub<br>Parts used: Leaves |

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| | Uses: Skin disease eczema, ring worm, spleen enlargement, expectorant, bronchitis, asthma. | | Uses: Anti-diabetic, also used to treat piles, inflammation, itching and dysentery. |
| 31 | Scientific name: *Withania somnifera* (L.) Kuntze<br>Family: Solanaceae<br>Common name: Awshagandha<br>Habit: Herb<br>Parts used: Seed, Leaves and root<br>Uses: Arthritis, anxiety, oligspermia, asthma, insomnia, ulcer and neurological disorder. | 32 | Scientific name: *Cissus quadrangularis* L.<br>Family: Vitaceae<br>Common name: Harjora<br>Habit: Climbing Herb<br>Parts used: Whole plant<br>Uses: Heal the broken bone and ligament. |
| 33 | Scientific name: *Amomum aromaticum* Roxb.<br>Family: Zingiberaceae<br>Common name: Alach<br>Habit: Herb<br>Parts used: Seed<br>Uses: Antioxidant, antiseptic, stomachic digestive. | 34 | Scientific name: *Clerodendrum indicum* L.<br>Family: Verbenaceae<br>Common name: Bamunhati<br>Habit: small tree<br>Parts used: Leaves<br>Uses: Allergy, asthma, fever, bronchitis, liver problem, tuberculosis. |
| 35 | Scientific name: *Psidium guajava* Linn.<br>Family: Mytraceae<br>Common name: Payara<br>Habit: Tree<br>Parts used: Fruits and Leaves<br>Uses: Fruit is used for laxative, leaf is used for wound ulcer. | 36 | Scientific name: *Adhatoda vasica* Nees<br>Family: Acanthaceae<br>Common name: Vashak<br>Habit: Shrub<br>Parts used: Leaves<br>Uses: Bronchial disease, cough, expectorates |
| 37 | Scientific name: *Wedelia calendula* (L.) Less.<br>Family: Asteraceae<br>Common name: Bhringaraj<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Hair fall treatment, skin disease. | 38 | Scientific name: *Terminalia chebula* Retz.<br>Family: Combrataceae<br>Common name: Haritaki<br>Habit: Tree<br>Parts used: Fruits and seed<br>Uses: Laxative, digestive, purgative, and healing properties. |
| 39 | Scientific name: *Asparagus racemosus* Willd<br>Family: Asparagaceae<br>Common name: Satamuli<br>Habit: Climber, Herb<br>Parts used: Roots and Leaves<br>Uses: Uterine tonic, hyperacidity, galactagogue. | 40 | Scientific name: *Euphorbia tirucalli* L.<br>Family: Euphorbiaceae<br>Common name: Lankaseji<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: Used for treatment for cancer, tomour. |
| 41 | Scientific name: *Justicia gendarusa* Burm. f. | 42 | Scientific name: *Stachytarpheta jamaicensis* L. |

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| | Family: Acanthaceae<br>Common name: Bishahari<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Asthma, rheumatism, colic of children | | Family: Verbenaceae<br>Common name: Jerbo<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Fresh leaf juice used to treat asthma, stomach ulcer |
| 43 | Scientific name: *Coleus aromaticus* Benth.<br>Family: Lamiaceae<br>Common name: Aijawan<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Treatment of cough, sore throat, nasal | 44 | Scientific name: *Centella asiatica* L.<br>Family: Apiaceae<br>Common name: Thankuni<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Leaf extract is used for liver complaints, gastric trouble, skin disease and amoebic dysentery. |
| 45 | Scientific name: *Hygrophyla spinosa* T. Anderson<br>Family: Acanthaceae<br>Common name: Kulekhara<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Leaf juice is used to treat anemia, jaundice and body pain. | 46 | Scientific name: *Abutilon indicum* (L.) Sweet<br>Family: Malvaceae<br>Common name: Atibol<br>Habit: Shrubs<br>Parts used: Seeds and Bark<br>Uses: Seed used in piles, gonorrhea |
| 47 | Scientific name: *Alstonia scholaris* R. Br.<br>Family: Apocynaceae<br>Common name: Chatim<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: The bark is used for digestion, antipyretics, laxatives, malaria fever, tumors, ulcers and cancer. | 48 | Scientific name: *Anacardium occidentali* L.<br>Family: Anacardiaceae<br>Common name: Kaju<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Root used as purgative, fruit used for skin disease. |
| 49 | Scientific name: *Acacia auriculiformis* A. Cunn. ex Benth.<br>Family: Mimosaceae (Fabaceae)<br>Common name: Sonajhuri<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Leaves used in dysentery. | 50 | Scientific name: *Bauhinia purpuria* L.<br>Family: Caesalpinaceae ( Fabaceae)<br>Common name: Rakta kanchan<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Bark is used for skin disease and ulcers and dried bud is used in piles. |
| 51 | Scientific name: *Gardenia latifolia* G. Don<br>Family: Rubiaceae<br>Common name: Gandharaj<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Root anti-helminths, antiseptic, dyspepsia and nervous disorder. | 52 | Scientific name: *Catharanthus roseus* (L.)G.Don.<br>Family: Apocynaceae<br>Common name: Nayantara<br>Habit: Herb<br>Parts used: Whole plant, Leaves, roots |

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| | | | Uses: Leaves and roots used diabetes, sore throat, lung congestion, skin infections |
| 53 | Scientific name: *Sanscvieria roxburghiana* Schult & Schult. f.<br>Family: Asparagaceae<br>Common name: Murga<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Plant sap has antiseptic qualities, and leaves are used for bandage. | 54 | Scientific name: *Bryophyllum pinnatum* (Lam.) Oken<br>Family: Crassulaceae<br>Common name: Pasan veda<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Dysentery, cough, asthma, fever, constipation. |
| 55 | Scientific name: *Kalanchoe pinnata*. Lamm<br>Family: Crassulaceae<br>Common name: Patharkuchi<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Diuretic, wound healing, inflammatory activity. | 56 | Scientific name: *Azadirachta indica* A. Juss.<br>Family: Meliaceae<br>Common name: Neem<br>Habit: Herb<br>Parts used: Whole plant, Leaves,<br>Uses: Leucoderma, piles, wounds, all types of skin inflammation. |
| 57 | Scientific name: *Nyctanthus arbortristis* Linn.<br>Family: Oleaceae<br>Common name: Sheuli<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Dry cough, Sciatica, arthritis, Dengue fever, ringworm. | 58 | Scientific name: *Termelia arjuna* (Roxb) Wight & Ara.<br>Family: Combrteceae<br>Common name: Arjun<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Hypolipiderma, reduced cholesterol level, a cardiac stimulant. |
| 59 | Scientific name: *Ocimum sanctum* L.<br>Family: Lamiaceae<br>Common name: Tulshi<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Common cold & antiseptic. | 60 | Scientific name: *Crotalaria juncea* L.<br>Family: Fabaceae<br>Common name: Atashi<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: To treat urinary problems, Eczema, and skin problems. |
| 61 | Scientific name: *Swietentia mahagoni* (L) Jacq<br>Family: Meliaceae<br>Common name: Mehogani<br>Habit: Tree<br>Parts used: Bark, Leaves and seed<br>Uses: Cure colon cancer, boost immunity, and reduce cholesterol level. | 62 | Scientific name: *Mentha arvenensis* Linn.<br>Family: Lamiaceae<br>Common name: Pudina<br>Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Antiseptic, diuretic digestive |
| 63 | Scientific name: *Emblica officinalis* L.<br>Family: Euphorbiaceae<br>Common name: Amlaki | 64 | Scientific name: *Mimusops enlengi* L.<br>Family: Sapotaceae<br>Common name: Bakul |

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| | Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Antioxidant | | Habit: Herb<br>Parts used: Whole plant, Leaves<br>Uses: Prevent bleeding of gum, used to treat dental caries and pyorrhea. |
| 65 | Scientific name: *Aerva aspera* L.<br>Family: Amaranthaceae<br>Common name: Apang<br>Habit: Herb<br>Parts used: Whole plant and seed<br>Uses: Used for treatment of depression, anxiety, and hydrophobia. | 66 | Scientific name: *Crenum asiaticum* L.<br>Family: Amaryllidaceae<br>Common name: Sukha darshan<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Leaves are used in carbuncle, cancer and wounds. |
| 67 | Scientific name: *Aloe berberadensis* Mill.<br>Family: Liliaceae<br>Common name: Ghrita kumari<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Joint pain, skin disease, liver problem. | 68 | Scientific name: *Rauvolfia serpentine* (wall.) Benth. ex. Hook. f.<br>Family: Apocynaceae<br>Common name: Sarphagandha<br>Habit: Herb<br>Parts used: Roots and seeds<br>Uses: Hypertension, reduce high blood pressure. |
| 69 | Scientific name: *Gomphrena globosa*<br>Family: Amaranthaceae<br>Common name: Botam phul<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Cough, diabetes, oliguria (child) | 70 | Scientific name: *Euphorbia ayapana* Vent.<br>Family: Euphorbiaceae<br>Common name: Ayapon<br>Habit: Herb<br>Parts used: Leaves<br>Uses: Leaves used in antiseptic, haemorrhage, foul ulcer, stomachache, anti-bacterial, and anti-fungal. |
| 71 | Scientific name: *Amaranthus spinosus* L.<br>Family: Amaranthaceae<br>Common name: Kata Notey<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: Whole plant as laxative, diuretic, stomachic, antipyretic, improve appetite, hallucination, bronchitis, Leucorrhoea | 72 | Scientific name: *Andrographis paniculata* (Brum. f.) Wall. ex. Nees<br>Family: Acanthaceae<br>Common name: Kal Megh<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: Whole plant is used for fever, dyspepsia, scabies, leprosy, whooping cough, liver disorders, and loss of appetite. |
| 73 | Scientific name: *Amaranthus viridis* L.<br>Family: Amaranthaceae<br>Common name: Bon Notey<br>Habit: Herb<br>Parts used: Whole plant | 74 | Scientific name: *Cassia tora* L.<br>Family: Caselpinaceae (Fabaceae)<br>Common name: Chakwar<br>Habit: Herb<br>Parts used: Seed and Leaves |

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| | Uses: Whole plant used in stomachic, diuretic, colic pain, piles, gonorrhea, and Root- stop bleeding from cut wounds. | | Uses: Leaves used in dysentery and skin disease. |
| 75 | Scientific name: *Carrica papya*<br>Family: Caricaceae<br>Common name: Pepe<br>Habit: Small tree<br>Parts used: Fruit and Milky juice, and leaves<br>Uses: The milky juice of fruit is used to remove blemishes, antihelminths, diuretics, constipation, glandular tumors, and eczema. | 76 | Scientific name: *Curcuma longa* L.<br>Family: Zingiberaceae<br>Common name: Halud<br>Habit: Herb<br>Parts used: Rhizome<br>Uses: Anti-oxidant, anti-inflammatory, anti-microbial and have healing properties |
| 77 | Scientific name: *Paederia foetida* L.<br>Family: Rubiaceae<br>Common name: Gadal<br>Habit: Climber, Herb<br>Parts used: Whole plant<br>Uses: Rheumatism, Leaves- applied to urinary infection, urinary bladder stone, flatulence, diarrhoea and dysentery, Fruit- toothache, Root- piles and liver inflammation. | 78 | Scientific name: *Tridax procumbens*.<br>Family: Asteraceae<br>Common name: Tridakha<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: Wound healing, anti-coagulant, anti-fungal and insect repellent, infectious skin disease, liver disorder, gastritis, heart burn. |
| 79 | Scientific name: *Pouzolzia indica*.<br>Family: Uitriaceae<br>Common name: Tuici<br>Habit: Herb<br>Parts used: Leaves and root<br>Uses: Leaves used in gangrenous ulcers, syphilis and gonorrhea, tumor and cancer. | 80 | Scientific name: *Commelina benghalensis*.<br>Family: Comelinaceae<br>Common name: Kansira<br>Habit: Herb<br>Parts used: Whole plant.<br>Uses: Leprosy, infertility in women, sore throat and burns, diarrhoea. |
| 81 | Scientific name: *Agaratum conyzoids*<br>Family: Asteraceae<br>Common name: Uchunti<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: (i) Whole plant: The whole plant is anti-inflammatory and anti-allergic. Its juice is used for healing wounds, cuts, etc.<br>(ii) Leaves: The fume of dried leaves used as mosquito repellents. | 82 | Scientific name: *Sida cordifolia* Linn.<br>Family: Malvaceae<br>Common name: Bala<br>Habit: Erect perennial herb<br>Parts used: Roots, Leaves and bark<br>Uses: (i) Root juice: Healing the wounds<br>(ii) Leaves: Used in ophthalmia, a decoction of a plant used in piles. It also used for respiratory troubles.<br>(iii) Barks: It is used as an astringent |
| 83 | Scientific name: *Sonchus arvensis* Linn.<br>Family: Asteraceae<br>Common name: Dudhi<br>Habit: Annual herb | 84 | Scientific name: *Piper longum L.*<br>Family: Piperaceae<br>Common name: pipul<br>Habit: Climber |

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| | Part Uses: Roots and leaves<br>Uses: Root-useful in jaundice and leaves - cooling, sedative, diuretic, useful in cough, bronchitis and asthma | | Parts uses: Seed and leaves<br>Uses: Commonly used in chronic bronchitis, asthma, constipation, gonorrhea, paralysis of the tongue, diarrhea, cholera, malaria and respiratory trouble |
| 85 | Scientific name: *Ricinus communis* Linn.<br>Family: Euphorbiaceae<br>Common name: Varenda<br>Habit: Annual Shrubs<br>Parts Uses: Leaves and seed<br>Uses: Seed oil is purgative, and leaf paste is used as poultice on sore, gout, or rheumatic swelling. | 86 | Scientific name: *Phyllanthus niruri* Auct.<br>Family: Phyllanthaceae<br>Common name: Bhui amla<br>Habit: Annual Herbs<br>Part uses: Whole plant<br>Uses: The seed is used to treat jaundice and liver disease. The whole plant is used to treat gonorrhea, menorrhagia, and other genital diseases. The leaves are used to treat stomachic, dysentery, and ulcer diseases. |
| 87 | Scientific name: *Oxalis corniculata* Linn.<br>Family:- Oxalidaceae<br>Common name: Amrul<br>Habit: Small perennial Herb<br>Parts Uses: Entire plant<br>Uses: Pant is used to treat scurvy, influenza fever, urinary tract infection, muscular swelling and in stomachic | 88 | Scientific name: *Heliotropium indicum* Linn.<br>Family: Boraginaceae<br>Common name: Hatisur<br>Habit: Erect annual herbs<br>Parts Uses: Leaves<br>Uses: Leaves - applied to boils, ulcers, wounds, and in stings of insect |
| 89 | Scientific name: *Ocimum basilicum* Linn.<br>Family: Lamiaceae<br>Common name: Babui tulsi<br>Habit: Branched scented herb<br>Part Uses: Whole plant<br>Uses: The root is used in children's bowel complaints, the seed is useful in dysentery and diarrhoea, the flower is diuretic and carminative, and the Leaves are used in respiratory trouble. | 90 | Scientific name: *Nicotiana plumbaginifolia* Viv.<br>Family: Solanaceae<br>Common name: Bon tamak<br>Habit: Annual Herbs<br>Parts Uses: Leaves<br>Uses: Sedatives, emetic, and anticeptics are used to treat rheumatic pain, swelling and skin disease. |
| 91 | Scientific name: *Nerium olenader* Linn.<br>Family: Apocynaceae<br>Common name: Rakta karabi<br>Habit: Small tree<br>Parts Uses: Leaves and roots<br>Uses: Root bark is used in skin diseases of a scaly nature and leprosy. Leaf paste is used to reduce swelling. | 92 | Scientific name: *Cajanus cajan* (Lin) Mill<br>Family: Papilionaceae (Fabaceae)<br>Common name: Arahar<br>Habit: Shrub<br>Parts uses: Leaves and seeds<br>Uses: Leaves are used to treat cough, bronchitis, diarrhoea, sores, wounds, and liver problems. Seeds are used to |

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| | | | treat mouth ulcers, tumors, and vomiting. |
| 93 | Scientific name: *Nymphaea stellata* Wild.<br>Family: Nymphaeaceae<br>Common name: Saluk<br>Parts used: Whole plants, seeds, flower<br>Uses: i) It has antiseptic and anti-microbial properties.<br>ii) It is used to treat chronic diarrhoea.<br>iii) Seed: Seed is used for diabetes<br>iv) Flower: Flower cooling is used as an astringent for piles, liver disease | 94 | Scientific name: *Lawsonia inermis* Lin.<br>Family: Lythraceae<br>Common name: Mehendi<br>Habit: Shrub<br>Parts used: Leaves and Bark<br>Uses: Bark is useful in jaundice, spleen enlargement, and skin disease. Leaves are externally used for headaches, hair growth promotion, and burning feet. |
| 95 | Scientific name: *Mimosa pudica* Linn.<br>Family: Mimosaceae (Fabaceae)<br>Common name: Lajjabati<br>Habit: Small prostrate diffuse herb<br>Parts used: Root and leaves<br>Uses: i) Root and leaves: Root and leaves are used in piles and fistula.<br>ii) Leaves: The pest of Leaves is applied to cure for hydrocele. | 96 | Scientific name: *Boerhaavia repens* L.<br>Family: Nyctaginaceae<br>Common name: Punarnava<br>Habit: Branched diffused herbs<br>Parts use: Whole plant<br>Uses: i) Whole plant is diuretic, laxative, expectorant, useful in asthma, diarrhoea, dysentery, Oedema, anaemia, Jaundice, Cholera |
| 97 | Scientific name: *Euphorbia hirta* Linn.<br>Family: Euphorbiacea<br>Common name: Dudurli<br>Habit: Herb<br>Parts used: Whole plant<br>Uses: i) The Plant is used in children's diseases, such as worms, bowel complaints, coughs, bronchial infections, asthma, and dysentery. | 98 | Scientific name: *Acalypha indica* Linn.<br>Family: Euphorbiacea<br>Common name: Muktojhuri<br>Habit: Erect annual herbs<br>Parts used: Root, leaves<br>Uses: Root: Decoction of root is emetic, expectorant and useful in pneumonia and asthma.<br>ii) Leaves: Laxative and also used in scabies. |
| 99 | Scientific name: *Croton bonplandianum* L.<br>Family: Euphorbiacea<br>Common name: Bontulsi<br>Habit: Erect much-branched herb<br>Parts used: Root, bark, seed and leaf<br>Uses: Seed and bark are used for the treatment of jaundice, acute constipation<br>ii) Leaves are used for the treatment of ring worm, bronchitis, asthma and body swelling | 100 | Scientific name: *Solanum nigram* Linn.<br>Family: Solanaceae<br>Common name: Kakamachi<br>Habit: Annual herb<br>Parts used: Leaves, fruits<br>Uses: (i) The Leaf is used to treat skin diseases like scabies, ringworm, swelling, and herpes.<br>(ii) Leaf juice used for the treatment of rat bites.<br>(iii) Leaves, fruits: Leaf and fruit used in asthma. |
| 101 | Scientific name: *Physalis minima*<br>Family: Solanaceae | 102 | Scientific name: *Vernonia cinerea* Linn. |

