Traditional Medicinal Plants

Volume - 10

Chief Editor

Dr. P. Shivakumar Singh
Assistant Professor, Head of the Department, Department of Botany,
Palamuru University, Mahabubnagar, Telangana, India

AkiNik Publications®
New Delhi

Published By: AkiNik Publications

AkiNik Publications
169, C-11, Sector - 3,
Rohini, Delhi-110085, India
Toll Free (India) – 18001234070
Phone No.: 9711224068, 9911215212
Website: www.akinik.com
Email: akinikbooks@gmail.com

Chief Editor: Dr. P. Shivakumar Singh

Publication Year: 2025

Pages: 197

Paperback ISBN: 978-93-6135-630-8

E-Book ISBN: 978-93-6135-161-7

Book DOI: https://doi.org/10.22271/ed.book.3300

Price: ₹ 807/-

Registration Details

- Printing Press License No.: F.1 (A-4) press 2016
- Trade Mark Registered Under
  - Class 16 (Regd. No.: 5070429)
  - Class 35 (Regd. No.: 5070426)
  - Class 41 (Regd. No.: 5070427)
  - Class 42 (Regd. No.: 5070428)

Message

Prof. LB Laxmikanth Rathod
Vice Chancellor

I am immensely happy to know that, Dr. P Shivakumar Singh, Department of Botany, Palamuru University has authored the Book entitled "Traditional Medicinal Plants Vol. 8". I congratulate him for his academic dedication. I hope this book will be useful for the faculty, students of plant science and interdisciplinary studies of life sciences.

I am sure the volumes books have all the content and wisdom in the related areas and will prove highly useful in enriching the knowledge and skill of readers.

I convey my best wishes and hope the author will come out with many more such works in the days to come.

I also appreciate AkiNik Publishers for their effort in volumes of books.

Vice Chancellor

Contents

Chapters	Page No.
1. Different Traditional System Various Ways uses of Medicines in Different Methods and its Examples used *(Sonia Singh, Chandrika Ahirwal and Rashmi Tiwari)*	01-20
2. Design, Formulation & Characterisation of an Effective Anti-Fungal & Anti-Microbial Poly-Herbal Formulation *(Ajay Kumar Suryawanshi, Purnima Baghel and Sweety Lanjhiyana)*	21-37
3. Ancient Wisdom in *Shopha* (Inflammation) and *Granthi* (Cysts) Related to Gynaecology: Medicinal Plants in Ayurveda *(Garima, Sujata Kadam and Meenakshi Pandey)*	39-56
4. Mulethi (*Glycyrrhiza glabra*): A Potential Medicinal Herb *(Rahul Kashid and Navnath Kashid)*	57-70
5. Pharmacological Insights into Ashwagandha (Withania Somnifera): A Traditional Herb with Exceptional Modern Therapeutic Potential *(Veerapuram Harika and U. Jaya Surya)*	71-104
6. Plants used as Antimicrobial Agents *(Dinesh Kumar, Navneet Verma, Sushil Kumar, Anesh Sagar and Kavya Vishnoi)*	105-116
7. Pharmacognosy *(Anesh Sagar, Navneet Verma, Sushil Kumar, Dinesh Kumar and Raj Kumar Singh Bharti)*	117-130
8. Traditional uses of Pteridophytes: A Forgotten Treasure in Herbal Medicine *(Harvi Patel and Susmita Sahoo)*	131-164
9. Secondary Metabolites Plays an Important Role in Traditional Medicinal Plants *(Shoeb Ahmad)*	165-185
10. Use of Some Traditional Medicinal Plants in Ayurveda for Diseases *(Raj Kumar Singh Bharti, Sushil Kumar, Krishna Kumar, Swatantr Bahadur Singh, Ravi Kumar and Yogesh Kumar)*	187-197

Chapter - 1
Different Traditional System Various Ways uses of Medicines in Different Methods and its Examples Used

Author

Sonia Singh
Associate Professor, Apollo College of Pharmacy, Durg, Chhattisgarh, India
Chandrika Ahirwal
Associate Professor, Bharti Vishwavidyalaya, Durg, Chhattisgarh, India
Rashmi Tiwari
Assistant Professor, Chhatrapati Shivaji Institute of Pharmacy Durg, Chhattisgarh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 1

Different Traditional System Various Ways uses of Medicines in Different Methods and its Examples used

Sonia Singh, Chandrika Ahirwal and Rashmi Tiwari

Abstract

Ancient civilizations had their own traditional ways of healing illnesses. Many of the traditional medical systems are based on sound fundamental principles and centuries of practices by healers. Greek medicine and Egyptian medicine have become of historical interest only, whereas Traditional Chinese Medicine (TCM) and Ayurveda from India are still popular. This article reviews some of the most commonly practiced traditional medical systems. The information presented is taken from reviews of various textbooks and articles rather than practical experiences. Because of length limitations, this article can be considered only an introductory review. One common factor noted in several traditional systems is a holistic approach to the well-being of a person's body, mind, and spirit. In different ways in the form of medicine people utilize these herbs like churna, extract, oil, extract, decoction etc.

Keywords: Traditional medicine, natural product, herbs

Introduction

Traditional medicinal plants are plants used in traditional healing practices to treat various ailments and promote health. They have been used for centuries across different cultures and continue to play a vital role in modern herbal medicine. Below are some notable examples of traditional medicinal plants and their common uses.

Plant that has been used historically in traditional healing systems to prevent, diagnose, or treat physical or mental health conditions. These plants are integral to indigenous cultures and are often employed based on knowledge passed down through generations. Their therapeutic properties typically derive from active compounds like alkaloids, flavonoids, tannins, and essential oils.

Cultural and Regional importance

Medicinal plants are often deeply integrated into the cultural and spiritual practices of societies:

- **Ayurveda:** Traditional Indian medicine emphasizes plants like neem, turmeric, and Ashwagandha.
- **Traditional Chinese Medicine (TCM):** Includes plants like ginseng and ginger.
- **African traditional medicine:** Uses plants like rooibos and devil's claw.
- **Native American practices:** Incorporate echinacea, willow bark, and sage.

Plant that has been used historically in traditional healing systems to prevent, diagnose, or treat physical or mental health conditions. These plants are integral to indigenous cultures and are often employed based on knowledge passed down through generations. Their therapeutic properties typically derive from active compounds like alkaloids, flavonoids, tannins, and essential oils.

1) **Cultural heritage:** Use rooted in traditional systems such as Ayurveda, Traditional Chinese Medicine (TCM), and Native American healing practices.
2) **Natural healing:** Utilized in raw or processed forms (e.g., teas, tinctures, powders, and ointments).
3) **Holistic approach:** Often supports physical, mental, and spiritual health.
4) **Scientific basis:** Many plants have been validated for their medicinal properties through modern research. Examples include aloe vera for burns, neem for skin health, and ginger for nausea.

Role

Traditional medicinal plants play a vital role in healthcare systems and cultural practices worldwide. Their contributions can be understood across various dimensions, including health, culture, economy, and environmental sustainability.

1. Role in healthcare

Primary healthcare resource: In many rural and developing areas, traditional medicinal plants are the primary or only source of medicine due to their accessibility and affordability.

- **Treatment of diseases:** They are used to treat a wide range of ailments, from common colds to chronic illnesses like diabetes, hypertension and arthritis.
- **Preventive medicine:** Some plants boost immunity and help in preventing diseases (e.g., echinacea for colds, turmeric for inflammation).
- **Complementary and Alternative medicine (CAM):** These plants complement modern medicine in integrative healthcare systems.

2. **Cultural and Spiritual significance**

- **Traditional healing practices:** Integral to systems like Ayurveda, Traditional Chinese Medicine (TCM), Unani, and African traditional medicine.
- **Ritualistic use:** Plants like sage, frankincense, and sandalwood are used in spiritual ceremonies and healing rituals.

3. **Contribution to modern medicine**

- **Source of active compounds:** Many modern pharmaceuticals are derived from plants (e.g., aspirin from willow bark, quinine from cinchona).
- **Drug development:** They serve as templates for developing synthetic drugs.

4. **Economic importance**

- **Livelihoods:** Cultivation and trade of medicinal plants support livelihoods, especially in rural areas.
- **Global herbal market:** The growing demand for herbal remedies has created a multibillion-dollar industry.

5. **Environmental role**

- **Biodiversity conservation:** Promotes the conservation of plant species and sustainable practices in harvesting.
- **Eco-friendly medicine:** Use of natural remedies reduces reliance on chemical-based pharmaceuticals, lowering environmental impact.

6. **Addressing modern health challenges**

- **Chronic diseases:** Increasing use in managing lifestyle diseases like diabetes, hypertension, and obesity.

- **Mental health:** Plants like ashwagandha and valerian are used to alleviate stress, anxiety, and insomnia.

Therapies used in traditional herbal system

Traditional medicinal systems incorporate a variety of therapies aimed at promoting health, preventing disease, and treating ailments. These therapies are deeply rooted in cultural practices and often emphasize a holistic approach, considering physical, mental, and spiritual well-being. Below are some widely recognized therapies across different traditional medicinal systems:

1) Ayurveda (India)

- **Panchakarma:** Detoxification and purification processes including enemas, nasal cleansing, and therapeutic vomiting.
- **Herbal medicine:** Use of plants like turmeric, neem, and ashwagandha
- **Oil massages (Abhyanga):** Promotes relaxation and detoxification.
- **Dietary therapy:** Personalized diets based on body types (doshas: Vata, Pitta, Kapha).
- **Yoga and Meditation:** Enhances physical and mental harmony.
- **Focus:** Balance of body, mind, and spirit.

2) Traditional Chinese Medicine (TCM)

- **Acupuncture:** Insertion of needles at specific points to balance Qi (energy flow).
- **Herbal medicine:** Use of combinations of herbs, such as ginseng and licorice root.
- **Cupping therapy:** Improves circulation and reduces pain through suction cups.
- **Moxibustion:** Burning dried mugwort (moxa) near the skin to warm.
- **Tai Chi and Qigong:** Physical exercises to improve energy flow and mental clarity.
- **Focus:** Restoring the balance of Yin and Yang.

3) Unani medicine (Middle East)

- **Regimenal therapy (Ilaj Bil Tadbeer):** Techniques like cupping, massage, and leech therapy.