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| | Common name: Bantepari or patka<br>Habit: Small annual Herb<br>Parts used: Fruit and leaf<br>Uses: leaves used for treatment of diabetes, jaundice, leprosy, measles, worm manifestation<br>ii) Fruit used as diuretic and purgative | | Family: Asteraceae<br>Common name: Kukasim<br>Habit: Perennial herb<br>Parts used: Entire plant<br>Uses: (i)The paste of the leaves and stems is used to treat wounds, localize swelling, elephantiasis, and skin diseases. (ii) Roots and leaves are also used for constipation. |
| 103 | Scientific name: *Eclipta alba*<br>Family: Asteraceae<br>Common name: Keshuth<br>Habit: Herb<br>Parts used: Leaves and root.<br>Uses: Root-emeti is a purgative and can be applied externally as an antiseptic to ulcers and wounds. The leaves are useful for jaundice and also promote hair growth. | 104 | Scientific name: *Scoparia dulcis*<br>Family: Plantaginaceae<br>Common name: Bon dhone<br>Habit: Small Herb<br>Parts used: Leaves<br>Uses: Traditionally used in diabetes, dysentery, headache, toothache, earache and stomach problems. |
| 105 | Scientific name: *Cassia occidentalis* L.<br>Family: Caesalpiniaceae (Fabaceae)<br>Common name: Chakor<br>Habit: Small shrub<br>Parts used: Whole plants<br>Uses: Plant- purgative, diuretic, febrifuge, tonic and used fully in skin disease | 106 | Scientific name: *Cassia alata* L.<br>Family: Caesalpiniaceae ( Fabaceae)<br>Common name: Dadmari<br>Habit: Shrub<br>Parts used: Leaves,<br>Uses: i) Leaves: Leaves are used for asthma, diuretics, purgatives, ringworms, and other skin diseases. |
| 107 | Scientific name: *Cyperous rotundus* L.<br>Family: Cyperaceae<br>Common name: Muthaghas<br>Habit: Herb<br>Parts used: Herb, Rhizome/<br>Uses: 2-3 teaspoons of rhizome extract or paste of (5 rhizomes) are used to treat for eliminating female infertility and irregular menstrual cycle 21 days after every menstrual cycle. | 108 | Scientific name: *Euphorbia meriifolia*<br>Family: Euphorbiaceae<br>Common name: Manasa Gach<br>Habit: Shrub,<br>Parts used: old Leaves<br>Uses: Dry cough, chest pain, broken bone pain. |
| 109 | Scientific name: *Barleria lupulina* Lindl.<br>Family: Acanthaceae<br>Common name: Kata Bishalya Karani<br>Habit: Shrub<br>Parts used: Leaves<br>Uses: Eczema, stop bleeding from cuts and wounds and accelerate their recovery. | 110 | Scientific name: *Stephania japonica* (Thumb) Miers<br>Family: Meninspermaceae<br>Common name: Nemuwa<br>Habit: Climber,<br>Parts used: Stem, Leaves<br>Uses: Rheumatic pain, arthritis, broken bone pain, joint pain |

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| 111 | Scientific name: *Jatropha gossypifolia* Linn.<br>Family: Euphorbiaceae<br>Common name: Lal Vanda<br>Habit: Shrub<br>Parts used: Exudates<br>Uses: Dysentery, skin diseases, rheumatism | 112 | Scientific name: *Cinnamomum aromaticum* J.Graham<br>Family: Lauraceae<br>Common name: Dar-chini.<br>Habit: Tree<br>Parts used: Bark<br>Uses: flatulence, loss of appetite, abdominal pain, diarrhea, inflame, leukorrhea, vaginitis, rheumatism and toothache |
| 113 | Duranta<br>Scientific name: *Duranta erecta* L.<br>Family:-Verbenaceae<br>Common name: Duranta<br>Uses:- Mosquito repellant, used to treat jaundice | 114 | Kul<br>Scientific name:-*Ziziphus jujube* Mill.<br>Family: Rhamnaceae<br>Common name:- Kul<br>Uses: Used for treat fever, wound ulcer, leaves used for anti-helminthes. |

**Table 2: Bioactive Components and Therapeutic Activity of some Medicinal Plants**

| Sl. No. | Common Name | Bioactive Components | Therapeutic Activity |
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| 1 | Tulsi | Tannins, flavonoids, eugenol, caryophyllenes, carvacrol, linalool, tulsinol, camphor, cinnamyl acetate, etc. (Prakash and Gupta, 2005). | Antimicrobial, anti-inflammatory, antioxidant, cardio-protective, anti-diabetic, anti-carcinogenic, analgesic, immunomodulatory, and more (Cohen, 2014). |
| 2 | Neem | Azadirachtin, nimbolinin, nimbin, nimbidin, nimbidol, quercetin, and more (Sarkar et al., 2021). | Antioxidant, anti-inflammatory, anti-cancer, anti-diabetic, antimicrobial and antiviral activity (Sarkar et al., 2021). |
| 3 | Patharkuchi | Tannins, steroid glycosides, flavonoids, polyphenols, triterpenoids, quercetin, bufadienolides, quercitrin, etc. (Khan et al., 2018). | Anthelmentic, wound healing, antinociceptive, anti-inflammatory, antidiabetic, nephroprotective, antioxidant, antimicrobial, analgesic activity (Khan et al., 2018). |
| 4 | Lajjabati | Mimosine, terpenoids, flavonoids, glycosides, alkaloids, phenols, tannins, saponins, coumarins, etc. (Gandhiraja et al., 2009). | Wound healing, antidepressant, antifertility, anti-diuretic activity. (Rajendran and Sundararajan 2010). |
| 5 | Halud | Curcumin, dimethoxy-curcumin, bisdemethoxy-curcumin and numerous secondary metabolites. (Jyotirmayee et al., 2023). | Anti-inflammatory, antioxidant, beneficial in metabolic syndrome, arthritis, anxiety and |

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| | | | hyperlipidemia activity. (Jyotirmayee et al., 2023). |
| 6 | Darchini | Cinnamic aldehyde, eugenol, tannin, mucilage, cinnamate, essential oils, etc. (Rao and Gan, 2014). | Antimicrobial, antioxidant, antidiabetic, anti-inflammatory, toothache relief (Rao and Gan, 2014). |
| 7 | Noni | Alkaloids, terpenoids, saponins, flavonoids, steroids, anthraquinones, ascorbic acid, etc. (Assi et al., 2017; Sarkar et al., 2022). | Protection against smoke-induced DNA damage, joint health improvement, immune activity enhancement, anti-oxidant effects (Assi et al., 2017; Sarkar et al., 2022). |
| 8 | Prishiparni | Alkaloids, saponins, flavonoids, glycosides, proteins, steroids, tannins, phytosterols, etc. (Aswathy and Ansary, 2022). | Antiseptic properties, treatment of wounds, genitourinary infections, urinary disorders, heart troubles, anti-inflammatory (Aswathy and Ansary, 2022). |
| 9 | Atashi | Alkaloids, carbohydrates, proteins, saponins, tannins, triterpenoids, fixed oils, etc. (Sinan et al., 2020). | Antioxidant, antipyretic, hepatoprotective, antibacterial, nephroprotective, hair and bone strength improvement & treatment for cancers (Sinan et al., 2020). |
| 10 | Aijawan | Carbohydrates, glycosides, saponins, phenolic compounds, volatile oil (thymol, γ-terpinene, paracymene), etc. (Bairwa et al., 2012). | Antifungal, antioxidant, antimicrobial, antinociceptive, hypolipidemic, antihypertensive, broncho-dilating actions (Bairwa et al., 2012). |
| 11 | Pudina | Carvone, carvacrol, camphene, limonene, menthone, linalool, p-cymene, germacrene D, etc. (El Menyiy et al., 2022). | Cancer prevention, anti-obesity, antimicrobial, anti-inflammatory, anti-diabetic, cardioprotective (El Menyiy et al., 2022). |
| 12 | Jibanti | α-amyrin, β-amyrin, ferulic acid, luteolin, diosmetin, rutin, β-sitosterol, stigmasterol, etc. (Das and Bisht, 2012). | Anti-cancer, antioxidant, anti-asthmatic, hepatoprotective, antimicrobial, anti-inflammatory, activity against tuberculosis (Das and Bisht, 2012). |
| 13 | Amlaki | Apigenin, luteolin, myricetin, phenolic acids, flavonoids, tannins, ellagic acid, ascorbic acid, etc. (Bhat et al., 2019; Acharya et al., 2021a, 2021b, 2022). | Antioxidant, antihyperlipidemic, cardioprotective, antidiabetic, gastroprotective, neuroprotective, anti-Alzheimer's, anti-ulcer activity (Bhat et al., 2019; |

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| | | | Acharya et al., 2021a, 2021b, 2022). |
| 14 | Shalparni | N-dimethyltrytryptamine, hypaphorine, horedinine, desmodine, caudicine, gangetinin, gangetin, etc. (Joshi et al., 2023). | Bronchitis management, antistress, antibacterial, and wound healing (Joshi et al., 2023). |
| 15 | Atibol | Mucilaginous compounds, alkaloids, flavonoids, essential oils (α-pinene, geraniol, etc.), saponins, etc. (Silva et al., 2021). | Fever, hematuria, leprosy, bronchitis, diarrhea, gonorrhea, toothache relief, bladder inflammation, hemorrhagic septicemia (Silva et al., 2021). |
| 16 | Sonajhuri | Hydroxyl-substituted flavonoids, chalcone, methylated teracacidins, fatty acid composition, etc. (Teli, 2013). | Anti-helminthic, anti-filarial, microbicidal, rheumatism treatment (Teli, 2013). |
| 17 | Kansira | Flavonol glycosides, antimicrobial compounds, haemagglutination activity, etc. (Sharma et al., 2020). | Hepatoprotective, anti-inflammatory, antitumor, antimicrobial, haem-agglutination activity (Sharma et al., 2020). |
| 18 | Aporajita | Alkaloids, saponins, tannins, phenolic compounds, flavonoids, pentacyclic triterpenoids, etc. (Multisona et al., 2023). | Hepatoprotective, antidiabetic, antioxidant, anti-inflammatory, anti-asthmatic, anti-leprosy and anti-tuberculosis (Multisona et al., 2023). |
| 19 | Kari Pata | Crystalline glycosides, folic acid, calcium, zinc, volatile oils, murragin, etc. (Balakrishnan et al., 2020). | Anticancer, hypoglycemic, anti-hypercholesterolemic, dental health, mosquito-killing properties (Balakrishnan et al., 2020). |
| 20 | Harjora | Quercetin, kaempferol, beta-carotene, ascorbic acid, tetracyclic triterpenoids, steroidal principles, etc. (Kumar, 2019). | Bone growth promotion, anti-inflammatory, antibacterial, antioxidant, pain relief (Kumar, 2019). |
| 21 | Sheuli | Glycerides, polysaccharides, nyctanthic acid, linoleic acid, tannic acid, phenylacetaldehyde, etc. (Hiremath et al., 2016). | Antimicrobial, anti-inflammatory, antipyretic, and anthelmintic properties (Hiremath et al., 2016). |
| 22 | Mahua | Alkaloids, carbohydrates, proteins, saponins, tannins, triterpenoids, etc. (Jha and Mazumder, 2018). | It is anti-inflammatory, antitumor, hepatoprotective, lowers blood pressure, heals wounds, and reduces fever (Jha and Mazumder, 2018). |

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| 23 | Rakta kanchan | Flavonol glycosides, antimicrobial compounds, haemagglutination activity, etc. (Mali et al., 2007). | Worm infestation treatment, wound healing, antitumor properties, antimicrobial activity, and anti-inflammatory effects (Mali et al., 2007). |
| 24 | Chaya | Phytochemical studies revealed the presence of carbohydrates, triterpenoids, flavonoids, glycosides and phenolic compounds (Mandal and Madan, 2016). | Antiurolithiatic, diuretic, hepatoprotective, anticancer, immunomodulatory, antioxidant, antimicrobial (Mandal and Madan, 2016). |
| 25 | Jarman lota | Mikanolide, dihydromikanolide, sterols, diterpenes, polyphenols, flavonoids (Khan et al., 2023). | Antimicrobial, analgesic, hypotensive, anti-inflammatory, immune-enhancing, and traditional use for cuts, bruises, and wounds (Khan et al., 2023). |
| 26 | Bontulsi | Alkaloids, Flavonoids, Phenols, Saponins, Anthocyanins, Phenolics, Alkaloids and Aromatic benzoids (Sharma et al., 2022). | Antioxidant, Antidiabetic and anti-inflammatory activities (Sharma et al., 2022). |
| 27 | Labanga | Vitamin, Phenolic acids, Flavonoids, Isothiocyanates, Tannins, and Saponins (Vergara-Jimenez et al., 2017). | Hypercholesteromia, High Blood Pressure, Anti-diabetic, Anti-cancer and Anti-inflammatory activities (Vergara-Jimenez et al., 2017). |
| 28 | Bazradanti | Terpenoid, Phenylethanoid glycoside, Iroid glycosidae, Phytosterols, Flavanoid, Phenolic acid (Gangaram et al., 2021). | Antimicrobial, anthelmintic, antifertility, antioxidant, antidiabetic, anti-inflammatory, anti-arthritic, cytoprotective, hepatoprotective, diuretic, antidiarrhoeal, enzyme inhibitory and anti-nociceptive activities (Banerjee et al., 2012). |
| 29 | Ash shaowra | Sesquiterpene, Diterpene, Fatty acid, Alkaloids (Prakasia and Nair, 2015). | Anti-microbial, Anti-inflammatory, anti-cancer, Phytotoxic inhibitor, Antioxidant, Anti-microbial (Prakasia and Nair, 2015). |
| 30 | Bel | Coumarin, Xanthotoxol, Imperatorin, Aegeline, and Marmeline (Pathirana et al., 2020) | Antidiabetic, Anticancerous, Antifertility, Antimicrobial, Immunogenic, and Insecticidal activities (Pathirana et al., 2020). |

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| 31 | Bara cooksina | Alpha-amyrin, ß-sitosterol, acetates, hentriacontane, stigmasterol, lupeol and lupeol acetate (Fanta et al., 2019). | Antipyretic, anti-inflammatory, anthelmintic, diuretic, antidiarrheal, antimicrobial, cytotoxic, astringent, hepatoprotective, sedative, anxiolytic, anti-viral, analgesic, hypothermic, anti-bacterial, anti-atherothrombotic, anti-leukemic and tranquilizing effects Fanta et al., 2019). |
| 32 | Jalpai | Flavanoids, Cardiac glycosides, Anthraquinone-glycosides, Steroids, Terpenoids, Quinones and Phenols (Sircar et al., 2017). | Anti-Bacterial activities (Sircar et al., 2017). |
| 33 | Pachouri | Terpenoids, Sesquiterpenoids, Phytosterols, Fatty acids, Glycosides, and Volatile oil (El-Saber et al., 2020). | Antibacterial, Antifungal, Analgesic, Insect repellent, Antiplatelet, Fibrinolytic, Antioxidant, Antithrombotic and Antidepressant (El-Saber et al., 2020). |
| 34 | Lebughash | Myrcene, Limonene, Citral, Geraniol, Citronellol, Geranyl Acetate, Neral, and Nerol (Lawalet al., 2017). | Antimicrobial, Anti-inflammatory, Antidiabetic and Anticancer (Lawal et al., 2017). |
| 35 | Nimukha | Flavonoids, Lignans, Steroids, Terpenoids and Coumarins (Semwal et al., 2010). | Analgesic, Anti-inflammatory and Bacteriostatic activities (Semwal et al., 2010). |
| 36 | Keu | Bioactive constituents like diosgenin, gracillin, dioscin, eremanthin, costunolide, β-sitosterol, β-D-glucoside, β-carotene, α-tocopherol quinine, dihydrophytylplastoquinone. (Sohrab et al., 2021). | Disease Resistance, Eye Diseases, Depurative, Anti-stress, Fertility Control (Sohrab et al., 2021). |
| 37 | Lal Vanda | Alkaloids, Coumarins, Flavonoids, Lignoids, Phenols, Saponins, Steroids, Tannins, and Terpenoids (Félix-Silva et al., 2014). | Antihypertensive, Anti-inflammatory, Antiophidian, Analgesic, Antipyretic, Antimicrobial, Healing, Antianemic, Antidiabetic and Antihemorrhagic activities (Félix-Silva et al., 2014). |

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| 38 | Lal vishyalikarani | Dimethyl Sulfaxide, 1H-Imidazale, Silicic acid, diethyl bis(trimethylsilyl) ester, Cycloheptasiloxane tetradecamethyl-, cyclononasiloxane octadecamethyl-, and cyclodecasiloxane eicosamethy (Andleeb et al., 2020). | Anti-inflammatory, Anti-viral, and Antioxidant effects (Andleeb et al., 2020). |
| 39 | Patpati | Flavonoids, Lignans, Coumarins, Alkaloids, Triterpenes, Sterols, Phenolic Glycosides, Phenyl ethanoids, Megastigmane Glycosides, Benzoxazinoid Glucosides (Samy, M. et al., 2015). | Wound healing, Cardiovascular, Anti-hyperglycemic, Antioxidant, Antimicrobial, Antibacterial, Anticancer, Antinociceptive, Anti-inflammatory, Aytotoxic and Gastroprotective activities, Purgative and Angiotensin-converting enzyme-inhibitory effects, Estrogenic and Cholinergic properties and Antifertility action (Samy et al., 2015). |
| 40 | Hijol | 3,3'-dimethoxy ellagic acid, Dihydromyticetin, Gallic acid, Bartogenic acid, Stigmasterol, Barringtogenic acid, Tangulic, and Acutangulic acids (Kaur et al., 2013). | Anti-nociceptive, anti-inflammatory, and Anti-helminth activities (Kaur et al., 2013). |
| 41 | Talakuch | Terpenoids, steroids, carotenoids, and flavonoids (Jamwal and Kumar, 2015). | Antiinflammatory, Antipyretic, Antimicrobial, Antidiabetic, Antiulcer, Antioxidant activities (Jamwal and Kumar, 2015). |
| 42 | Ananta mul | 2-hydroxy-4-methoxy benzaldehyde, dimethylbenz(*a*)anthracene (DMBA) and 12-*O*-tetradecanoyl phorbol-13-acetate (TPA), tannins, saponins, and flavonoids (Aikat et al., 2023). | Anti-cancer, Anti-Inflammatory, Anti-microbial, Cardio-protective, Anti-diabetic, and Anti-oxidant activities (Aikat et al., 2023). |
| 43 | Jam | Myricetin, Quercetin, 3-*O*-b-D-xylopyranosyl, (1-2) a-L-rhamno-pyranosides, Phenylbutazone and Indomethacine, Flavanoids, Pedunculagin, Casuarinin, Tellimagrandin I, Strictinin, Casuarictin, 2,3-HHDP-glucose and Tellimagrandin II (Mohanty and Cock, 2010). | Anti-microbial and Anti-inflammatory activities (Mohanty and Cock, 2010). |
| 44 | Nagdola | α-Pinene, Camphene, Sabinene, p-Mentha-1(7), 1-Octen-3-ol, β-Myrcene, Yomogi alcohol, 1,3-Cyclohexadiene,1- | Anti-bacterial and Anti-fungal activities (Singh et al., 2023). |