- **Dietotherapy (Ilaj Bil Ghiza):** Healing through specific diets and nutritional plans.
- **Pharmacotherapy (Ilaj Bil Dawa):** Use of herbal formulations, minerals, and animal-derived substances.
- **Spiritual healing:** Recitation of prayers or verses for mental well-being.
- **Focus:** Maintaining balance between four humors (blood, phlegm, yellow bile, black bile).

4) African traditional medicine

- **Herbal remedies:** Use of roots, barks, leaves, and seeds for treating ailments.
- **Ritual healing**: Involves ceremonies and spiritual practices to ward off illness.
- **Bone setting:** Traditional techniques for treating fractures and dislocations.
- **Steam therapy:** Use of herbal steam for respiratory conditions.
- **Focus:** Integration of physical and spiritual health.

5) Native American medicine

- **Sweat lodge ceremonies:** Detoxification through steam and heat.
- **Herbal remedies:** Use of plants like sage, echinacea, and willow bark
- **Chanting and Drumming:** Spiritual practices to restore balance and health.
- **Vision quests:** Seeking spiritual guidance for healing.
- **Focus:** Harmony with nature and spiritual well-being.

6) Siddha Medicine (South India)

- **Herbal and Mineral remedies:** Use of complex formulations including metals.
- **Varma therapy:** Focuses on pressure points for healing.
- **Kaya Kalpa:** Anti-aging and rejuvenation therapy.
- **Yoga and Meditation:** For physical and spiritual health.
- **Focus:** Achieving perfection in health through spiritual and physical balance.

7) European traditional medicine

- **Herbal medicine:** Use of plants like chamomile, valerian, and nettle.
- **Hydrotherapy:** Water-based treatments for circulation and detoxification.
- **Balneotherapy:** Healing baths using mineral-rich waters.
- **Homeopathy:** Use of highly diluted natural substances.
- **Focus**: Strengthening the body's natural healing ability.

8) Japanese Kampo Medicine

- **Herbal Formulations:** Derived from Chinese medicine, using plants like licorice and cinnamon.
- **Acupuncture:** Balancing energy through targeted needle therapy.
- **Shiatsu massage:** Pressure therapy for relaxation and healing.
- **Focus:** Personalized care based on body constitution.

9) Islamic medicine (Tibb-e-Nabawi)

- **Hijama (Cupping Therapy):** For detoxification and improving circulation.
- **Prophetic medicine:** Remedies based on sayings of Prophet Muhammad, including honey, black seed, and dates.
- **Spiritual healing:** Recitation of Quranic verses for mental and physical health.
- **Focus:** Balance between physical health and spiritual faith.

10) South American traditional medicine

- **Herbal remedies:** Plants like ayahuasca for spiritual healing and coca leaves for stamina.
- **Shamanic practices:** Spiritual rituals and ceremonies.
- **Steam baths:** Using herbs for detoxification.
- **Focus:** Connection with the spiritual realm for holistic healing.

Methods of prepration of traditional herbal medicines

The methods of preparation in traditional medicinal systems vary depending on the plant materials, cultural practices, and intended use. Below are common preparation methods across different traditional medicinal systems:

1) **Infusions (Teas):** Boil water and pour it over fresh or dried plant parts (leaves, flowers, or soft stems). Steep for 5-15 minutes, then strain and consume.

Examples: Chamomile tea for relaxation and Peppermint tea for digestion

2) **Decoctions:** Simmer tougher plant parts (roots, bark, or seeds) in water for 15-60 minutes to extract active compounds. Strain and use the liquid.

Examples: Boiling ginger root for cold and nausea relief and preparing ashwagandha decoction for stress.

3) **Powders** Dry the plant material and grind it into a fine powder. Use directly or mix with water, honey, or milk.

Examples: Turmeric powder mixed with milk for anti-inflammatory benefits. Neem powder for detoxification.

4) **Tinctures:** Soak plant material in alcohol or vinegar for several weeks to extract active compounds. Strain the liquid and store in a dark glass bottle.

Examples: Echinacea tincture for boosting immunity and Ginseng tincture for energy.

5) **Pastes:** Crush fresh plant materials or mix powders with water, oil, or ghee to form a paste. Apply externally for skin conditions or wounds.

Examples: Aloe vera gel for burns and Turmeric paste for wounds or inflammation.

6) **Oil:** Infuse plant materials in carrier oils (e.g., coconut or sesame oil) through cold infusion or gentle heating. Strain and use as massage or medicinal oil.

Examples: Neem oil for skin infections and Herbal hair oils for scalp health.

7) **Syrups:** Boil plant extracts with water and sugar or honey to create a thick syrup. Store in sterilized bottles.

Examples: Tulsi (holy basil) syrup for cough and colds. And Ginger and honey syrup for sore throat.

8) **Poultices:** Crush fresh plant materials and wrap them in a clean cloth. Apply directly to affected areas for healing.

Examples: Onion poultice for inflammation and Plantain leaf poultice for wounds.

9) **Inhalations:** Boil aromatic plants or essential oils in water. Inhale the steam for respiratory relief.

Examples: Eucalyptus steam inhalation for nasal congestion and Mint leaves for sinus relief.

10) **Fermented preparations:** Allow plant materials to ferment naturally or with added cultures for increased bioavailability.

Examples: Kombucha.

(fermented tea) for gut health. And Arishtas (fermented herbal formulations) in Ayurveda.