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| | | methyl-4-(1-methylethyl)-, o-Cymene, Linalool, 1,7-Octadien-3-one,2-methyl-6-methylene-, (-)-Alcanfor, Isobornyl formate, trans-Verbenol, endo-Borneol, 5,10-Pentadecadiyn-1-ol, Caryophyllene oxide, (-)-Globulol, 2-Methyl-3-(3-methyl-but-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane, Cedren-13-ol, 8-, 11,11-Dimethyl-4,8-dimethylenebicyclo [7.2.0]undecan-3-ol, Dihydro-cis-α-copaene-8-ol, 10-epi-γ-Eudesmol, 10-Epijuneol (Singh et al., 2023). | |
| 45 | Ashok | Alkaloids, Flavonoids, Glycosides, Saponins, Phenols, Steroids, Tannins and Triterpenoids (Mohan et al., 2013). | Antibacterial CNS depressant, Anti-pyretic, Anthelmintic and Analgesic activities (Mohan et al., 2013). |
| 46 | Nishinda | Lignans, volatile oils, glycosides, alkaloids, polyphenolic chemicals, p-hydroxybenzoic acid, etc. (Ahuja et al., 2015). | Germicidal properties include treatment for eczema, abscesses, rheumatism, asthma, jaundice, toothaches, and fever (Ahuja et al., 2015). |
| 47 | Nayantara | 130 alkaloids predominantly ajmalcine, vinceine, resperine, vincristine, vinblastine and raubasin (Sarma, 2016; Dubey et al., 2020). | Anticancer, Antidiabetic Activity, hypoglycemic, anti-hypercholesterolemic, are utilized for the therapy of different kinds of malignancy, for example, Hodgkin's sickness, bosom disease, skin disease and lymphoblastic leukemia (Sarma, 2016; Dubey et al., 2020). |
| 48 | Awshagandha | Alkaloids, Steroidal lactones, and Flavonoids (Ahmad and Dar, 2017). | Antiinflammatory, Antitumor, Neuroprotective, Antimicrobial, Antistress, Antidiabetic, and Cardioprotective (Ahmad and Dar, 2017). |
| 49 | Alach | 8-cineole, limonene, Sabinene, Terpinenes, Pinenes, Terpinols, Essential oils, Flavonoids, Carbohydrates, Fats, Glycosides (Subulin, Petunidin-3,5-diglucoside, others) (Bisht et al., 2011). | Anti-microbial, Anti-oxidant, Anti-inflammatory, Anti-ulcer, Hepatoprotective activity, Cardiac-adaptogen, and Analgesic properties (Bisht et al., 2011). |

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| 50 | Bamunhati | Alkaloids, Flavonoids, Glycosides, Terpenoids, and Tannins (Wang et al., 2018). | Anti-inflammatory, Anti-nociceptive, Anti-oxidant, Anti-hypertensive, Anticancer, Antimicrobial, Anti-diarrheal, Hepatoprotective, Hypoglycemic and Hypolipidemic, and memory enhancing and Neuroprotective (Wang et al., 2018). |
| 51 | Payara | Flavonoids, Tannins, Phenols, Alkaloids, Triterpenes, Saponins, Carotenoids, Lectins, Vitamins, Carbohydrate, Fiber fatty acids, and Glycosides (Ugbogu et al., 2022). | Antidiabetic, Antidiarrhoeal, Hepatoprotective, Anti-cancer, Anti-oxidant, Anti-inflammatory, Antiestrogenic, and antibacterial activities (Ugbogu et al., 2022). |
| 52 | Vashak | Quinazoline alkaloids, Vasicine, Vasicinone, Vasicine acetate, 2-acetyl benzyl amine, Saponins (Maddineni et al., 2023). | Antiarthritis, Antiseptic, Antimicrobial, Anti-tuberculosis, Anti-inflammatory and Abortifacient properties (Maddineni et al., 2023). |
| 53 | Bhringaraj | Apigenin, Phenolic, Flavanoids (Islam et al., 2021). | Anti-cancer, Anti-hepatotoxic, Antiinflammatory, Anti-microbial and Anti-oxidant activities (Islam et al., 2021). |
| 54 | Haritaki | Chebulagic acid, Chebulinic acid, Gallic acid, Ellagic acid, Tannic acid, Corilagin, Polyphenolic compounds, Triterpenoids, and Ascorbate (Gupta et al., 2021). | Antioxidant, Antiinflammatory and Analgesic activities (Gupta et al., 2021). |
| 55 | Satamuli | Steroidal saponins and Flavonoids (Mishra and Verma, 2017). | Antioxidant, Antimicrobial, Antiviral, Anticancer, Anti-inflammatory, Antidiabetic, Cooling, moisturizing, Aphrodisiac, Laxative, Stomachic, Diuretic and Antiseptic (Mishra and Verma, 2017). |
| 56 | Lankaseji | Tirucalicine, Cyclotirucanenol, Cycloeuphordenol, Euphorginol, Lupeol (Gupta et al., 2013) | Anantibacterial, Molluscicide, Antiherpetic, and Antimutagenic, Anticrcinogenic (Gupta et al., 2013). |

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| 57 | Bishahari | Alkaloids, Flavonoids, Phenolic compounds, Steroids, Carbohydrate, Carotenoids and Terpenoids (Samy et al., 2008). | Antidiabetic, Antioxidant, Antinociceptive, Antimicrobial, Anticancer, Hepatoprotective, and Immunomodulatory activities (Samy et al., 2008). |
| 58 | Jerbo | Alkaloids, Flavonoids, Phenols, Steroids, and Terpenoids (Liew and Yong, 2016). | Analgesic, Antidiarrheal, Antimicrobial, Antioxidant, Antihypertensive, Antinociceptive, and Anti-inflammatory (Liew and Yong, 2016). |
| 59 | Thankuni | Triterpenes, Flavonoids and Vitamins (Seong et al., 2023). | Cardioprotection, Wound healing, and Neuroprotection, Anti-oxidant and Antitumor activities (Seong et al., 2023). |
| 60 | Kata Notey | Alkaloids, Flavonoids, Glycosides, Phenolic acids, Steroids, Saponins, Amino acids, Vitamins, Minerals, Terpenoids, Lipids, Betaine, Catechuic Tannins and Carotenoids (Peter and Gandhi, 2017). | Anti-cancerous, Anti-viral, Hepatoprotective, neuroprotective, Cardioprotective and Antidiabetic properties (Peter and Gandhi, 2017). |
| 61 | Kulekhara | Phytosterols, Fatty acids, minerals, polyphenols, proanthocyanins, mucilage, alkaloids, enzymes, amino acids, carbohydrates, hydrocarbons, flavonoids, terpenoids, vitamins, and glycosides (Kshirsagar et al., 2010). | Anti-tumor, Anti-inflammatory, Anti-pyretic, Hematopoetic and Hepatoprotective activities (Kshirsagar et al., 2010). |
| 62 | Chatim | Alkaloids, Terpenoids, Flavonoids, Phenolic acids, Fatty acids, Lignans, Esters (Zhao et al., 2023). | Antifungal, Anti-neoplastic, Antiplasmodial, Anti-inflammatory, Anti-bacterial, Antioxidant, Analgesic, and Radioprotective activities (Zhao et al., 2023). |
| 63 | Kaju | Phenolic compounds, Flavonoids, Alkaloids, Terpenoids, Steroids, Tannins, Saponins and Cardiac glycosides (Chen et al., 2023). | Anti-tumor, Anti-oxidant, Neuroprotective, Cardiovascular and cerebrovascular protection, Anti-diabetic, Gastroprotective, Anti-microbial, Anti-tyrosinase, Insecticide activities (Chen et al., 2023). |

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| 64 | Tuici | Friedelin,28-hydroxy-3-friedelanone and 7-methoxy-coumarin FFIII contained 6,7-dimethoxy-coumarin 4, scopoletin 5, methyl caffeate ,FFIV contained sitosteryl glucoside, glycosphingolipid (Sangsuwon et al., 2013). | anticancererous wound healing, antitumor, aniproliferative (Sangsuwon et al., 2013) |
| 65 | Gandharaj | Alkaloids, Saponins, Glycosides, Flavonoids, Phenols and Terpenoids (Reddy et al., 2021) | Antioxidant and Antimicrobial potential (Reddy et al., 2021). |
| 66 | Murga | Saponins, Tannins, Alkaloids, Alkenyl Phenols, Glycol-alkaloids, Flavonoids, Sesquiterpenes Lactones, Terpenoids and Phorbol esters (Anuradha and Mani, 2021). | Antipyretic, Analgesic, Antiinflammatory, Anti-arthritic, Antioxidant and Immuno-modulatory properties (Anuradha and Mani, 2021). |
| 67 | Pasan veda | Steroids, Flavonoids, Terpenoids, Fatty acids, Bufadienolides, Proteins, Peptides, Vitamins, and Polysaccharides (Samy et al., 2008). | Antimicrobial, Anti-ulcer, Antihypertensive, Antileishmanial, Anti-cancer, Antidiabetic, and Immuno-modulatory properties (Samy et al., 2008). |
| 68 | Arjun | Tannins, Alkaloids, Carbohydrates, Terpenoids, Steroids, Flavonoids, and Phenols (Amalraj and Gopi, 2016). | Antioxidant, Hypotensive, Anti-atherogenic, Anti-inflammatory, Anti-carcinogenic, Anti-mutagenic, and Gastro-productive effects (Amalraj and Gopi, 2016). |
| 69 | Mehogani | Azadirachtin, Nimbin, Swietenine, Meliacarpinin, and Azedarachin, Flavanoids, Terpenoids, Alkaloids (Moghadamtousi et al., 2013). | Antifungal, Antiviral, Anti-bacterial and Anti-inflammatory, Anti-cancer, Anti-diabetic, Anti-oxidant, Anti-ulcer activities (Moghadamtousi et al., 2013). |
| 70 | Duranta | Iridoid glycoside, Alkaloids, Flavonoids, Saponins, Terpenes, Tannins, and Sterols (Butle et al., 2020). | Antimalarial, Antibacterial, Antioxidant, and Cytotoxic activity (Butle et al., 2020) |
| 71 | Kul | Polyphenols, Flavonoids, Polysaccharides and Saponins (Chen et al., 2022). | Antioxidant, Antimicrobial, Anti-melanogenesis, Anti-inflammatory (Chen et al., 2022). |
| 72 | Bakul | Alkaloids, Flavonoids, Tannins, Phenolic Compounds, Terpenoids and Glycosides (Srivastava et al., 2023). | Antioxidant, Anti-cancer, Anti-inflammatory, Antiviral, Anti-diabetic, Anthelmintic, Antidotal, Analgesic, Antipyretic (Srivastava et al., 2023). |

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| 73 | Apang | Alkaloids, Flavonoids, Phenolics, Tannins, Polyphenols, Terpenes, Coumarins, Quinones, Lectins, Saponins (Ahmad et al., 2022). | Antimicrobial, Anti-cancerous, Anti-ulcer, Anti-inflammatory activities (Ahmad et al., 2022). |
| 74 | Sukha darshan | Cycloneolitsol, Hippeastrine, β-sitosterol and Alkaloids isolated (Molina-Cortés et al., 2023). | Anticancer, Immune-stimulating, Analgesic, Antiviral, Antimalarial, Antibacterial and Antifungal (Molina-Cortés et al., 2023). |
| 75 | Ghrita kumari | Alkaloids, phenolic acids, flavonoids, glycosides, and saponins (Mitra et al., 2023). | Anti-cancer, antimicrobial, antioxidant, and antidiabetic properties (Mitra et al., 2023). |
| 76 | Sarphagandha | Alkaloids, Reserpine, Ajmaline, Serpentine, Phenols, Tannins, Flavanoids, Saponins (Bunkar, 2017). | Anticholinergic, Hypotensive, Anticontractile, Sedative, Relaxant, Hyperthermic, Antidiuretic, Sympathomimetic, Hypnotic, Vasodialater, Antiemetic, Anti-fibrillar activity Tranquilizing agent, Anti-arrhythmic, Antifungal, Nematocidal and Anti-inflammatory (Bunkar, 2017). |
| 77 | Botam phul | Flavonoids, Saponin, Terpeneproteins, Tannins, Phenols, Alkaloids, and Steroids (Ningrum and Wijayanti, 2019). | Anti-oxidant, Anti-diabetic, Neural disorders, Cardiovascular (Ningrum and Wijayanti, 2019) |
| 78 | Ayapon | 29-nor-cycloartanol, lanost-8-en-3-ol, cycloartanol, kampferol-3,4'-dimethyl ether, 4-O-β-D-glucopyranosyl-2-hydroxy-6-methoxy-acetophenone, 4-O-α-L-rhamnosyl-(1→6)-β-D-glucopyranosyl-2-hydroxy-6-methoxy-acetophenone, quercetin-3-O-glucopyranoside, isoorientin (Aljubiri et al., 2021) | Anti-bacterial, Wound healing, Cytotoxic activities (Aljubiri et al., 2021). |
| 79 | Kal Megh | Diterpenoids, Flavonoids and Terpenoids (Mishra et al., 2007). | Hepatoprotective, antibacterial, anti-inflammatory, immunological, antiviral, anticancer, antimalarial, anti-filarial, antidiarrheal, antipyretic, antiallergic, treats central nervous system (CNS) ailments, gastrointestinal relief, cardiovascular health, treatment of snake bites (Mishra et al., 2007). |

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| 80 | Bon Notey | Carotenoids, Flavonoids, Phenolic, and Anthocyanin (Haider et al., 2023). | Antioxidant, Anti-inflammatory, Antibacterial, Antifungal, Antidiabetic and Antihelmintic properties (Haideret al., 2023). |
| 81 | Chakwar | Anthraquinone, Chrysophanic acid, Phenolics, Flavonoids and Anthocyanins (Islam et al., 2023). | Anti-oxidant, Anti-diabetic, Anti-fungal, Antihepatotoxic, Anti-genotoxic, Anti-mutagenic (Islam et al., 2023) |
| 82 | Pepe | Alkaloids, Saponins, Glycosides, Phenolic compounds and Flavonoids (Sharma et al., 2022). | Antidengue, Anticancer, Antidiabetic, Neuroprotective, and Anti-inflammatory effects (Sharma et al., 2022) |
| 83 | Gadal | Iridoid Glycosides, Flavone Glycosides, Anthraquinones and Terpenoids (Dutta et al., 2023). | Analgesic, Anti-inflammatory, Anti-arthritic, Antimicrobial, Hepatoprotective, Anti-diabetic, Antioxidant, Gastrointestinal, Antihyperuricemic, Anthelmintic, Cytotoxic, Renoprotective, Cardiotonic, Wound healing, Sedative, Anxiolytic, Anticonvulsant (Dutta et al., 2023) |
| 84 | Tridakha | Procumbetin , 8,3′-dihydroxy-3,7,4′-trimethoxy-6-*O*-β-D-glucopyranosyl flavone, 6,8,3′-trihydroxy-3,7,4′-trimethoxyflavone; Puerarin, Centaurein, and Centaureidin (Andriana et al., 2019). | Allelopathic activity, Larvicidal activity, Anti-hyperglycemic activity, Anti-fungal activity, Anti-leishmanial activity, Hepatoprotective activity, Anti-inflammatory activity, Anti-cyclooxygenase activity, Antioxidant activity, Anticoagulant activity, Anti-hepatic activity, Antibacterial activity (Andriana et al., 2019). |
| 85 | Krishna Tulsi | Flavonol glycosides, antimicrobial compounds, haemagglutination ac Oleanolic acid, Ursolic acid, Rosmarinic acid, Eugenol, Carvacrol, Linalool, and β caryophyllene, activity, etc. (Sharma et al., 2020). | antimicrobial activity was s against certain Gram-positive and Gram-negative bacteria pathogens Ch.Venkata Ramana Devi et al /Int.J. PharmTech Res. 2015,8(1),pp 88-95. Hepatoprotective, anti-inflammatory, antitumor, antimicrobial, and haemag-glutination activity (Sharma et al., 2020). |

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| 86 | Uchunti | Alkaloids, Cumarins, Flavonoids, Chromenes, Benzofurans, Sterols and Terpenoids (Kamboj and Saluja, 2008). | Antimicrobial properties, Bacterial infections, Arthrosis, Headaches, Dyspnea, Pneumonia, Analgesic, Anti-inflammatory, Antiasthmatic, Antispasmodic and Haemostatic effects, Stomach ailments, Gynaecological diseases, Leprosy (Kamboj and Saluja, 2008). |
| 87 | Bala | Vasicinol, Ephedrine, Vasicinone and Hypaphorine (Joseph et al., 2011). | Anti-inflammatory, Analgesic, Anti-bacterial activities (Joseph et al., 2011). |
| 88 | Dudhi | Alkaloids, Phenolics, Flavonoids, and Terpenoids (Rafi et al., 2022). | Antioxidant, Antibacterial, Anti-inflammatory, Antihypertensive, Antihyperuricemic, and Antidiabetic activities (Rafi et al., 2022). |
| 89 | Pipul | Phenolic, Tannins, Saponins, Alkaloids, Flavonoids, Glycosides, and Terpenoids (Carsono et al., 2022). | Anticancer, Antioxidant, Anti-inflammatory, Immunomodulatory, Antiplatelet, Analgesic, Radioprotective, and Antifertility (Carsono et al., 2022). |
| 90 | Varenda | Alkaloids, Flavonoids, Terpenes, Saponins, Phenolic compounds Kaempferol, Gallic acid, Ricin, Rutin, Lupeol, Ricinoleic acid, Pinene, Thujone and Gentisic acid (Abdul Waseem et al., 2018). | Anticancer, Antimicrobial, Insecticidal, Antioxidant, Anti-diabetic, Antinociceptive, Anti-inflammatory, Bone regenerative, Analgesic, and Anticonvulsant activity (Abdul et al., 2018). |
| 91 | Bhui amla | Lignans, Phyllanthin, Hypophyllanthin, Flavonoids, Glycosinoids & Tannins (Kamruzzaman and Hoq, 2016). | Antimicrobial, Antiviral, Hepatoprotective, Antioxidant, Anticancer, Anti-inflammatory, Antiplasmodial and Diuretic (Kamruzzaman and Hoq, 2016). |
| 92 | Amrul | Flavanoids, Tannins, Phytosterols, Phenol, Glycoseides, Fatty acids, Galacto-glycerolipid and Volatile oil (Badwaik et al., 2011). | Antioxidant, Anticancer, anthelmintic, Anti-inflammatory, Analgesic, Steroidogenic, Anti-microbial, Antiamoebic, Antifungal, Astringent, Depurative, Diuretic, Emmen-agogue, Febrifuge, Cardio relaxan, stomachic and Styptic (Badwaik et al., 2011). |
| 93 | Hatisur | Alkaloids, Triterpenes, Sterols, Amines and Volatile oils (Lal et al., 2023). | Anti-oxidant, Analgesic, Antinociceptive, Anti- |