11) **Compresses:** Soak a cloth in an infusion or decoction and apply to the skin.

Examples: Warm herbal compress for muscle pain. And Cold compress for fevers using herbs like mint.

12) **Tablets and Capsules:** Compress powders into tablets or encapsulate for easy ingestion.

Examples: Triphala tablets in Ayurveda for digestion. And Ginseng capsules in TCM.

13) **Smoking or Burning:** Dry plant materials and burn them for inhalation or fumigation.

Examples: Burning sage for purification. And Tobacco for ceremonial purposes in Native American traditions.

14) **Maceration:** Soak plant materials in cold water for several hours to extract delicate compounds.

Examples: Cold infusion of hibiscus flowers for cooling drinks. And Macerated marshmallow root for soothing the digestive tract.

15) **Pills and Pastilles:** Combine powdered herbs with honey or ghee to form small balls or lozenges.

Examples: Herbal pills like "Chyawanprash" in Ayurveda for immunity.

Traditional Herbal Drugs

S. No.	Name of Drug	Image	Biological Source	Chemical Constituents	Use
1.	**Turmeric**		*Curcuma longa , family* Zingiberaceae, *part use*, rhizome	Curcumin demethoxycurcumin, 5'-methoxycurcumin, and dihydrocurcumin.	Used for thousands of years in cooking and medicine alike, it has recently garnered attention for its potent anti-inflammatory properties.
2.	**Ginger**		*Zingiber officinale*, family Zingiberaceae, part used rhizome, root	Gingerols, shogaols, and paradols. In fresh ginger, gingerols are the major polyphenols,	Used in traditional and folk practices to treat colds, nausea, migraines, and high blood pressure.
3.	***Sambucus nigra* plant**		Sambucus nigra part, family Viburnaceae, used fruits and leaves	Quercetin-3-6-acetylglucoside, Isorhamnetin dihexoside	Used to relieve headaches, nerve pain, toothaches, colds, viral infections, and constipation.

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

4.	**Ginseng**		*genus Panax , family Araliaceae , part used Root, stem, and leaves*	Ginsenosides and polysaccharide glycans (quinquefolans A, B, and C)	Reduce inflammation and boost immunity, brain function, and energy levels.
5.	**Maidenhair tree**		*Ginkgo biloba, family Ginkgeaceae , used part leaf and seed*	Potent antioxidants	Used to make teas and tinctures, but most modern applications use leaf extract.
6.	**Echinacea**		*Echinacea purpurea, Asteraceae roots, leaves, and flowers*	Polysaccharides, glycoproteins, alkamides, volatile oils, and flavonoids	Practices to treat a variety of ailments, including wounds, burns, toothaches, sore throat, and upset stomach.

7.	**Basani**		*Hypericum perforatum*, Pteridaceae, Leaves and stem	Tannins (ranging from 3% to 16%), xanthones (1.28 mg/100 g), phenolic compounds (caffeic acid, chlorogenic acid, and p-coumaric acid), and hyperfolin	Historically, it was utilized to aid wound healing and alleviate insomnia.
8.	**Valerian**		*Valeriana officinalis* , Caprifoliaceae, roots and rhizomes	Alkaloids, terpenes, organic acids and its derivatives, valepotriates and flavones	It was taken to relieve restlessness, tremors, headaches, and heart palpitations.
9.	**Chamomile**		Matricaria chamomilla, Asteraceae, flower head	terpenoids (bisoprolol, matricin, and chamazulene), flavonoids (luteolin, rutin, and apigenin)	Used to make tea, but the leaves may also be dried and used for making tea, medicinal extracts, or topical compresses.

10.	**Wheat**		*Triticum aestivum, Poaceae , the bran, endosperm, and germ*	Besides carbohydrates, the starchy endosperm consists of 15% fats and 13% proteins, such as globulins, albumins, glutenins, and gliadins	It is used in a variety of pharmaceutical and nutraceutical dosages including swallowable tablets, hard capsules, blends, granules and pellet premix.
11.	**Rice**		*Oryza sativa , Poaceae, straw, husk, and bran*	Amylose and amylopectin. The rice grain constitutes 12% water, 75%-80% starch and only 7% protein with a full complement of amino acids.	Rice is used in traditional medicines as a remedy against inflammation, gastrointestinal ailments, hypercholesterolemia, diabetes, and skin diseases.
12.	**Cabbage**		*Brassica oleracea, Brassicaceae, vegetative bud.*	Glucosinolates, Vitamin C, Carotenoids, and Polyphenols.	Used for stomach pain, excess stomach acid, stomach and intestinal ulcers, and a stomach condition called Roemheld syndrome.

13.	**Tomato**		*Solanum lycopersicum, Solanaceae, fruit,*	carotenoids such as β-carotene, a precursor of vitamin A	Preventing cancer of the breast, bladder, cervix, colon and rectum, stomach, lung, ovaries, pancreas, and prostate.
14.	**Mustard**		*Brassica nigra, Brassicaceae, seeds* and *leaves*	Brassicasterol, campesterol, sitosterol, avenasterol, and stigmasterol.	It has traditionally been used as an emetic and diuretic, as well as a topical treatment for inflammatory conditions such as arthritis and rheumatism.
15.	**Radish**		*Raphanus sativus , Brassicaceae , the root*	Pentyl hexyl, 4-methylpentyl isothiocyanate, dimethyl disulfide, methyl methanethiolsulfinate, and 1-methylthio-3-pentanone.	Use radish for disorders affecting bile flow in the liver, diabetes, and many other conditions.

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

16.	**Sunflower**		*Helianthus annuus , Asteraceae , leaves, seeds, stem, flower*	62-69% linoleic acid and 20-25% oleic acid.	Use sunflower oil for high cholesterol and preventing heart disease
17.	**Carrot**		*Daucus carota, Apiaceae, roots*	Moisture (86%), protein (0.9%), fat (0.2%), carbohydrate (10.6%), crude fiber (1.2%), total ash (1.1%), Ca (80 mg/100 g), Fe (2.2 mg/100 g) and p (53 mg/100 g).	Carrot root is taken by mouth for cancer, constipation, diabetes, diarrhea, fibromyalgia, vitamin A deficiency, vitamin C deficiency, and zinc deficiency.
18.	**Turnip**		*Brassica rapa , Brassicaceae , the stems*	Glucosinolates and isothiocyanates (mainly 2-phenylethyl, 4-pentenyl, and 3-butenyl derivatives)	Turnips contain glucosinolates, which are known for their anticancer properties.

19.	**Sweet Basil**		*Ocimum basilicum , Lamiaceae , Leaf, flower, inflorescence*	Caffeic, Vanillic, Rosmarinic Acids, Quercetin, Rutin, Apigenin, Chlorogenic and p-Hydroxybenzoic.	Antimicrobial, insect repellent, anti-inflammatory, cardiovascular, CNS, and antidiabetic activities.
20.	**Common thyme**		*Thymus vulgaris, Lamiaceae, flowers, leaves*	Thymol (36.0-55.0%), carvacrol (1.0-4.0%), p-cymene (15.0-28.0%), γ-terpinene (5.0-10.0%), linalool (4.0-6.5%), β-myrcene (1.0-3.0%), and terpinen-4-ol (0.2-2.5%)	Used to flavor foods and are also used as medicine. Thyme contains chemicals that might help bacterial and fungal infections.
21.	**Bay**		*Laurus nobili, Lauraceae, floral part*	Consisting of 45% eucalyptol, 12% other terpenes, 8-12% terpinyl acetate, 3-4% sesquiterpenes, 3% methyleugenol, and other α- and β-pinenes, phellandrene, linalool, geraniol, terpineol, and also contain lauric acid.	To treat certain types of hepatocellular carcinoma (a type of liver cancer), renal cell carcinoma (a type of kidney cancer)

22.	**Common Sage**		*Salvia officinalis, Lamiaceae, leaves*	1,8-cineole, camphor, α-thujone, β-thujone, borneol, and viridiflorol	Used in traditional medicine for the relief of pain, protecting the body against oxidative stress, free radical damages, angiogenesis, inflammation.
23.	**Greek Oregano**		*Origanum vulgare, Lamiaceae, leaves*	Carvacrol, p-cymene, c-terpinene, limonene, terpinene, ocimene, caryophyllene, β-bisabolene, linalool, and 4-terpineol.	Tomato-centric recipes, like pizza and pasta sauce, as well as olive oil-based dishes.
24.	**Chives**		*Alliums schoenoprasum, Amaryllidaceae, leaves*	Calcium, Iron, Phosphorus and Sulfur	Soups, dips, mashed or baked potatoes, fish, seafood dishes and omelets.

25.	**Dill**		*Anethum graveolens, Apiaceae, Flowers*	Vitamin A, C, D, riboflavin, manganese, folate, iron, copper, potassium, magnesium, zinc and dietary fibres.	Dill seeds and the parts of the plant that grow above the ground as medicine

Conclusion

Conclusion of this article is not only Herbal drugs continue to be widely used today due to their natural origin, therapeutic efficacy, and minimal side effects compared to synthetic drugs. The increasing global preference for holistic and alternative medicine has further boosted the demand for herbal formulations. lots of reasons like natural and safer alternative, traditional and cultural significance, growing scientific validation, Rising Demand for Herbal Supplements & Nutraceuticals, Sustainability and Eco-Friendliness, Global Recognition & WHO Support, Effective in Chronic and Lifestyle Diseases

References

1. Narayana DBA, Katayar CK, Brindavanam NB. Original system: search, research or re-search. IDMA Bull. 1998;29(17):413-6.
2. Dev S. Ancient-modern concordance in Ayurvedic plants: some examples. Environ Health Perspect. 1999;107(10):783-7.
3. Jaiswal YS, Williams LL. A glimpse of Ayurveda-The forgotten history and principles of Indian traditional medicine. J Tradit Complement Med. 2017;7(1):50-3.
4. Bodeker G, Graz B. Traditional medicine. In: Hunter's tropical medicine and emerging infectious diseases. Elsevier; 2020. p. 194-9.
5. Stoner BP. Understanding medical systems: Traditional, modern, and syncretic health care alternatives in medically pluralistic societies. Med Anthropol Q. 1986;17(2):44-8.