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| | | | inflammatory, Anti-microbial, Anti-tuberculosis, Antihyperglycemic, Anti-cataract, Anti-plasmodial, Anti-fertility, Anthelmintic, Antitumor activity (Lal et al., 2023). |
| 94 | Bon tamak | Anthoxanthins (e.g., Flavones, Flavonols), Flavanones, Flavanonols, Flavans, and Anthocyanidins (Shajib et al., 2018). | Antinociceptive, Analgesic, Anti-inflammatory and Neuro-pharmacological activities (Shajib et al., 2018). |
| 95 | Rakta Karabi | Alkaloids, Flavonoids, Carbohydrates, Tannins, Phenolics, Saponins, Cardenolides, Cardiac Glycosides, Pregnanes, Triterpenoids, Triterpenes and Steroids (Al-Snafi, 2020). | Antioxidant, Anticancer, Antimicrobial, Antiparasitic, Anti-inflammatory, Analgesic Dermatological, Hypolipidemic, Antidiabetic, Cardiovascular and Central nervous effects (Al-Snafi, 2020). |
| 96 | Arahar | Polyphenols, Quercetin, Luteolin, Apigenin, Isorhamnetin, Flavonoids, Cajaninstilbene acid (Gupta, 2021). | Anti-bacterial, Anti-microbial, Anti-inflammatory, Hypocholesterolemic effects, Anti-diabetic, Anti-cancer, Neuroactive properties, Antioxidant, Hepatoprotective, Anthelmintic, Glycemic (Gupta, 2021) |
| 97 | Saluk | Alkaloids, Monoterpenes (iridoid and secoiridoids), Sesquiterpene lactones, Diterpenes, Triterpenes, and rarely Flavanones, Acyl phloroglucides, and Steroids (pregnane type) (Raja et al., 2010). | Hepatoprotective, Anti-inflammatoryand particularly Antidiabetic activity (Raja et al., 2010). |
| 98 | Mehendi | Flavonoids,Coumarins, Triterpenoids, Steroids, Xanthones, Polyphenols, Fatty acids, Alkaloids, Quinones, Tannins, Leucocyandin, Epicatechin, Catechin, and Quercetin (Batiha et al., 2023). | Antioxidant, Anti-inflammatory, Analgesic, Antiparasitic, Hepatoprotective, Antifungal, Antitumor, Wound healing and Hypoglycemic effects (Batiha et al., 2023). |
| 99 | Punarnava | Phenolic glycosides, Flavonoids , eupalitin, Rotenoids like Boeravinones, Coccineons, Alkaloids, i.e., Betanin, and Punarnavine (Patil and Bhalsing, 2016). | Anticancer, Anti-inflammatory, Antioxidant and Immuno-modulatory (Patil and Bhalsing, 2016). |

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| 100 | Dudurli | Flavonoids, Steroids, Terpenoids, Coumarins, Tannins, and Polyphenols (Meda et al., 2023). | Antioxidant, Antimicrobial, Sedative anxiolytic, Antiepileptic, Anti-inflammatory, Analgesic, Antipyretic, Antihistaminic, Antiasthmatic, Antidiabetic, Anticancer, Wound healing, Gastrointestinal, Diuretic, Antiparasitic, Immunological, Hepatoprotective, Galactogenic, Angiotensin-converting enzyme inhibiting and Anti-dipsogenic activities (Meda et al., 2023). |
| 101 | Muktojhuri | Tannins, Flavonoids, Cyanogenic Glucoside (Acalyphin), Pyranoquinolinone and Alkaloids (Dineshkumar et al., 2010). | Antioxidant, Antimicrobial, Anti-inflammatory, Anti-diabetic, Wound healing effect, Anti-venom and Anti-fertility activities (Dineshkumar et al., 2010). |
| 102 | Kakamachi | Steroidal saponins, Alkaloids, Phenols, and Polysaccharides (Chen et al., 2022). | Antitumor, Anti-inflammatory, Antioxidant, Antibacterial, and Neuroprotective activities (Chen et al., 2022). |
| 103 | Bantepari or patka | Flavonoids, Steroid alkaloids, Ellagic acid, Catechol, Gallic acid, Catechins, vitamin C, Free amino acetamide, Cyclopentane, Palmitic acid, Stearic acid, Octadecanoic and Linoleic acids (Novita et al., 2020). | Anti-inflammatory, Analgesic, Antipyretic, Antioxidant, Smooth muscle relaxation, Immune-enhancing, and Antibacterial (Novita et al., 2020). |
| 104 | Kukasim | Flavonoids, Alkaloids, and Terpenoids (Divya and Nirmala, 2023). | Anti-inflammatory, Antioxidant, and Antimicrobial activities (Divya and Nirmala, 2023). |
| 105 | Keshuth | Glycosides, Triterpenoids, Alkaloids, Flavonoids, Coumestans and Polyacetyl (Khairullah et al., 2022). | Antibacterial, Antifungal, Anthelmintic, Antimalarial, Hepatoprotective, Neuroprotective, Immunomodulatory, Analgesic, Diuretic, Hypolipidemic, Anti-inflammatory, Antidiabetic, Antioxidant, Anticancer, Hair growth promoting, Memory enhancing and Antivenom (Khairullah et al., 2022). |

| | | | |
|---|---|---|---|
| 106 | Bon dhone | Scoparic acid A, Scoparic acid D, Scutellarein, Apigenin, Luteolin, Coixol, and Glutinol (Pamunuwa et al., 2016). | Analgesic, Antimalarial, Hepatoprotective, Sedative, Hypnotic, Antiulcer, Antisickling, and Antimicrobial activities (Pamunuwa et al., 2016). |
| 107 | Chakwar | Alkaloids, Anthocyanosides, Phenolics, Proteins, Phlobatannins, Steroids, Tannins, Flavonoids, Anthroquinone, Saponins, Terpenes, Resins, Balsams, Amino acids, Carbohydrates, Sugars and Cardiac Glycosides (Al-Snafi, 2015). | Antimicrobial, Anthelmintic, Insecticidal, Antioxidant, Antianxiety, Antidepressant, Antimutagenic Antidiabetic, Wound healing, Hepato-protective, Renoprotective, Sun protective, Smooth muscles relaxation, Immune-modulating, Antiinflammatory, Analgesic, Antipyretic and other effects (Al-Snafi, 2015). |
| 108 | Dadmari | Tannins, Alkaloids, Flavonoids, Terpenes, Anthraquinone, Saponins, Phenolics, Cannabinoid Alkaloids, 1,8-cineole, Caryophyllene, Limonene, α-selinene, β-caryophyllene, Germacrene D, Cinnamic acid, Pyrazol-5-ol, Methaqualone, Isoquinoline, quinones, Reducing sugars, Steroids, and Volatile oils (Oladeji et al., 2020). | Antibacterial, Antioxidant, Antifungal, Dermatophytic, Anticancer, Hepatoprotective, Antilipogenic, Anticonvulsant, Antidiabetic, Antihyperlipidemic, Antimalarial, Anthelmintic and Antiviral activities (Oladeji et al., 2020). |
| 109 | Muthaghas | Alkaloids, Flavonoids, Terpenoids, Chromones, Phenylpropanoids, Phenolic acids, Iridoides (Dhar et al., 2017). | Astringent, Diaphoretic, Diuretic, Analgesic, Antispasmodic, Aromatic, Carminative, Antitussive, Emmenagogue, Litholytic, Sedative, Stimulant, Stomachic, Vermifuge, Tonic and Antibacterial (Sivapalan, 2013). |

| | | | |
|---|---|---|---|
| 110 | Manasa Gach | Euphol, Nerifoliol, Taraxerol, Euphonerins A–G, Lectin (Chaudhary et al., 2023). | Antioxidant, Anti-diabetic, Immunomodulatory, Anti-inflammatory, Anti-arthritic, Wound healing, Anti-Atherosclerosis, Radioprotective, Anti-anxiety, Anti-convulsant, Anti-psychotic, Anti-thrombotic, Dermal irritation, Hemolytic, Analgesic, Anti-fertility, Diuretic, Anti-microbial, Anti-diarrheal, and Anti-carcinogenic activities (Chaudhary et al., 2023). |
| 111 | Kata Bishalya Karani | Flavonoids, Quinones, Iridoids and Phenylethanoid glycosides (Gangaram et al., 2021) | Antioxidant, Antibacterial, Antifungal, Anti-inflammatory, Anticancer, Antidiabetic, Antiulcer, Hepatoprotective, Analgesic, Antiamoebic, Antihelminthic, Antiarthritic, Antihypertensive, Antiviral properties (Gangaramet al., 2021). |
| 112 | Nemuwa | Alkaloids, Steroids, Saponins and Fats (Das et al., 2019). | Anti-inflammatory, Antioxidant, Antidiarrheal, Antimicrobial, Insecticidal, Anti-nociceptive, Neuro-protective, Analgesic and Anti-hyperglycaemic activities (Das et al., 2019). |
| 113 | Babui Tulsi | Eugenol, Linaloo, Thymol, Camphor, Ocimumoside, Rosmarinic Acid (Pattanayak et al., 2010). | Antimicrobial Activity, Anti-inflammatory Effects, Antioxidant Properties, Antidiabetic Potential, Analgesic Effects, Anticancer Properties (Pattanayak et al., 2010). |
| 114 | Chandan tulsi | α-Santalol, β-Santalol, Santalene, Santyl acetate (Pattanayak et al., 2010). | Colds, coughs, bronchitis, Asthma, Antimicrobial, Adaptogen etc.(Pattanayak et al., 2010). |

## Dominant Families:

The medicinally important plant species belong to 47 different families, among them dominant families are as follows-

Fabaceae: 12 species

Euphorbiaceae: 9 species
Asteraceae: 9 species
Acanthaceae: 7 species
Lamiaceae: 7 species.
Amaranthaceae: 6 species


**Figure 2. Medicinal Plant Garden**

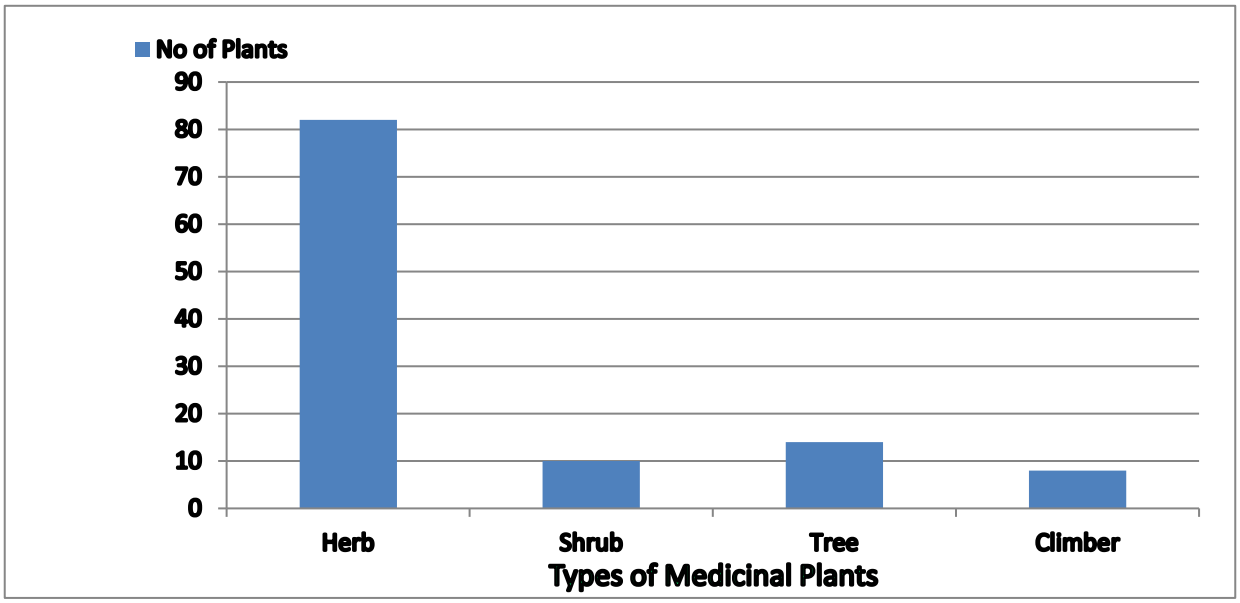


**Figure 3. Types of medicinal plants in the medicinal garden.**

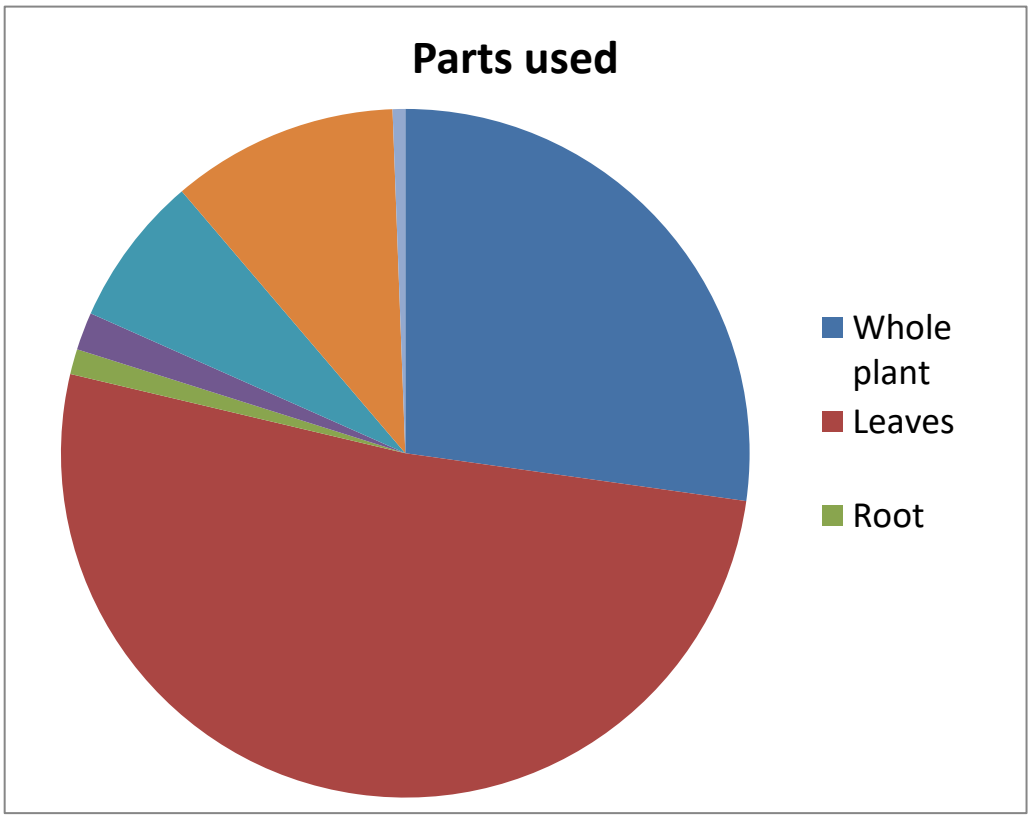


**Figure 4. Graph showing percentages of plant parts used by medicine men/women/ local peoples of semi-urban areas.**


**Figure 5.** ***Aerva aspera*** **L. (Ajwain)**

**Figure 6.** ***Morinda citrifolia***


**Figure 7.** ***Mikania micrantha***

**Figure 8.** ***Abutilon indicum***


**Figure 9. Hemidesmus indicus**

**Figure 10.** ***Tradescantia spathacea***

**Figure 11.** ***Kalanchoe pinnata***

**Figure 12.** ***Mimosa pudica***

**Figure 13.** ***Cinnamomum zeylanicum*** **(Darchini)**

**Figure 14.** ***Oscimum gratissimum*** **(Ram tulsi)**


**Figure 15.** ***Ocimum gratissimum*** **(Chandam tulsi)**


**Figure 16.** ***Coleus aromaticus*** **(Aijawan)**

**Figure 17. *Curcuma longa* ( Turmeric)**

**Figure 18. *Nyctanthes arbortristis* (Shiuli)**

## Discussion

The pollution on the campus of Acharya Prafulla Chandra College has been surveyed and a wide number of plants from distinct families has been reported. The wave of today's crowd to traditional medicinal herbs in place of most pharmaceutical drugs with negative side effects makes this research very compulsory. The study is both enlightening and promising and it lays out the entire botanical make-up of the college and reveals the option of regional cultivation, sustainable harvesting, as well as gaining from trade in the production of useful herbal plants (Madhu and Jana, 2014; Madhu et al., 2015; Madhu and Sarkar, 2015; Kar et al., 2022; Haloi et al., 2023; Jyotirmayee et al., 2023; Pawar et al., 2023). We have identified 47 families from the tested area and the report notes down the scientific names, families, local names, components utilized, and uses for each of the plant species in medicine.

The Fabaceae family alongside others in the guise of Euphorbiaceae, Asteraceae, Acanthaceae, Lamiaceae and Amaranthaceae, is well recognized as members of various families.