Chapter - 2
Design, Formulation & Characterisation of an Effective Anti-Fungal & Anti-Microbial Poly-Herbal Formulation

Authors

Ajay Kumar Suryawanshi
Student Scholar, School of Pharmacy, Chouksey Engineering College, Bilaspur, Chhattisgarh, India

Purnima Baghel
Assistant Professor, School of Pharmacy, Chouksey Engineering College, Bilaspur, Chhattisgarh, India

Sweety Lanjhiyana
Professor, School of Pharmacy, Chouksey Engineering College, Bilaspur, Chhattisgarh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 2

Design, Formulation & Characterisation of an Effective Anti-Fungal & Anti-Microbial Poly-Herbal Formulation

Ajay Kumar Suryawanshi, Purnima Baghel and Sweety Lanjhiyana

Abstract

Objective: *Momordica charantia*, Cassia, Calendula, and Abelmoschus are traditional medicinal plants known for their antifungal and antimicrobial properties. This study aims to formulate and evaluate a polyherbal gel combining these plants to enhance both antifungal and antimicrobial activity.

Methods: The antifungal and antimicrobial activities of extracts from *M. charantia*, Cassia, Calendula, and Abelmoschus were assessed using the agar well diffusion method. A polyherbal topical gel was then prepared using Sodium carboxymethyl cellulose as a gelling agent at concentrations of 1%, 1.5%, and 2%. The gel's efficacy was evaluated against *Candida albicans* for antifungal activity and various microbial strains for antimicrobial activity. Parameters tested included organoleptic properties, pH, extrudability, spreadability, diffusion, and stability.

Results: The combined extracts of *M. charantia*, Cassia, Calendula and Abelmoschus demonstrated significant antifungal and antimicrobial activities. The gel formulation with optimal concentrations of these extracts exhibited a synergistic effect against Candida albicans and other tested microbes. Stability tests confirmed that all gel formulations remained stable after 30 days.

Conclusion: This study provides the first scientific evaluation of a polyherbal gel combining extracts from *M. charantia*, Cassia, Calendula and Abelmoschus for antifungal and antimicrobial use. The results indicate that this gel formulation is effective against fungal and microbial infections and maintains satisfactory physicochemical properties.

Keywords: Herbal drugs, hplc methods, hot continuous extraction method, antifungal and antimicrobial activities

1. Introduction

In India, traditional medicine systems such as Ayurveda, Unani, Siddha, and various tribal practices have long incorporated herbal remedies, including those with antifungal properties. Ayurveda, in particular, is the most widely practiced and respected among these systems. Over the past few decades, there has been a notable shift in how herbal medicine is viewed in developed countries. Once seen as outdated and unreliable, herbs with antifungal benefits, such as neem and turmeric, are now recognized for their potential in treating fungal infections. This shift began in the 1960s with the 'hippie' movement, which emphasized natural living and alternative therapies [1, 2]. The rise of the conservation movement and the establishment of companies that focus on eco-friendly, natural products also played a role in this change. Today, a variety of herbs with antifungal properties are available in different forms, including fresh, dried, and as ingredients in cosmetics, perfumes, and over-the-counter medications. While conventional medicine continues to advance, the resurgence of interest in herbal remedies highlights their historical importance and effectiveness. For most of human history, plants have been the primary treatment for a range of ailments, including fungal infections, and their relevance is growing once more as resistance to conventional antifungal treatments increases [2, 3].

- *Momordica charantia* L. (Bitter melon) is known for its potential in managing diabetes and its anti-inflammatory properties.
- *Cassia fistula* L. (Golden shower tree) is celebrated for its laxative effects and its role in treating digestive disorders.
- *Calendula officinalis* L. (Marigold) is widely used for its anti-inflammatory and wound-healing properties.
- *Abelmoschus moschatus* Medik. (Musk mallow) is recognized for its antimicrobial and anti-inflammatory benefits [4, 5, 6].

These plants are rich in various phytochemicals such as flavonoids, saponins, and alkaloids, which contribute to their therapeutic effects. The study of these plants aims to explore their antifungal activities and their potential use in combined formulations to enhance efficacy. Gel formulations are particularly suitable for these applications due to their ease of application, prolonged contact time, and minimal side effects compared to other topical or oral treatments.

Antifungal medications, including azoles, polyenes, echinocandins, and pyrimidine analogs, are commonly used to treat denture stomatitis. However, the effectiveness of these treatments is diminishing, largely due to the development of antifungal resistance, varying resistance profiles among Candida species, and issues with patient adherence to treatment regimens [7, 8].

There has been a growing shift towards using natural substances, such as phytochemicals, to address fungal infections. Advances in science have led to the identification of more pharmacologically active Ayurvedic medicines that offer effective treatment options. The beneficial effects of these herbal medicines are attributed to their bioactive compounds, including saponins, tannins, alkaloids, and flavonoids [9].

Terpenoids and sesquiterpenes are examples of compounds that work together to produce beneficial effects. Herbal treatments are increasingly favored for their compatibility with biological systems and their reduced side effects compared to synthetic medications.

For many years, essential oils and herbal extracts have been used in pharmaceuticals, alternative medicine, and natural therapies. These oils and extracts are well-known for their antimicrobial properties and other uses, such as in perfumes (cedarwood and rosewood), flavoring agents (lime and juniper oil), and preservatives (lemongrass oil).

Herbal preparations consist of active substances derived from one or more herbs, including various plant parts such as leaves, flowers, fruits, seeds, stems, bark, or roots, either fragmented or powdered. When multiple herbs are combined, the result is a mixed herbal product or polyherbal formulation [10, 11]. These polyherbal formulations benefit from the synergistic effects of their active constituents, often providing enhanced therapeutic outcomes and better patient compliance compared to single-herb formulations. Additionally, they are generally more affordable, eco-friendly, and safe.

Topical biphasic dosage forms offer properties between solid and liquid dosage forms and possess distinctive rheological properties. They are advantageous for their ease of application and prolonged presence at the site of application. Gels, in particular, are valued for their compatibility with various excipients, thixotropic nature, easy spreadability, and non-staining, greaseless characteristics.

Emulsion hydrogels, also known as emulgels, are typically created by either dispersing an oil phase into an aqueous phase or by inducing gelation within the oil phase of an emulsion. Oil-in-water (O/W) emulsions are commonly used for water-soluble drugs and cosmetic bases, while water-in-oil (W/O) emulsions are preferred for treating dry skin conditions. Polymers function as emulsifiers and thickening agents in these formulations [12, 13]. By altering surface and interfacial tension, and enhancing the viscosity of the water phase, polymers help maintain the stability of the formulation. The gelling agents in the water phase are crucial in converting standard emulsions into emulgels, which offer several advantages over both novel and traditional drug delivery systems. Emulgels can be enhanced with various penetration enhancers, making them a superior option for topical drug delivery.

This study aims to develop and evaluate a polyherbal gel containing extracts from *Momordica charantia* L., *Cassia fistula* L., *Calendula officinalis* L., and *Abelmoschus moschatus* Medik. The focus is on comparing the antifungal activity and clinical efficacy of this gel against commercially available options for treating antifungal antimicrobial action [14, 15].

2. Methods & Materials

2.1 Material selection

It was decided that the studies could be made for further research on those plants which are potentiallyanti-fungal and anti-microbial for fungal treatment as per prior art and traditional knowledge and practice.

Collection of plant materials, Identification and primary Processing of the materials

1) *Momordica Charantia L*. collected locally from the Bilaspur Market and store in glass container. Identity was confirmed by Dept. of Pharmacy, CEC SOP, Bilaspur, Chhattisgarh. Tinospora cordifolia (Guduchi) growing on neem trees collected from Koni village, Bilaspur. Identity was confirmed by Dept. Of Botany, CEC SOP, Bilaspur, Chhattisgarh. Stem immediately processes for cold Extraction.
2) *Cassia fistula* L. collected from Bilaspur and Identity was confirmed by Dept. of Pharmacy, CEC SOP, Bilaspur, Chhattisgarh, Purified arial plant part with water &Distil water, sun dried &

powder immediately sieve under 60 mesh. Store in air tight Container.

3) *Calendula officinalis* L., collected from Ameri road, nearby Institute of Pharmacy & Technology, SVITS, Bilaspur. Leaves of the plant separated, purified with water & distil water and dried under sun. Powder immediately sieves under 60 meshes. Store in air tight container.

4) *Abelmoschus Moschatus* Medik., collected from Herbal Garden, Koni, Bilaspur. Leaves of the plant separated, purified with water & distil water and dried under sun. Powder immediately sieves under 60 meshes. Store in air tight container.

2.2 Preparation of extract

Theaboveplantsandmodifiedherbalmaterialsweremixedindifferentcompositionandratiotogetextract formulations. The fresh leaves were collected, air-dried in the shade, and then stored in polyethylene bags. The dried leaves were mechanically powdered. The powdered leaves were subsequently extracted using a hydro-methanol solution through the maceration method.

2.3 Preformulation study

2.3.1 Incompatibility study

Identifying potential chemical or physical interactions is crucial as they can influence the drug's bioavailability and stability.

a) Fourier transform infrared spectroscopy

Compatibility studies were conducted at room temperature using FTIR spectroscopy. This technique helped assess interactions between drugs, as well as between drugs and excipients or polymers used in the formulation.

2.4 Preparation of polyherbal gel

Plants are considered a valuable source of potentially beneficial compounds for developing new therapeutic medications due to their generally low risk of adverse effects. Topical gels, in particular, offer significant advantages over creams or ointments by delivering medication more quickly and effectively to the targeted area. This mode of administration is increasingly preferred for its efficacy. Gels can be formulated with various plant and herb extracts that possess specific therapeutic properties, enhancing their effectiveness. In this study, a polyherbal gel was formulated using an optimized 2% Carbopol gel base.

The ethanolic extract was tested at varying concentrations (1%, 1.5%, and 2%), while the concentration of another component was consistently maintained at 5 mL in each gel formulation. Details of these polyherbal gel formulations are provided in Table 1.

Table 1: Formulation of Polyherbal gel

Ingredients	F1	F2	F3
Polyherbal extract	1%	1.5%	2%
Carbopol 940	2%	2%	2%
Propylene glycol	5ml	5ml	5ml
Methyl paraben	0.15gm	0.15gm	0.15gm
Propyl paraben	0.30gm	0.30gm	0.30gm
Triethanolamine	5ml	5ml	5ml
Water	q.s.	q.s.	q.s.

2.5 Phytochemical evaluation parameters

The alcoholic extract of plants was screened qualitatively for the presence of various phytoconstituents, such as flavonoids, proteins, amino acids, phenol, and organic acid.