The family Fabaceae (which is also known as Leguminosae) is definitely the most representative one in terms of species diversity, which certainly underlines the numerous medicinal plants the family is attributed. On this account the use of Fabaceae variety of plant seems quite promising to achieve the goal of incorporation in the conventional system of medicine. In all, one hundred fourteen (114) species are recorded during the day on site and each plant brings a special therapeutic quality. The plants are taken into use in a wide range of ways, including the leaves, roots, stems, bark, flowers, fruits and seeds, which describes their properties for medicinal use accordingly and their individual medicinal qualities. As student-researchers have accumulated hands-on, practical knowledge through successive trials and errors, the indigenous people usually retain the one-on-one connections with the local herbal as one of their most valued assets. Furthermore, similar ethnobotanical reports throughout India have made records about applications of these herbal medicines for patients having a variety of ailments like diarrhea, diabetes, asthma, fever, jaundice, and rheumatism, as well as injuries from wounds, cuts, stomach pain, cough, cold, body pain, weight loss, bronchitis, dysentery and leprosy. In

order to sum up, the study that was conducted on the therapeutic plants that exist on the campus of Acharya Prafulla Chandra College furnishes necessary knowledge that not only improves our action with the native flora but also presents the prospects of sustainable practices, business opportunities and the preservation of the traditional knowledge relevant to therapeutic plants.

## Conclusion

This survey highlights the uninterrupted development of medicinal herbs from one end of the country to another. The major shift in the usage of herbal medicines from removing disease to preventing it is due to initiated access to good health. The conclusion that we have arrived at reveals that this campus has many useful botanical resources and properties with medicinal significance. In order to help conserve the waning biosphere of this campus area there are other researches and studies required. This study reveals the merit of upholding the pharmacological validation of these substances alongside their practical use in the community. More in-depth research, alongside the collection of ethnobotanical data, chemicals and tests for medicinal healthcare, will combine to create cheaper and more reliable medicine. The practicality of such medicines could be increased by giving such medicine to the communities around campus.

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Chapter- 15

# Potential Applications of Traditional Medicinal Plants for Treating Sleep Disorders

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**Keywords:** Ashwagandha, Brahmi, Jatamansi, Sleep disorders, Medicinal plants.

**Abstract:**

Sleep disorders involve conditions such as insomnia, sleep apnoea and restless leg syndrome and they are realised in almost everyone ranging from children to the elderly globally. To this time, folk medicinal practices in India including West Bengal are rich in terms of Ayurveda, Unani and folk medicine: a number of herbs from these practices have been used to cure sleep disorders. Hence, vegetation and herbal medicine like Valerian (*Valeriana officinalis)*, Chamomile (*Matricaria chamomilla)*, Passionflower (*Passiflora incarnata)*, Ashwagandha (*Withania somnifera)*, Lemon Balm (*Melissa officinalis)*, Lavender (*Lavandula angustifolia)*, Hops (*Humulus lupulus)*, Kava (*Piper methysticum)*, St. John's Wort (*Hypericum perforatum)*, Magnolia bark (*Magnolia officinalis)*, Jujube (*Ziziphus jujuba)*, California Poppy (*Eschscholzia californica)*, Ginkgo (*Ginkgo biloba)*, Chinese Skullcap (*Scutellaria baicalensis)*, Saffron (*Crocus sativus)*, Brahmi (*Bacopa monnieri)*, Jatamansi (*Nardostachys jatamansi)*, Tagar (*Valeriana wallichii)*,Tulsi (*Ocimum sanctum)* and Shushni shak (*Marsilea minuta*) are used consistently in order to treat sleep disorders as they act as sedatives & stress busters. Ashwagandha commonly referred to as the 'Indian ginseng' is an effective adaptogen that has the benefits of decreasing stress and anxiety, two relevant causes of insomnia. Antioxidants, withanolides in particular have also exhibited a potential capacity to improve sleep quality via regulation of the body's stress levels. Brahmi, another valued plant, is devoted to increasing the intelligence of people. Some traditional pharmacological uses include the enhancement of mental stability, eradication of anxiety and the general prevention of sleeplessness. That is why the effect of Brahmi on different neurotransmitter concentrations has been proven to help improve the limits of sleep regulation. Jatamansi, because of its calming nature was traditionally used for ailments that caused sleeplessness such as insomnia and other nervous disorders. Owing to its constituents like jatamansone and nardostachone it is used for its root extract that exhibits sedative activity through its action on the CNS. Tagar has valerenic acid and other oils that soothe the brains and nervous system of a human being. Shankhapushpi plant is used to cure mental disorders which it achieves through the presence of alkaloids and flavonoids that enable a person to have sound sleep. The tea prepared using dried chamomile flowers is consumed by many people as a treatment for mild cases of insomnia and anxiety. Vacha is used in either a form of decoction or as a powder to cure sleep disorders induced by stress as well as mental tiredness. The use of these plants in the modern approaches to the management of sleep disorders is perfect since it provides a natural way to manage it. In this particular book chapter, the author discussed the possibility of using plants traditional medicinal plants for treating sleep disorders.

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## Introduction:

Sleep disorders are a common clinical problem which interferes with the quantity and quality of life of millions of people globally. They have adverse effects on work performance and health (Morin et al., 2015). These disorders are best defined as, insomnia disorders, sleep apnea and hypoventilation disorders, restless legs syndrome and narcolepsy among others. However, there are drugs that are traditional pharmacological treatments nevertheless, they have their side effects and are addictive (Bent et al., 2006). Consequently, logical and reasonable focus has developed on different forms of treatment, especially non-conventional healing systems – presumably derived from folk literature – that have supported sleep and rest for thousands of years.

For generations, people in different parts of the world have relied on traditional medicinal plants that have been known to have sleep-promoting and anti-anxiety effects. Such natural remedies provide an optimistic focus for the progression of novel therapeutic strategies in sleep disorders, although seem to have fewer adverse effects and are significantly less probable for addiction in contrast to specific medications (Yurcheshen et al., 2021). However, the hope for a goodnight's sleep has for centuries been guided by conventional systems of healing like Traditional Chinese Medicine (TCM) or Ayurveda or many indigenous systems prevalent across the globe.

Recent scientific interest in these traditional remedies has led to a growing body of research investigating their efficacy, safety and mechanisms of action. Several plants, including Valerian (*Valeriana officinalis)*, Chamomile Valerian (*Valeriana officinalis)*, Chamomile (*Matricaria chamomilla)*, Passionflower (*Passiflora incarnata)*, Ashwagandha (*Withania somnifera)*, Lemon Balm (*Melissa officinalis)*, Lavender (*Lavandula angustifolia)*, Hops (*Humulus lupulus)*, Kava (*Piper methysticum)* St. John's Wort (*Hypericum perforatum)*, Magnolia bark (*Magnolia officinalis)*, Jujube (*Ziziphus jujuba)*, California Poppy (*Eschscholzia californica)*, Ginkgo (*Ginkgo biloba)*, Chinese Skullcap (*Scutellaria baicalensis)* Saffron (*Crocus sativus)*, Brahmi (*Bacopa monnieri)*, Jatamansi (*Nardostachys jatamansi)*, Tagar (*Valeriana wallichii)*,Tulsi (*Ocimum sanctum)* and Shushni shak (*Marsilea minuta*) have shown promising results in preclinical and clinical studies for their sleep-promoting effects (Leach and Page, 2015).

These plants' potential lies in their direct sleep-inducing properties in the sense that they treat the root causes of sleep disorders such as anxiety, stress and circadian disruption. Some of these plants possess bioactive substances that influence on types of neurotransmitters that relate to the circadian sleep-wake cycles such as GABA, serotonin and melatonin (Shi et al., 2018).

A number of prior publications agree that sleep disorders are more rampant among elderly persons than among the young (Ohayon et al., 2004; Irwin, 2015; Buxton et al., 2014; Brewster et al., 2018). Sleeping is one of the essential factors of human life and people work effectively if enough time for sleep is provided. Dean et al. (2017), while explaining it, have defined this disruption in the past as a multifaceted syndrome which affects the elderly population. This

should not be associated with aging since sleep disorders increase the risk of death, cardio-vascular diseases and likelihood of falling (Schubert et al., 2002; Clark et al., 2016; Da Silva et al., 2017; Min and Slattum, 2018). This is so because sleep impairment is regarded as being among the domains that need to be treated in a patient-positioned care delivery model. Ernst (2006), Kucharczyk et al. (2012), McIntyre et al. (2015), Harvey (2001) all have similar opinions that anxiety and sleeplessness are two common mental practices that are related to disability issues in nearly all countries globally.

O'Donnell, (2009) is of the opinion that there is one question that most cancer patients stole from the movie 'Battlefield Earth' Why can I not sleep? Some of the related signs include; inability to fall asleep, staying awake after going to sleep, waking up too early or having non-refreshing sleep (Savard et al., 2001). O'Donnell (2009) and Innominato et al. (2015) whose results regarded misery and in consequence lowered quality of life as well as immunosuppression and dementia due to insomnia and other sleep disturbances and also affected the disease course.

Now a days, controlling histrionics or traditional medical practices have been integrated with ethnicities & for over five and half decades natural medicine cures are available to treat all types of diseases. Hence, it could be mentioned that the research exploring traditional medicinal herbs in addressing the problem of sleep disorders could be referred to as a line of research that might prove to have rather high scientific relevance. Since the population's demand is getting radically higher, enhanced attention should be focused on the concerns related to sleep disorders which can be defined as difficulty in falling asleep, sleep apnea and restless legs syndrome. These conditions may lead to the emergence of various health problems: reduced cognitive function, changes in mental state, or disorders of the circulatory system.

Consequently, the use of synthetic pharmaceuticals for those intents and purposes has been criticized in recent years since these cause dependency and effects of the administered medicine. Therefore, the focus has shifted to the consumption of medicinal herbs that local West Bengal people have been using for treatment purposes for hundreds of years. These products that can be extracted from plants, which might be growing in the green forests or well-cultivated gardens of the area, are reputed to be powerful natural agents that spread total health all over the body and that is why they are valued.

Leach and Page (2015) have stated in their work quite enthusiastically their hypothesis that THM use is rampant, especially in treating insomnia. As confirmed in the research of Cho et al. (2009) concerning the impact of THM, it can be concluded that this substance can interact with 5-HT and GABA receptors, which are consistent with the research of Awad et al. (2007). In addition, THM has been observed regarding the impact of the enzymes in the brain associated with the GABA system.

The following are some of the more well-known of these early treatments that include Valerian (*Valeriana officinalis),* Chamomile Valerian (*Valeriana officinalis),* Chamomile (*Matricaria chamomilla),* Passionflower (*Passiflora incarnata),* Ashwagandha (*Withania*

*somnifera),* Lemon Balm (*Melissa officinalis),* Lavender (*Lavandula angustifolia),* Hops (*Humulus lupulus),* Kava (*Piper methysticum)* St. John's Wort (*Hypericum perforatum),* Magnolia bark (*Magnolia officinalis),* Jujube (*Ziziphus jujuba),* California Poppy (*Eschscholzia californica),* Ginkgo (*Ginkgo biloba),* Chinese Skullcap (*Scutellaria baicalensis)* Saffron (*Crocus sativus),* Brahmi (*Bacopa monnieri),* Jatamansi (*Nardostachys jatamansi),* Tagar (*Valeriana wallichii),*Tulsi (*Ocimum sanctum)* and Shushni shak (*Marsilea minuta*).

Most of the plants are acclaimed in the market for their neuroprotective effect combined with improvement of memory, which is as a result of its effectiveness in eradicating stress-related sleeplessness. Hence, the actions required in the decision-making or planning of sleep at night when the Ashwagandha supplements have been taken are less stressful since Ashwagandha is an adaptogen with properties that help to reduce tension and anxiety. In regard to folk medicine, the plant named Jatamansi under what has been socially constructed as a night rest pill for thousands of years, was being used to treat diseases such as insomnia and to put the human body to relax.

If you dwell on such plants, extensive research reveals the fact that there is a cocktail of chemicals that make some concoction in synergy hence interfering with the neurochemistry of the human being. From research studies on similar products that are associated with traditional remedies, there is enough evidence to prop up the argument that AEMA and the physical world need protection as these products present improved and safer remedies for sleep disorders. Hence, while the geographical location of West Bengal is replete with a vast botanical lineage it seems that the area remains virgin ground where such concepts as Ayurveda, Homeopathy, Allopathy, modern chemistry, molecular biology, etc, can be implemented systematically and effectively to solve the problems associated with sleep disorders that are a global product of the so-called advanced civilization. The goal of this paper is to conduct a detailed review and critical evaluation of the existing literature focusing on the traditional medicinal plants that have been used in the treatment of sleep disorders. Regarding their ethnobotanical background, their phytochemistry, pharmacology and available clinical trials will be discussed here. Moreover, further discussion will be made regarding the possibility of creating prescribed formulas of phytoagents and possible applications of traditional herbalism in contemporary sleep pharmacotherapy.

## Methodology:

The primary database search provided 75 articles that could potentially be used for further analysis. Google Scholar were for only relevant articles identified out of the 75 whose titles and abstracts passed all the screening stages and full-texts of 49 articles were hence reviewed for their eligibility to be included in the study. Last, 49 papers were selected for this book chapter according to the inclusion criteria.

## Traditional Medicinal Plants for Sleep Disorders:

Based on the literature review, we identified 20 traditional medicinal plants with the strongest evidence for their potential in treating sleep disorders.

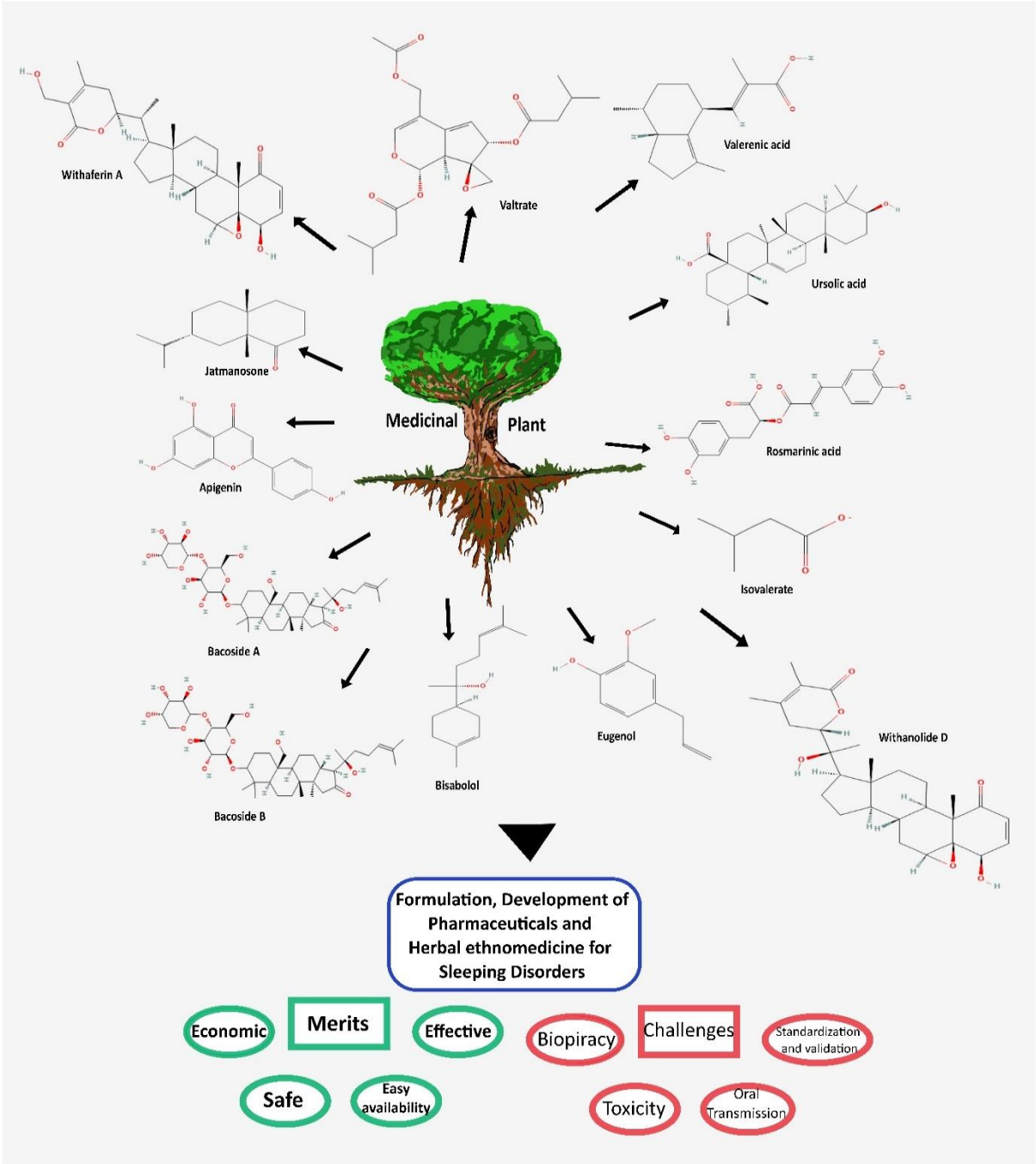


**Figure 1. Diagrammatic illustration of several phytochemicals for sleeplessness (Created by Corel Draw).**

**Table 1. The phytochemical composition revealed diverse bioactive compounds responsible for the sleep-promoting effects**

| Common name & Scientific name | Family & Parts used | Phytochemical Composition (sleep-promoting effects) & References | Therapeutic Activity |
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| Valerian, *Valeriana officinalis* L. | Caprifoliaceae<br><br>Root. | Valerenic acid and its derivatives, ridoids (valepotriates), Sesquiterpenes, Lignans, Flavonoids, Gamma-aminobutyric acid (GABA)<br><br>Chen et al., 2015 | Possibly, valerian can lead to a decrease in the onset of sleep and produce a positive effect on sleep quality in general. It is suggested that lerenic acid exerts the influence on GABA receptors, and this may lead to an increase in content of GABA in the brain which provides a person with the relaxing sleep. A few trials propose that valerian impacts on the receptors of melatonin which assists in the sleep wake cycle regulation. |
| Chamomile, *Matricaria chamomilla* L. | Asteraceae (daisy family)<br><br>Leaf, flower. | Flavonoids (apigenin, quercetin, patuletin), Terpenoids (α-bisabolol, chamazulene), Coumarins, Sesquiterpenes. | This flavonoid shows affinity to benzodiazepine receptors in the brain; therefore, it may lead to sedation and decreased anxiety. Some of the ingredients such as α-bisabolol have been suggested to produce a |

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| | | Mailänder et al., 2022 | sedating impact on the nervous system. One of the most apparent effects is a mild sedative impact which usually means reduced stress levels and therefore – better night sleep. |
| Passionflower, *Passiflora incarnata* L. | Passifloraceae (Passion flower family)<br><br>Flower. | Alkaloids (e.g., harman, harmine, harmaline), Flavonoids (e.g., vitexin, isovitexin, orientin, isoorientin), Gamma-aminobutyric acid (GABA), Maltol, Coumarins, Sterols.<br><br>Michael et al., 2022 | Taking passionflower can be effective in lowering the level of anxiety, therefore, can enhance sleep quality. The alkaloids and flavonoids usually found in the plant are considered to be responsible for the mild sedative effect of the plant. Presumably, it could further improve the quality of total sleep, but studies on the subject should be conducted to determine this feature. |
| Ashwagandha, *Withania somnifera* (L.) Dunal | Solanaceae<br><br>Root. | Terpenoids (e.g., valerenic acid in valerian, Withanolides, including withaferin A and withanolide D).<br><br>Saleem et al., 2020 | It was, therefore, considered that these compounds exerts sedative/anxiolytic properties, that may facilitate relaxation and enhance sleep. Studies indicate that this herb may help normalize the hormones released by the hypothalamic-pituitary-adrenal (HPA) |

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| | | | axis and decrease cortisol response to stress and its impact on sleep. |
| Lemon Balm, *Melissa officinalis* L. | Lamiaceae (mint family)<br><br>Leaf | Terpenes (e.g., citral, citronellal, geraniol), Flavonoids (e.g., luteolin, apigenin, quercetin), Essential oils (containing various compounds).<br><br>Petrisor et al., 2022 | Lemon balm may also raise the levels of GABA in the brain, which results to relaxation and sleep. Daily use might be beneficial in reducing cortisol levels and thus, a person may be able to have a good night's sleep. Steady consumption of lemon balm helps in lowering anxiety thus enhancing the quality of the sleep. |
| Lavender, *Lavandula angustifolia* Mill. | Lamiaceae<br><br>Flowers and leaves | Linalyl acetate, Linalool, Camphor, 1,8-cineole (eucalyptol), β-ocimene, Terpinen-4-ol.<br><br>Dobros et al., 2022 | Two fragrant compounds in lavender, linalool and linalyl acetate may prolong the action of GABA – the inhibitory neurotransmitter involved in sleep. Some studies have indicated that effects of lavender have a positive impact on anxiety hence enhancing sleep. Linalool and linalyl acetate have been believed to have effects of calming down that may lead to sleep. |
| Hops, *Humulus lupulus* L. | Cannabaceae (Hemp | Alpha and beta acids (humulones | Hops contain some ingredients which may |

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| | family)<br><br>Dried flower | and lupulones), Flavonoids (xanthohumol, isoxanthohumol), Tannins.<br><br>McCallum et al., 2019 | enhance the efficacy of the neurotransmitter known as gamma-aminobutyric acid (GABA) which enhances relaxation and sleeping patterns. Hops may also directly affect the levels of this compound since it is involved in controlling the sleep-wake cycle. |
| Kava, *Piper methysticum* G.Forst. | Piperaceae (pepper family)<br><br>Root. | Kavalactones (major active compounds), Flavokawains, Chalcones, Piperidine alkaloids.<br><br>Xuan et al., 2008 | Lactones in kavas may work with GABA receptors, increasing the effect of this inhibitory neurotransmitter. Composing of Kava has compounds known as kavalactones and these may help to decrease anxiety, facilitate the relaxation process and bring about the onset of sleep. |
| St. John's Wort, *Hypericum perforatum* L. | Hypericaceae | Hypericin, Hyperforin, Flavonoids (e.g., quercetin, rutin), Tannins, Essential oils.<br><br>Piatti et al., 2022 | May affect the body rhythm, thereby affecting sleep. Actually, due to the ability to reduce anxiety, it can cause an indirect effect on sleep in specific clients. |
| Magnolia, *Magnolia officinalis* Rehder & Wilson | Magnoliaceae<br><br>Bark | Magnolol, Honokiol, Obovatol, Alkaloids (e.g., magnoflorine), | While honokiol and magnolol also interact with GABA-A receptors positively, these compounds |

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| | | Volatile oils, Lignans.<br><br>Cristea et al., 2024 | probably may augment the sleep-inducing effect of the GABA-A receptor. While some investigations indicate that the effects of magnolia bark might contain cortisol, and this may have something to do with sleep. Magnolia bark may increase the levels of melatonin in the body, although scientifically established facts to back this claim are scarce. |
| Jujube, *Ziziphus jujuba* **Mills** | Rhamnaceae<br><br>Dry seeds | Saponins, flavonoids, and polysaccharide.<br><br>Song et al., 2019 | Due to its ability to act as a sedative and anxiolytic, jujube is a natural medicine useful for increasing the quality of sleep and decreasing anxiety levels. |
| California Poppy, *Eschscholzia californica* Cham. | Papaveraceae (Poppy Family)<br><br>Leaves | Alkaloids (including californidine, eschscholtzine, and protopine), Flavonoids, Saponins, Carotenoids.<br><br>Becker et al., 2023 | California poppy has in the past been especially utilized in calming the nerves and this makes it have an impact with regards to bringing about sleep. The alkaloids found in the plant affect the nervous system and thus the anxiety levels as well as the ability to relax are affected. |

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| Ginkgo(*Ginkgo biloba* L.) | Ginkgoaceae<br><br>Leaves | **Flavonoids:** Quercetin, kaempferol, and isorhamnetin, **Terpenoids:** Ginkgolides (A, B, C, J) and bilobalide. **Biflavones:** Sciadopitysin, ginkgetin, isoginkgetin.<br><br>Noor-E-Tabassum et al., 2022 | There are some papers referring to the effect of *Ginkgo biloba* on sleep parameters, including better quality and quantity of sleep. It is believed to have a tranquillising effect and may be useful with reference to anxiety hence improving sleeping patterns. |
| Chinese Skullcap (*Scutellaria baicalensis* Georgi*)* | Lamiaceae (Mint family)<br><br>Root. | Flavonoids (e.g., apigenin in chamomile, baicalin).<br><br>Wang et al., 2018 | Apigenin being an inverse agonist at the benzodiazepine receptor in the brain has the ability to induce sedation which is important for sleep. |
| Saffron (*Crocus sativus* L.) | Iridaceae<br><br>Pistils | Crocins, Picrocrocin, Safranal, Flavonoids.<br><br>Maqbool et al., 2022 | Safranal and crocins – the main components of saffron – possess a small amount of sedative effects that could contribute to better night's sleep. |
| Brahmi [*Bacopa monnieri* (L.) Pennell] | Plantaginaceae (formerly classified under Scrophulariaceae)<br><br>Whole Plant | Bacosides, particularly bacoside A and B.<br><br>Jeyasri et al., 2020 | These compounds influence the serotonin levels in the brain and the serotonin is pivotal in the regulation of any pattern of sleep. Brahmi is effective in the enhancement of cognitive processes in the brain; therefore, it has reduced anxiety |

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| | | | levels and made it possible for people to have a sound sleep without frequent interruptions. |
| Jatamansi, *Nardostachys jatamansi* (D.Don) DC. (1830) | Valerianaceae<br><br>Roots &rhizomes | Sesquiterpenes and jatamansone in Jatamansi are the primary active components.<br><br>Gottumukkala etal., 2011 | This has the effect of helping in the reduction of anxiety, relaxation, and promotion of sleep. Insomnia and other stress related sleep disorders are best treated by Jatamansi. |
| Tagar (*Valeriana wallichii* DC) | Caprifoliaceae<br><br>Whole plant | Valerenic acid, valtrate, and isovalerate.<br><br>Toolika et al., 2015 | These compounds operate on the gamma-aminobutyric acid (GABA) receptors in the brain which are responsible for management of sedation and anxiety. |
| Tulsi (*Ocimum sanctum* Linn) | Lamiaceae (mint family)<br><br>Leaves | Eugenol, ursolic acid, and rosmarinic acid.<br><br>Baliga et al., 2013 | These compounds assist to alleviate stress and anxiety, two factors that are known to be the causes of sleeplessness. |
| Shushni shak (*Marsilea minuta* L.*)* | Marsileaceae, Leaves | **Flavonoids:** These include quercetin and kaempferol derivatives. **Phenolic Compounds:** Includes caffeic acid and ferulic acid. **Tannins:** Present in significant amounts. **Alkaloids:** Some | *Marsilea minuta* is commonly used in ethnopharmacological treatments with therapeutic action that manifests as anxiety relief and sleep induction. |

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| | | studies have identified the presence of alkaloids in Marsilea minuta. **Saponins:** Detected in the plant. **Steroids:** Includes phytosterols like β-sitosterol. Bhattamisra et al., 2008 | |

## Pharmacological Mechanisms of Action:

The review of pharmacological studies revealed several mechanisms through which these plants exert their sleep-promoting effects (Toolika et al., 2015; Maqbool et al., 2022; Piatti et al., 2022; Michael et al., 2022; Noor-E-Tabassum et al., 2022; Varinthra et al., 2024):

# **GABA receptor modulation:** It was identified that many plants, such as the valerian, passion flower, and hops improve GABAergic activity resulting in sedation and anxiolysis. # **Serotonin receptor interactions:** Studies have demonstrated that extracts from St. John's Wort and saffron possessed serotonin receptor binding and thus, might affect the sleep-wake behaviors explosively.

# **Melatonin synthesis and secretion:** The participants that took Jujube and St. John's Wort were witted to improve synaptic connections related to the regulation of sleep. # **Adenosine receptor binding:** According to the findings publicized in other studies, the active compounds like caffeoylquinic acids in plants including passionflower interrupted adenosine receptors and affected sleep homeostasis.

# **Anti-inflammatory and antioxidant effects:** Some of the plants like ashwagandha and ginkgo demonstrated high levels of anti-inflammatory and antioxidant effects, which, in turn, might ameliorate sleep quality via decreasing oxidative stress and neuroinflammation.

## Clinical Efficacy:

Analysis of clinical trials revealed varying degrees of efficacy for the identified plants (Shinjyo et al., 2020; Srivastava et al., 2010; Janda et al., 2020; Chandrasekhar et al., 2012; Kajjari et al., 2022):

# Valerian: While complemting that a meta-analysis of 8 RCTs (n=1,529) demonstrated only moderate benefit compared to placebo in terms of sleep quality (SMD = -0. 70; 95% CI: -1. 05

to -0. 18; p<0. 001) compared to placebo. In addition, the same study showed lower cholesterol levels (25; p<0. 001) in the patients treated with flupirtine.

# Chamomile: A systematic review analyzing 5 clinical trials (n=502) revealed substantial enhancements in SOL and global SE especially in setting up older people.

# Passionflower: In one double blind, placebo controlled RCT designed with n=110, improvements in sleep quality (p<0. 01) and daytime functioning (p<0. 05) were shown in the treatment group after 4 weeks of therapy compared to placebo.

# Ashwagandha: The meta-analysis of the five RCTs (n=400) for sleep quality demonstrated positive and statistically significant effects on overall sleep quality with SMD=-0. 59 (95% CI=-0. 86 to -0. 32; p<0. 001) and the time required to fall asleep with a Mean Difference = -10. 73 minutes (95% CI = -17. 82 to -3.

# Lavender: Inhalation studies and oral administration of lavender oil were found to significantly influence anxiety levels and sleep quality in 7 journal-reported studies involving 731 participants.

## Safety and Adverse Effects:

The current systematic review of the traditional medicinal plants revealed that the plants had moderate to low toxicity with mild and rarely serious side effects. The most commonly reported side effects included: The most commonly reported side effects included: Particles, gastrointestinal disturbances, whereas others are not (for example, nausea, weak or mild abdominal pain).

#Headache

# Dizziness

# Excessive sleepiness especially during part of the day, usually during the daytime or at night when one wishes to be awake (this is more evident especially when taking high doses).

The clinical trials reviewed in this work showed no signs of any serious adverse effects. However, Herb-drug interactions were pointed out for St. John’s Wort due to it being labelled as an inducer of cytochrome P450 enzymes that means that it influences the metabolism of some medications.

## Discussions:

Traditional use of these plants Perhaps the most striking ethnopharmacological implication of these plants is the fact that at least one of them has been used for many centuries. Several of these treatments involve the use of Valerian and Chamomile, being are natural remedies that are known to have been in use in traditional medicine systems in Europe and the Middle East for centuries. Like ashwagandha and jujube, this list of plants has traditionally been used in Ayurvedic medicine and even Traditional Chinese Medicine. This overlapping of different species of plants used across various cultures for sleep-related disorders provides a good ground for their pharmaceutical usage.

These mentioned phytochemicals show the richness in therapeutic effects of these plants since it is difficult to point out one phytochemical that acts definitely in a certain way. While most normal drugs have a single compound that provides therapeutic action, traditional medicines, such as herbal ones, possess multiple active compounds that could act in conformity with one another. For example, the modulatory effects of valerenic acid, valepotriates and flavonoids in valerian might collectively serve as the source of this drug's sedative effect via different pathways (Fernández-San-Martín et al., 2010). The given multi-compound, multi-target approach of herbal medicines correlates with the multifactorial character of sleep disorders and may influence different spheres of sleep disturbance at the same time. However, this poses the problem of how herbal preparations can be standardized and whose quality can be guaranteed for it to be clinically applied. Pharmacology is also briefly explained to show how these plants work on the nervous system to induce sleep. The mode of action of most of the common sedative hypnotics involves the enhancement of the inhibitory effects of GABAergic neurotransmission; this is a modulation that is also brought about by the majority of the herbal sedative hypnotics including valerian, passion flower and hops. Nevertheless, the impact on the serotonergic, melatonergic and adenosinergic systems may have certain advantages when it comes to the complex regulation of sleep. Besides, the anti-inflammatory and antioxidant characteristics demonstrated by plants like ashwagandha and ginkgo direct towards fresh pathways to treatment in sleep medication. Based on developing investigative data about the role of neuroinflammation and oxidative stress in sleep disturbances (Irwin et al., 2016), these things can contribute to more benefits related to the test subjects, which, in addition to improved sleep, can promote further effects related to neuroinflammation.

The research findings of the efficacy of such traditional plants for sleep disorders are favourable, especially for the widely researched plants such as valerian, chamomile, and ashwagandha. From the findings of randomized controlled trials of these plants moderate to significant changes in sleep parameters were noted hence these could act as good substitutes or even an addition to the traditional remedies.

Although there is evidence that youth theatre has benefits for the participants, it is necessary to state the shortcomings of the research done at this time. Some of the investigations had limited the number of participants, short time and irregular dosing schedules while the latter concerned several formulations and dosing regimens. Also, the choice of many sleep quality indicators applied in the related studies raises questions about the necessity for more objective methods, including polysomnography and actigraphy, to be incorporated into successive research.

It is now possible to observe that the majority of the reviewed plants have relatively favorable safety profiles, which is quite promising compared to some of the conventional sleep medications that come with dependence potential and serious adverse effects. Nevertheless, most of the herbal interventions indicate the scarcity of long-term efficacy and safety data, which makes it crucial to carry out long-term follow-up studies together with post-marketing

surveillance.

***Future research should focus on:***

# Carrying out large-scale, long-term double-blind experiments, with intervention and control preparations.

# Exploring such issues as herb-drug interactions and herb-drug contra-indications.

# Determination of the right doses and drug-drug interactions

## Conclusion:

The traditional medicinal plants of India specially West Bengal offer a promising significant of natural remedies for sleep problems. Incorporation of these herbs in the daily lives of people is a powerful form of natural treatments that, when taken under doctor's prescription, pose no danger to the patient as compared to synthetic sleeping pills. While modern research corroborates these uses, there may be even more uses with the help of these plants for countless people affected by sleep disorders.

There is a lot of potential in the research of various ethnopharmacological uses of plants for the treatment of sleep disorders in West Bengal. Therefore, through ethnopharmacological investigation together with scientific methods, the goal of this research is to prove the efficiency and use of those plants in contemporary medicine to provide better and more effective medical assistance and to enhance the people's respect towards the indigenous cultures. These natural resources from traditional medicine stores could be another or additional method for treating sleep disorders. Currently, more studies are still required in order to fully elucidate the working of these herbs and their degree of effectiveness, but irrespective of that, these herbs have been used for a long time and they are now being increasingly endorsed by researchers. Incorporating these plants in the contemporary models of sleep management might help fight the diseases concerning sleep, as the established tactics are aimed at reducing the symptoms but not eliminating their root causes.

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Chapter- 16

# Shak (Vegetables) as Traditional Medicine in Medinipur District in West Bengal

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**Keywords:** Shak (vegetables), traditional treatment, medicinal benefits.

**Abstract:**

Various traditional vegetables are grown year-round in urban and rural areas of Medinipur District in West Bengal. Most vegetables naturally have numerous nutrients like potassium, dietary fiber, folate, vitamins A, C, K and B-complex, etc. According to the basic concept of local people and research, those who consume at least 1 to 3 servings of shaks (vegetables) daily have the lowest risk of developing several ailments, such as cancer, heart disease, urinary problems, etc. This paper attempts to aware the common people anywhere and in any place to protect himself or herself from different diseases. So, take some vegetables into a daily diet with a meal or any other way. The best result will come from maintaining daily routine service or intake at certain times. Enjoy this article's shak (vegetables) to complement your normal daily diet. Daily vegetable consumption is crucial for good health. They deliver vital nutrients like fiber, antioxidants, vitamins, minerals, and other foods. Enjoy a variety of vegetables every day to obtain the most health advantages. Numerous traditional vegetables in the Medinipur District have therapeutic properties. These vegetables are frequently consumed and used medicinally by rural, urban, and cosmopolitan residents without regard to dosage. According to the paper, research is crucial for these shak (vegetables). In Medinipur, various traditional vegetables are grown around the year in the whole district. According to a growing body of evidence, persons who consume at least 1-2 servings of shak (vegetables)daily have the lowest chance of developing various diseases. Healthy vitamins, minerals and dietary fibers are found in every vegetable. Certain veggies may benefit particular people more, depending on their diets, general health, and nutritional requirements. Those shak (vegetables) deliver vital vitamins, minerals and other nutrients, such as fibre and antioxidants.. Healthy vitamins, minerals and dietary fibers are found in every vegetable. Certain veggies may benefit particular people more, depending on their diets, general health, and nutritional requirements. Those shak (vegetables) deliver vital vitamins, minerals and other nutrients, such as fibre and antioxidants.

## Introduction:

It's hard to find people with no physical problems these days. Sugar, pressure, cholesterol, triglycerides, liver problems, hormonal imbalances etc. are causing people distress, fatigue, and shortening life span. As a result, from morning to night – the list of medicines keeps getting longer and longer. Very few people have the opportunity to eat rice with a five-course dish. People have forgotten the habit of eating bitter in the first leaf or eating rice with vegetables. Neither bitters nor vegetables are on the list of preferences and the priority is chicken-mutton. Eating too much chicken is not good for health at all. From doctors to nutritionists alike,

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everyone says to avoid red meat altogether. Many diseases like cancer, diabetes and obesity are the source of problems, but this meat.

In earlier days, people's demand for food was less. Local vegetables in the fields were the hope. Daily life was spent with fresh fish from the pond, vegetables, fruits etc. Vegetables fell regularly. There was no inclination towards exotic fruits and vegetables. They looked healthy by eating local food. The incidence of diseases was also low because of that. This vegetable grows the most in abandoned land or potato-garlic-onion fields. It grows neglected even near the drains of the house. No care, no fertilization required. These vegetables are as low in cost as they are packed with nutrients. From phlegm, cough and bile to diabetes - the solution to all problems lies in this herb. Contains a lot of vitamins. And so, this vegetable has a role in increasing the immune system of the body, preventing the problem of gas heartburn and reducing weight (Ahmad et al., 2016; Almed, 2019; Bachheti et al., 2014; Chandrasekara & Kumar, 2016; Das, 2022; Das et al., 2013; Datta et al., 2011; Ghosh et al., 2014; Gupta et al., 2004; Liu et al., 2011; Mirza and Navaei, 2006; Bussmann & Weckerle, 2012).

The topic of those vegetables from the Medinipur region of India came up in our discussion. This has been making people's daily lives absolutely dependent on survival for ages, even in the current situation (Das, 2022). Also mentioned is the general identity of each herb, its various chemical constituents, medicinal properties and how it is used.

## Description of Shak (Vegetables) as Traditional Medicine:

1. **Common name:** Palak shak (Spinach leaf)
   **Scientific name:** *Spinacia oleracea* L.
   **Family:** Amaranthaceae.

**Figure 1. Spinach leaf**

## General Characteristics:

Spinach is green in appearance. It is generally eaten cooked. Spinach is in demand in various parts of India, including West Bengal. Rich in various chemical elements and vitamins, this vegetable fulfills the various needs of the human body. However, it is taken as food in different ways in different places.

## Ingredients/Chemical Composition:

All important vitamins stored in spinach are Vitamin A, Vitamin C, Vitamin K, Magnesium, Manganese, Iron, etc. It also contains important elements like vitamin B, riboflavin and vitamin

B6, vitamin E, calcium and potassium. Not only that, but it also contains fiber, fatty acids, palmitic acid, linoleic acid, etc.

**Medicinal Values**:

1. Medicinally, spinach is used in the treatment of stomach and intestines.
2. It is used to relieve fatigue.
3. It is also used as a blood-builder and appetite stimulant.
4. Spinach is rich in iron, vitamins C and E, potassium and magnesium. As a result, it plays an important role in increasing the body's immunity.
5. It is now believed that this herb also contains anti-cancer properties.

**How to use:**

1. Many people consume spinach juice.
2. Many people eat its leaves boiled.
3. Spinach is eaten as salad in some regions.
4. But the most common method is to cook spinach.
5. In Bengal, it is used as a mixed vegetable, particularly in Midnapore region.

**2.** **Common name:** Lau shak (lau leaf)
**Scientific name:** *Lagenaria siceraria*
**Family:** Cucurbitaceae

**Figure 2. Lau shak**

## General characteristics:

It is a climbing plant. It’s leaves are green, which looks a lot like our heart. Of course, not only in Medinipur but all over India and even Bangladesh, Gourd is grown in a wide area. It is one of the vegetables that is easily available here and there for the residents.

## Ingredients/Chemical Composition:

All the important ingredients we find in gourds are vitamins, flavone-C glycosides, fatty acids and omega-3. Also, several other minerals, including iron, potassium, magnesium and zinc, are essential.

**Medicinal value**:

It contains several important components of a balanced diet in the human body. Apart from this, gourd greens are used for various problems like fever, cough, pain and asthma. Many people use it as a pain reliever.

**How to use**:

It is generally recommended that the gourd be washed and cooked in clean water.

3. **Common name:** Kumro shak (pumkin leaf)
**Scientific name :** *Cucurbitaceae Pepo var moschala*
**Family :** Cucurbitaceae

**Figure 3. Kumro shak**

## General Characteristics:

Pumpkin leaves are quite large in size. These leaves are dark green in colour. The stem of the pumpkin plant is round but hollow. Pumpkin leaves are round and veined.

## Constituents/Chemical Composition:

Pumpkin leaves also contain several important chemical constituents. For example, calcium, iron, magnesium etc. Also acts as a source of fibre and tannins.

**Medicinal Values**:

1. Pumpkin generally energizes the body.
2. It helps us in mental treatment by keeping the brain cool.
3. Pumpkins are used to relieve constipation.
4. Pumpkin contains several essential minerals, including potassium, which plays an important role in muscle contraction, maintaining fluid balance in the body, and transmitting chemical signals through neurons.
5. Pumpkin are also particularly helpful in kidney and digestive system functions.
6. It is used to cure infertility problems in both men and women.
7. Many people recommend eating pumpkin greens to increase and improve sperm count in men.

**How to use**:

Pumpkin is usually eaten cooked fried, alone or in some spices or used mixed up with potato.

4. **Common name:** Methi shak(methi leaf)
**Scientific name:** *Trigonella foenum graecum* L.
**Family:** Fabaceae

**Figure 4. Methi leaf**

## General Characteristics:

Methi is a plant belonging to the Fabaceae family. It is a perennial and semi-cereal plant. Fenugreek seeds and leaves are used as a common food ingredient in the Indian subcontinent. Two types of methi leaves are widely cultivated in India. A dark green, oval-shaped and mildly bitter leaf. The other is a small variety with small green leaves with white roots. It is found all over India, including Medinipur.

## Constituents/Chemical Composition :

Several important medicinal chemical constituents are present in methi leaves, such as alkaloids, saponins and mucilages.

**Medicinal value**:

The mixture of fenugreek spice enhances the flavour of food, drinks and tobacco. Fenugreek extract is also used in soaps and cosmetics. Fenugreek is traditionally used to relieve diabetes and increase milk supply in lactating women. All important chemical constituents of fenugreek leaves are carbohydrates, proteins, lipids, alkaloids, flavonoids, fiber, saponins, steroidal saponins, vitamins and minerals, nitrogen, etc.

**How to use:**

Fenugreek greens are used to make paste like gravies and spices. That is, fenugreek greens are first washed well in clean water and

**5.** **Common name:** Chola shak (Chickpeas leaf)
**Scientific name:** *Cicer arietinum* L.
**Family :** Leguminosae, Fabaceae

**Figure 5. Chickpeas leaf**

## General Characteristics:

Chickpeas leaf is a plant belonging to the Fabaceae family. It is a perennial. It is known by different names in different places. It is very healthy. A portion of the food was rich in fiber and protein. It plays an important role in controlling blood pressure and blood sugar in the human body. Has a low glycemic index (GI). As a result, chickpeas help regulate cholesterol, triglycerides, blood sugar and blood pressure, maintain a healthy body weight, and support gut health. Hormonal fluctuations, particularly the decline in estrogen, are the cause of many menopausal complaints. Chickpeas are a good source of phytoestrogens, which are plant

compounds that are able to bind to estrogen receptors and replace some of the effects of estrogen that are no longer being produced.

### Constituents/Chemical Composition:

Chickpeas' important medicinal chemical constituents are carbohydrates, proteins, fatty acids, linoleic acid, etc.

**Medicinal Values:**

1. Low glycemic index Chickpeas leaf helps control blood sugar.
2. It helps in weight control.
3. Chickpea leaf is important in maintaining proper heart and intestinal health.

**How to use:**

1. It is cooked and eaten mixed with various vegetables.
2. Chickpea leaves are often eaten fried in a little oil.

**6.**

**Common name:** Sojne shak (*Moringa* leaf)
**Scientific name:** *Moringa oleifera*
**Family :** Moringaceae

**Figure 6. Sojneshak**

### General Characteristics:

Moringa (scientific name: *Moringa oleifera*) is a plant belonging to the Moringaceae family. This plant is commonly found in tropical regions. Cuttings and seeds propagate this plant. Summer is the perfect time to plant saplings. Many people call the leaves of Sajina tree as miracle leaves. It is considered to be the most nutritious herb in the world.

It acts as an anti-diabetic and helps lower blood glucose levels. Many also use it as an anti-cancer agent.

### Constituents/Chemical Composition:

Sajina leaves contain a large amount of bioactive compounds. It is also rich in vitamins, carotenoids, polyphenols, phenolic acids, and glucosinolates.

**Medicinal Values:**

1. Sajina leaf is used as a healthy food.
2. Sajina Shaka plays a significant role in reducing the burning pain in the human body.
3. Its leaves are used to brighten the skin.

**How to use:**

1. Sajina leaf paste is used to increase skin radiance. The paste is left on the skin for 10 to 15 minutes and then washed off. This is beneficial.
2. Many people eat vegetables like salad.

**7.**

**Common name:** Alu shak (Potato leaf)

**Scientific name:** *Solanum tuberosum*

**Family:** Solanaceae

**Figure 7. Potato leaf**

## General Features:

Potatoes are a very familiar vegetable to us. Its leaves are green in colour. Potatoes are a very important balanced diet. It is rich in vitamin C, which is an anti-oxidant.

## Ingredients/Chemical Composition:

All the important chemical ingredients present in potato leaves are vitamin C and potassium. Among the flavonoid components, anthocyanin is the main compound.

**Medicinal value**:

Potatoes help prevent diabetes, heart disease, high blood pressure, indigestion etc.

**How to use**:

Potato greens are usually cooked and eaten.

**8.**

**Common name:** Sorche shak(mustard leaf)

**Scientific name :** *Brassica juncea* L.

**Family:** Crucifers

**Figure 8. Sorche shak.**

## General Characteristics:

Brassica is a genus of plants in the mustard family (Brassicaceae). It looks green. Members of this genus are commonly known as cruciferous vegetables, cabbage or mustard plants. Many people cook mustard leaves and eat them with hot rice. It is a very nutritious vegetable. Mustard leaves contain several important components that play an important role in skin care in general and diabetes prevention.

## Ingredients/Chemical Composition:

Mustard leaves contain many health-enhancing anti-oxidants like beta-carotene, which play an important role in keeping the skin healthy and also reduces the risk of diabetes a lot. All the important chemical elements present in mustard leaves are thiamin, niacin, pyridoxine etc. Vitamin K is also present in mustard leaf.

**Medicinal Values:**

Various studies have shown mustard leaves to be anti-cancer, antibacterial, antifungal, anti-oxidant and anti-inflammatory.

**How to use**:

1. In most cases, cooking mustard leaves with spices is common.
2. Some also eat mustard leaf as a salad.
3. Many eat mustard leaves mixed in soups or stews.
4. Some times, the method of frying vegetables with mustard is also common.

**9.**

**Common name:** Kolmi shak (water spinach leaf)
**Scientific name:** *Ipomoea aquatica*
**Family:** Convolvulaceae

**Figure 9. Kolmi shak**

## General Features:

Kalmi is commonly known as water spinach. It is a semi-aquatic plant. This plant is commonly found in tropical regions. This plant can be seen more or less all over India, not only in Medinipur and West Bengal. Not only that, but it is also widely cultivated in Southeast Asia, East Asia, and South Asia.

Common people use it to treat jaundice, liver problems, anaemia and improve digestion. It is also used for anti-ageing and relief of acne, eczema and psoriasis.

## Constituents/Chemical Composition:

The important chemical constituents observed in kalmi are various vitamins, proteins, sulphurous amino acids and tryptophan.

**Medicinal Values**:

1. The Folkpeople use this leaf extract to treat jaundice and mental illness.
2. Kalmi works well in relieving piles and nosebleeds.
3. Used as an anthelmintic and in the treatment of hypertension.
4. This vegetable is eaten to improve eyesight.
5. The use of Kalmi herb can be observed in improving hair and skin health.

**How to use:**

1. Spinach juice contains a lot of anti-oxidants and beneficial compounds, so many people consume spinach juice after twisting it.
2. Applying Kalmi juice on hair roots stops hair loss.
3. Kalmi leaves are cooked and eaten to control blood pressure.

**10.**

**Common name:** Susni shak (Marsilea leaf)
**Scientific name:** *Marsilea minuta*
**Family:** Marsiliaceae

**Figure 10. Susni shak**

## General features:

Susni leaf is one of the shak that people living in the Medinipur district of West Bengal keep in their daily diet. It can be called herb. Susni leaf also grows in Central and Southern Europe, Caucasus, Western Siberia, Afghanistan, Southwest India, China, Japan and Vietnam. In some places, it has been used as food for over 3000 years. Susni shak keeps the brain cool. It is diuretic, astringent, febrifuge and refrigerant. In some places, it is also used to treat snake bites.

## Constituents/Chemical Composition:

The important chemical constituents found in Susni shak are phenols, flavonoids, tannins, saponins, quinones, terpenoids, coumarins and anthraquinones.

**Medicinal value**: We commonly use the leaves and shoots of Susni plant as vegetables. Plays an important role in the treatment of cough and respiratory problems. The juice and

decoction of these leaves are used by the people of India and our neighbouring country, Bangladesh, to treat cough and other respiratory problems.

**How to use**:

1. Generally, this vegetable is eaten in a cooked way.
2. The juice of this leaf is given in the form of a poultice in the treatment of several diseases.
3. Sometimes, the juice of this leaf is recommended.
4. A decoction of Susni leaves is used in the treatment of several diseases.

**11.**

**Common name:** Pui shak (Ceylon spinach leaf)

**Scientific name:** *Basella alba* L.

**Family:** Basellaceae

**Figure 11. Pui shak**

## General Characteristics:

Pui shak is a very well-known plant in Medinipur region. It is a member of the Basellaceae family and its scientific name is *Basalla alba*. It is a climbing plant. Weed grows very fast. This herb has many qualities. This Plays an important role in increasing digestion. Its mucilaginous stems and fiber-rich leaves aid in proper digestion. Eliminates various problems caused by acid. Pui shak is very beneficial for pregnant and lactating mothers. Pui shak is a food rich in vitamin B12, vitamin B6, folic acid, calcium etc.

## Constituents/Chemical Composition:

The chemical constituents present in Puisha are fatty acids such as lauric acid, arachidic acid, behenic acid, lignocenaric acid, palmitic acid, stearic acid and myristic acid. Also note the presence of oleic acid, eicosenoic acid, palmitoleic acid, urosic acid, docosonic acid, linoleic acid and alpha-linoleic acid.

**Medicinal Values:**

1. Pui shak is used as food to keep the stomach healthy.
2. Pui shak is used to remove various problems caused by acid.
3. It is recommended to eat pui shak to increase work capacity and overcome body fatigue or lethargy.
4. Pui shak plays an important role in the formation of blood in the human body.
5. Pui shak is used as food to increase appetite.
6. Many people recommend eating Pui shakas to improve children's overall development and get rid of various ailments.

**How to use:**

The young leaves of Pui Shak can be eaten like spinach, either raw in salads or boiled, steamed, fried or added to soups, stews and curries.

**12.**

**Common name:** Hingche or Helenchashak (Enhydra leaf)
**Scientific name:** *Enhydra fluctuans*
**Family:** Asteraceae

**Figure 12. Helenchashak**

## General Characteristics:

Helencha shak gram is a very well-known Bengal plant. It is also known by different names in the Medinipur region, like- Helencha, Hincha, Hinche, Hincha, Helchi, Teeter Doga, Teeter Shak etc. It is better to call it a type of flowering plant. As mentioned earlier, the scientific name of this herb is Enhydra fluctuans and it belongs to the Asteraceae family. Its English name is Common Enhydra, Buffalo spinach, Helancha etc. It is commonly found growing in turbid water. It is bitter in taste and full of medicinal properties. This vegetable is eaten cooked.

## Constituents/Chemical Composition:

The active chemical constituents present in Helencha leaves are Germacranolides, Sesquiterpenes, Lactones, Flavonoids, Essential Oils, Steroids, Diterpenoids, Melampolides, Sesquiterpene Lactones etc.

**Medicinal or Traditional uses**:

Helencha herb has many benefits like – used in herbal treatment for constipation, asthma, nervous system, arthritic pain, itching, burning hands and feet etc. Modern scientific research has also found many of its characteristics, such as anti-oxidant, germ killer, pain reliever, reduces diarrhoea, relieves nervous tension etc. In Ayurveda, Helencha is identified as a blood purifier, choleretic, appetite suppressant, analgesic, antiseptic and antipyretic. Kabiraj as recommend eating this vegetable to cure skin diseases. Eating this vegetable regularly increases the amount of haemoglobin in the blood. Helencha is used in treating constipation, asthma, diarrhoea and nervous disorders. After prolonged fever, eating fish broth with Helencha vegetables increases appetite and restores taste in the mouth. Helencha is very useful for skin diseases, itching, indigestion, burning hands and feet, dysentery and bronchitis. Due to their high antioxidant content, Helencha leaves play an important role in preventing cancer.

Applying this herb to the head for headaches reduces the pain. Regular consumption of helencha leaves lowers blood sugar.

**How to use:**

It is eaten as a vegetable in almost every region of India, not just Midnapore. In the case of curing some diseases, however, the method of using Helencha's juice is common. According to Ayurveda, it has many medicinal properties and is used to cure bilious diseases, convulsions, epilepsy, gonorrhoea, high blood pressure, inflammation, liver diseases, nervous diseases, paralysis, skin diseases etc.

**13.** **Common name:** Kulekhara shak (Hygrophila leaf)
**Scientific name :** *Hygrophila auriculata*
**Family :** Acanthaceae

**Figure 13. Kulekhara shak**

## General Characteristics:

Kulekhara is known as an essential vegetable to the people of every village in Bengal. It has many medicinal properties. It is a herb. It is commonly found growing in wetlands. Kulekhara is found not only in Medinipur and India but also throughout tropical Asia and Africa.

Kulekhara leaf extract also treats diarrhoea, inflammation, painful stomach disorders and anaemia. The seeds of this plant also have medicinal properties. Kale plays an important role in curing various blood disorders and treating urinary problems.

## Ingradients/Chemical compositions :

This plant contains terpenoids, alkaloids, flavonoids, aphrodisiacs, renal tonic etc. as significant constituents.

**Medicinal values :**

The leaves of Hygrophila are used in several treatments. Such as dysuria, urinary calculi and urinogenital tract disorders such as cystitis. Hygrophila leaves are also used to increase libido and in various sperm treatments. The leaves of this plant are used in traditional medicine to cure rheumatic arthritis, kidney infection, jaundice, gout etc.

**How to use :**

1. Take a bunch of leaves.
2. Separate from the branch.
3. Rinse thoroughly under running water.

4. Discard any white spots on the side.
5. Boil a glass of water.
6. Add cleaned leaves to it (3-4 leaves).
7. Boil for a few minutes until the water is reduced to half. Strain the water and take it as necessary.

**14.**

**Common name:** Thankuni shak (Thankuni leaf )
**Scientific name:** *Centella asiatica*
**Family:** Apiaceae

**Figure 14. Thankuni leaf**

## General Characteristics :

Thankuni is a climbing herb. In Medinipur, i.e., India and Bangladesh, it is known as Thankuni, but in English, this plant is known as Centella. This thankuni vegetable is eaten in many ways. Some people like to eat it by mixing it with onions and chillies. Many people also consume the juice of Thankuni leaves. No matter how it is consumed, its medicinal properties are maintained to a considerable extent. In general, this Thankunipata is used to treat gas problems, high blood pressure, and various stomach problems to bring taste to the mouth.

## Ingredients/Chemical compositions :

The major chemical constituents in the leaves of Centella asiatica are betulinic acid, thanchunic acid, isothanchunic acid, asiatic acid, medecassic acid and brahmic acid. Also contains asiaticside, brahmoside, madasiatic acid, centylose and centeloside.

**Medicinal values :**

Thankuni leaf tea works very well to calm the mind. This herb is also used to reduce stress and anxiety. This herb is used to improve memory, digestion, and stomach function. Thankuni leaves have also been used for centuries in traditional medicine. Also, in many cases, it is seen that the leaves of this plant are used to remove acne, cure mouth sores, relieve colds and coughs, control diabetes, relieve sore throat, enhance the beauty of the face and reduce the chances of fever.

**How to use :**

1. Thankuni pata is used for savoury dishes like batter, dal and fry.
2. Traditionally, it was believed that eating a Thankuni Pata Bata at the beginning of a meal could act as an appetite stimulant and help promote nutrient absorption and better digestion.
3. It is said to make juice from this leaf and eat it twice a day to control diabetes.

4. Chewing this leaf increases the secretion of digestive acids, which in turn helps to increase digestion.

5. Applying the juice of this leaf on the face removes nutritional deficiency of the skin, thereby increasing the beauty of the face.

6. The juice of this leaf mixed with a small amount of sugar can cure cold and cough within a week.

7. Many times, it has been observed that the juice of this leaf is consumed on an empty stomach for several mornings to keep away the fever that occurs due to changes in weather.

**15.**

**Common name:** Pat sakh(Jute leaf)

**Scientific name:** *Corchorus olitorius*

**Family:** Malvaceae

**Figure 15. Jute leaf**

## General characteristics:

Jute leaf is a very popular and versatile vegetable. It is rich in calcium, vitamin A, and vitamin C. It helps to increase immunity in the human body. Not only this, but it also keeps the bones strong. Jute vegetables are eaten in different ways. Specially can be eaten fried and cooked like a vegetable.

## Ingradients/Chemical composition :

Jute leaf (*Corchorus olitorius*) is consumed in Medinipur and remote parts of India, which are rich in various nutrients. All the medicinal chemical constituents present in jute leaf are — protein, fat, carbohydrates, fibre, calcium, potassium, iron, sodium, phosphorus, beta-carotene, thiamin, riboflavin, niacin, ascorbic acid etc.

**Medicinal value :**

*Corchorus olitorius* contains various medicinal chemicals that help reduce anxiety, inflammation, strengthen bones, increase immunity, reduce the risk of heart disease, maintain normal weight, skin health, normal cell formation and wound healing. This plant is also used to improve digestion, relieve colds and cure eye problems.

**How to use :**

1.They're rich in immune and bone-supporting nutrients like calcium and vitamins A and C, just to name a few.

2. You can enjoy jute leaves by adding them to stews and stir-fries.
3. Alternatively, you can also enjoy them raw by adding them to smoothies and salads, which are healthy and delicious.

**16.**

**Common name:** Neem shak (Neem leaf)
**Scientific name:** *Azadirachta indica* L.
**Family :** Meliaceae

**Figure 16. Neem leaf**

## General Characteristics:

Neem trees are found all over India. It is a tree-like plant. The properties of the neem tree are endless. Neem leaves are an important tool in various treatments in the human body. Neem leaves

Effective against various skin diseases, septic sores and infected burns. Neem leaves are washed in clean water and applied in the form of a poultice or decoction in boils, ulcers and eczema. Neem oil is also used for various skin diseases. Fried neem eggplant with hot rice helps to bring the taste to the mouth. Neem leaves play an important role in blood purification.

## Ingradients/Chemical compositions :

*Azadirachta indica* L. (Neem) contains a variety of medicinal chemicals. This plant has a very important therapeutic role in the plant world. The important constituents present in this plant's leaves are azadirachtin and nimbolinin, nimbin, nimbidin, nimbidol, sodium nimbinate, gedunin, salanin and quercetin.

**Medicinal values:**

Neem (*Azadirachta indica*) profoundly affects human life due to its medicinal properties. Neem leaves are used in various ways to cure various skin diseases, remove worms, relieve diabetes, cure liver problems, cure loss of appetite, cure any problem of blood vessels, relieve pain caused by body stiffness, relieve fever, cure various eye diseases, to prevent leprosy. Also, this plant is currently being used to treat diseases like cancer.

**How to use :**

1. Consuming around 4-5 neem leaves daily on an empty stomach is safe.
2. However, using this habit for a short period of time (up to 10 weeks) is recommended because long-term use of heavy doses can negatively affect your kidneys and liver.
3. Neem oil is used on the scalp to get rid of dandruff.

4. Neem oil is used on the scalp to strengthen the hair roots.
5. Applying neem leaf juice to the wound gives relief.
6. Neem leaves are boiled in hot water and used while cleaning various skin diseases such as scabies.

**17.**

**Common name:** Mulo shak(Raddish leaf)
**Scientific name:** *Raphanus sativus* L.
**Family :** Brassicaceae

**Figure 17. Raddish leaf**

## General Characteristics:

Mulo shak is known as an important vegetable to the people of rural Bengal. This herb also has many medicinal properties. There are various ways of eating vegetables. Mulo greens are fried in very little oil and eaten with hot rice. Many times, this vegetable has been used to make salad pakora pickles. Mulberry leaves are rich in fibre, vitamin C, copper and folate. These ingredients help the human body control blood sugar, maintain weight balance, and increase immunity.

## Ingradients/Chemical compositions:

All the important elements that are present in mulo vegetables are carbohydrates, fibre, protein, thiamin, riboflavin, niacin, vitamin B, folate, vitamin C, calcium, potassium, manganese, phosphorus, iron, magnesium etc.

**Medicinal values:**

Radish has many medicinal properties. For example, it is used to increase digestion, control blood pressure, increase immunity, increase haemoglobin levels in the blood, and prevent diabetes.

**How to use:**

1. Daikon leaves go well with oils such as sesame oil.
2. They can be pre-boiled to reduce the characteristic bitterness and greenish taste, but if they are fried in oil, they do not suffer from this, so pre-cooking is unnecessary.
3. Spicy is also mild, making it easy for children to eat.

**18.** **Common name:** Chalkumro shak (wax gourd leaf)
**Scientific name:** *Benincasa hispida*
**Family:** Cucurbitaceae

**Figure 18. Chalkumroshak**

## General characteristics:

Gourd leaf is a popular dish in the Medinipur region and all over India. It is generally eaten cooked. Guard leaf are hairy when young; when mature, they have a coating of white powdery substance instead of rum. This powder makes it storable for a long time. Apart from India, it is widely cultivated in various countries in Asia.

## Ingredients/Chemical compositions:

All the important medicinal chemicals present in wax gourd are — carbohydrates, fibre, protein, vitamins, riboflavin, niacin, vitamin B, vitamin C, calcium, magnesium, iron, phosphorus, potassium, sodium, zinc, selenium etc.

**Medicinal values:**

The wax gourd vegetable has many immunity properties. For example, it can be said to relieve tuberculosis, maintain the balance of human body weight, take care of skin and hair properly, relieve leprosy, eliminate various harmful bacteria in the intestines, cure gastric diseases, relieve Ansar and keep the brain healthy and normal. Also, wax gourd is traditionally used to relieve colds, kidney diseases, worm removal and common fever.

**How to use:**

1. Using wax gourd vegetables in the daily diet is recommended, especially to eliminate iron deficiency in women's bodies.
2. Wax gourd leaves are rich in vitamin C, so applying the juice of this leaf on the wound is beneficial.
3. Wax gourd vegetable curry can be included in the daily diet to strengthen teeth and bones.
4. Consumption of wax gourd leaf sap or juice is very beneficial for maintaining good eyesight.
5. Wax gourd leaf curry is used for skin and hair care.
6. This vegetable can be eaten as a curry to keep blood sugar levels under control.

**19.**

**Common name:** Beto shak (Bathua leaf)
**Scientific name:** *Chenopodium album*
**Family:** Amaranthaceae

**Figure 19. Beto shak**

## General characteristics:

Bathua or Beto Shak, is an ancient plant. It looks green. It is also cooked and eaten as a vegetable. This vegetable has many benefits. The popularity of this herb in Ayurveda is also noticeable. This plant is grown in various winter vegetable fields.

## Ingradients/ Chemical compositions:

The chemical elements in bathua leaf are vitamin A, C, B6, potassium, calcium, iron and magnesium.

**Medicinal values:**

Bathua leaf has several important medicinal properties. It is used to control blood sugar bone problems, relieve toothache, relieve leg pain, cure gum pain, and relieve joint pain. Also, this herb is used to heal blisters, kidney and urinary problems, cure whites, relieve constipation and remove worms.

**How to use:**

1. The leaves of the Bathua plant are the primary edible part and are commonly eaten as leafy greens.
2. They have a slightly earthy and nutty flavour, which makes them a popular addition to salads, sauces and various culinary dishes.
3. Regular beetroot juice consumption can eliminate kidney and urinary problems.
4. Drinking beetroot juice on an empty stomach is said to eliminate worms.
5. If applied in the form of a bandage on the blistered wound, the wound heals.

## General Characteristics:

Gulanch Shak is a well-known herb in the Midnipur region. This herb is very popular in Ayurvedic medicine. In Ayurveda, it is mixed with various herbs to make it a remedy for various diseases. Gulancha works as a versatile and powerful herb. For example –

It works very well in treating chronic fever, improving digestion and treating diabetes. Gulanch is also used to reduce stress and anxiety. Many times, this herb is used to relieve respiratory problems.

20. **Common name:** Gulancho shak (Giloy leaf)
**Scientific name:** *Tinospora cordifolia*
**Family:** Menispermaceae

**Figure 20. Gulancho shak.**

## Ingredients/Chemical compositions:

Several important chemical constituents are present in Gulancho shak. For example – calcium, iron, cobalt, nickel, zinc, titanium, chromium, manganese, chlorine, copper, bromine etc.

**Medicinal values:**

This herb is used to boost immunity, prevent diabetes and relieve dengue disease. It also has the ability to prevent excessive weight gain. Traditional medicine is used in women to prevent bone loss, relieve colds and coughs, protect mental health, improve digestion, treat heart problems, and prevent cancer.

**How to use:**

1. Bathua plant leaves are usually cooked and eaten.
2. Some times, the leaves of this plant are used to enhance the flavour of other vegetables.
3. It is also customary to fry this vegetable in very little oil.

21. **Common name:** Jayanti shak
**Scientific name :** *Sesbania sesban*
**Family :** Fabaceae

**Figure 21. Jayanti shak**

## General Characteristics:

Jayanti Shak is known as a familiar dish in the Midnapur region. The scientific name of this plant is Sesbania grandiflora. It is a fast-growing plant. Its leaves are green in colour and rounded in shape. Depending on the type, white, red and pink flowers can be seen on this tree. Its fruits look like beans. Jayanti Shak has various medicinal properties.

### Ingradients/Chemical compositions:

All the active ingredients that we find in jainthi shak are vitamins, carbohydrates, amino acids, proteins, tannins, saponin glycosides and steroids.

**Medicinal values:**

This herb is used to relieve colds and coughs in children, to cure diabetes, to remove leucoderma, as an anthelmintic, to relieve pain and to relieve smallpox.

**How to use:**

1. Sesbania sesban leaf juice mixed with warm oil and massaged on the baby's chest and back to reduce colds.
2. The juice of this leaf is used to open the blocked nose due to cold.
3. The juice of this leaf is also used to relieve constipation.

## 22.

**Common name:** Red spinach shak

**Scientific name:** *Amaranthus dubius*

**Family:** Amaranthaceae

**Figure 22. Red spinach.**

### General features:

Red spinach, from this name, it is understood that it is not green like other vegetables. Its colour is red. Usually, this plant is 30-45 cm in height. However, depending on the species, the leaves of this vegetable are small or large in size. This vegetable is popular as food.

### Ingradients/Chemical compositions:

All the active ingredients that are included in red spinach are anti-oxidants, phosphorus, iron, amino acids, potassium, magnesium, etc. In addition, this vegetable contains vitamins A and C, which are very important for the human body.

**Medicinal values:**

Red spinach, the whole part of this herb has medicinal value. Its leaves, roots and whole plant help to keep the digestive process normal. This herb is used to purify the blood, as a

diuretic, to increase body strength, to refresh the mind, to prevent miscarriage and to reduce the venom of snake bites.

**How to use:**

This vegetable is very valuable in Medinipur of West Bengal and all over India. Some times, it is eaten as a curry, sometimes fried, and sometimes raw as a salad. But, no matter how it is eaten, its benefits are substantial. Also, taking the juice of its leaves helps in reducing the venom of snake bites. Consuming the boiled plant will help prevent miscarriage.

**23.** **Common name:** Pointed gourd leaf (potol pata)
**Scientific name:** *Trichosanthes dioica*
**Family :** Cucurbitaceae

**Figure 23. Potol pata**

## General features:

This herbaceous vine is a perennial plant. This herbaceous vine grows up to about 5-6 m. Its leaves are dark green.

## Ingradients/Chemical compositions:

All the chemical components stored in the leaves of the pointed gourd are vitamin A, vitamin C, tannin, saponin and alkaloids. Proteins also contain tetra and pentacyclic triterpenes.

**Medicinal values:**

We use the leaves of the pointed gourd for various purposes. For example, its leaves are used to bring taste to the mouth, improve the liver's health, eliminate worms, and relieve nausea.

**How to use:**

The juice of this plant's leaves is consumed to relieve various diseases. Again, in many cases, the custom of eating by digesting through cooking is also prevalent.

**24.** **Common name:** Kochu shak (Arum leaf)
**Scientific name:** *Colocassia sp.*
**Family:** Araceae

**Figure 24. kochu shak.**

## General features:

This herb can be found all over India, including Manipur in West Bengal. The height of this herb is 30-50 cm. This vegetable can be found in India, Malaysia, Indonesia, and other places.

## Ingradients/ Chemical compositions:

All the medicinal chemical components present in arum leaves are protein, calcium, magnesium, iron, vitamin A, vitamin C, Phosphorus, manganese etc.

**Medicinal values:**

With about 114 genera and 3,750 species, this vegetable is essential for human benefit. This vegetable is analgesic as well as anti-inflammatory and antidiarrheal. It is used to heal wounds, treat piles and heal ulcers.

**How to use:**

It is usually eaten by cooked.

**25.**

**Common name:** Ol shak
**Scientific name:** *Amorphophallus paeoniifolius*
**Family:** Araceae

**Figure 25. Ol shak**

## General features:

This vegetable table is found not only in West Bengal but also in various places in India. It is known to all as a very good food. It contains several important medicinal chemicals which play a very important role in the human body. This vegetable contributes significantly to improving memory concentration.

## Ingradients/Chemical compositions:

Found almost everywhere in Bengal, this plant contains several constituents such as tannins, alkaloids, steroids, fats and fixed oils, flavonoids, proteins and carbohydrates.

**Medicinal values:**

The whole body of this plant is popularly used in the treatment of several diseases like tumours, haemorrhage, cough, bronchitis, asthma etc. It is also used in traditional medicine for vomiting, cough, asthma, haemorrhoids, constipation, flatulence etc.

**How to use:**

Its leaves and stems are cooked well and eaten as a vegetable.

**26.**

**Common name:** Dhone shak (Daniya leaf )
**Scientific name:** *Coriandrum sativum*
**Family:** Apiaceae

**Figure 26. Dhoniya shak**

## General features:

Coriander is a herb. Leaves are small, green in colour and smooth. This aromatic herb is an annual plant. Stems are numerous and very narrow in appearance. This plant bears small clusters of white flowers. The grainy fruit is produced later from its flower. Fruit is green when raw. Coriander seeds and leaves are used almost everywhere in Bengal as a food spice. It is eaten as chutney, salad and salsa both in this country and abroad.

## Ingradients/Chemical compositions:

Fresh green coriander leaves contain linalool (72.7%), terpinene (8.8%), pinene (5.5%), camphor (3.7%), limonene (2.3%), geranyl acetate (1.9%) and p-cymene (1.5%). On the other hand, the oil's composition varies depending on its seeds' maturity.

**Medicinal values:**

Two important components of coriander leaves are alkaloids and flavonoids. These ingredients help cure liver diseases like biliary disorders and jaundice. Coriander leaves are consumed to maintain the normal functioning of the digestive system and cure intestinal diseases. Also, daily consumption of fresh green coriander leaves helps boost your immune system, reduce high cholesterol levels, normalize your skin, normalize digestion, improve blood sugar levels and increase bone strength.

**How to use:**

1. Try adding them to pulses, vegetables, salads or rice.
2. For the skin, make a coriander paste, apply it to your skin, and wash it off after 15 minutes.
3. Fresh juice is very beneficial in helping to meet our recommended daily intake of vitamins and minerals.

## Conclusion:

Vegetables are significant in terms of nutrients. Almost all veggies naturally contain a few calories from fat. Numerous nutrients, such as potassium, dietary fibre, folate, vitamins A and C, vitamin B-complex, and others, are in significant amounts in nuts. These Vegetables are a

component of plants eaten as food by people and other animals. When applied to plants, the original definition is still frequently used to refer to all edible plant material, including flowers, fruits, stems, leaves, roots, and seeds. Traditional native veggies are abundant in vitamins and nutrients and may positively affect health. The Medinipur district is home to many species of vegetables that are used medicinally to treat various disorders that can be cured. To benefit from as many health advantages as possible, consume a variety of veggies every day. One of the easiest methods to increase health and happiness may be to eat a lot of vegetables. Most nutrients, fibre, minerals, and natural vitamins may be crucial in treating numerous serious illnesses, including those of the heart, kidney, blood, lungs, and neurological system. This article discusses the many listed vegetables' ethnobotanical andmedicinal benefits.

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