2.6 Evaluation parameters: Evaluation parameters for the gel

Table 2: Physical appearance of the formulated gel

Characteristics	F1	F2	F3
Physical appearance	Transparent gel	Transparent gel	Transparent gel
Colour	Pale Yellow	Pale Yellow	Pale Yellow
Homogeneity	Absence of aggregates	Absence of aggregates	Slight aggregates

Fig 1: Prepared Polyherbal Gel Formulation

2.6.1 Homogeneity

Each gel was visually inspected for uniformity once it had set in the container. The appearance of the gels was assessed to ensure consistent texture and lack of any visible separation or clumping.

2.6.2 pH of the Gel

The pH level of the gel was measured using a digital pH meter to ensure it was within the desired range.

2.6.3 Extrudability

For the extrudability test, 20 grams of the gel formulation were placed into standard collapsible aluminum tubes, which were then sealed by crimping. The initial weight of each tube was recorded. The tubes were positioned between two glass slides and clamped securely. A 500-gram weight was applied on top of the slides, and the cap of the tube was removed. The gel that was extruded was collected, weighed, and the percentage of extruded gel was calculated.

2.6.4 Spreadability

To assess spreadability, the gel formulation was sandwiched between two glass plates measuring 5 cm x 2 cm. A 100-gram weight was evenly distributed over the plates to ensure uniform application of pressure. After removing the weight, any excess gel was scraped off. The two glass plates were then positioned at a 45° angle, with one plate held firmly in place by a clamp and the other allowed to move freely. A 20-gram weight was attached to the upper plate to facilitate its movement. The time taken for the upper plate to separate from the lower plate was recorded. The spreadability was calculated using the formula:

$$S = \frac{W \times L}{T}$$

Where (S) is the spreadability, (L) is the length of the glass plate, (W) is the weight tied to the upper plate, and (T) is the time taken (in seconds). The experiment was conducted in triplicate for accuracy, results are shown in Table 3.

Table 3: Measurement of pH, Viscosity, spread ability

Formulation code	pH	Viscosity (cps)	Spread ability (g/cm/s)
F1	5.9	1428	16.37

F2	5.7	1425	23.45
F3	5.8	1356	22.16

2.6.5 *In vitro* diffusion study

An in vitro diffusion study was conducted using a Franz diffusion cell with a 25 ml volume. A 1-gram portion of the gel was applied evenly onto the surface of an egg membrane within the cell. The receptor chamber was filled with freshly prepared phosphate buffer (pH 5.8), and the solution was stirred with a magnetic stirrer. At specified time intervals, 1.0 ml aliquots were withdrawn from the receptor chamber and replaced with fresh buffer solution. The samples were analysed for drug content using a UV-visible spectrophotometer at 280 nm and 342 nm for eugenol and piperine, respectively, after appropriate dilution. The cumulative amount of drug released through the egg membrane was calculated as a function of time.

2.6.6 Antifungal activity

The antifungal activity of hydro-methanolic leaf extracts of *Piper betel* and *Piper nigrum* incorporated into a gel was evaluated. A fungal culture of *Candida albicans* was spread on a plate with Potato Dextrose Agar media. Wells were filled with different concentrations of the leaf extract (1 mg/ml) in dimethyl sulfoxide (DMSO) and a standard solution of 2% ketoconazole. The plate was incubated at room temperature for 2-3 days. The zone of inhibition around each well was measured in millimetres.

2.6.7 Stability study

Both placebo and medicated gels were assessed for their thermo stability.

3. Results and Discussion

3.1 Organoleptic evaluation of extract

Organoleptic evaluation is a qualitative assessment method where the unique characteristics of substances, especially plant-based drugs, are examined using the senses-sight, smell, taste, touch, and hearing. This approach involves recording attributes such as size, shape, colour, and texture to provide a comprehensive description of the extract's sensory qualities, results are shown in Table 4.

Table 4: Evaluation of organoleptic characteristics of the extract

Characteristics	Observation
Physical state	Semisolid
Colour	Green
Odor	Characteristics
Taste	Characteristics

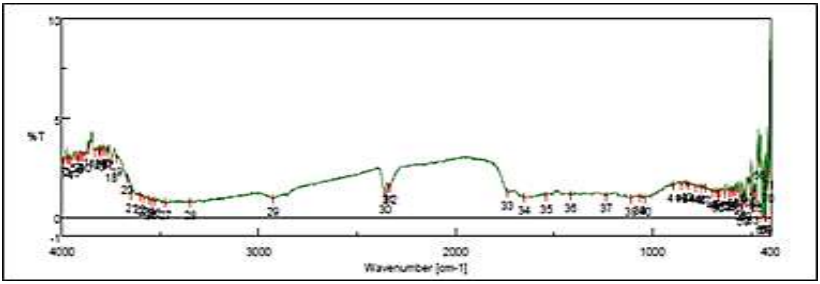
3.2 Phytochemical analysis of the extract

Phytochemical analysis plays a crucial role in identifying and characterizing various plant-derived compounds. This process involves examining and isolating different classes of phytoconstituents present in plant extracts. Such analysis helps in determining which compounds are most prevalent and in identifying bioactive substances that may be useful in developing therapeutic agents. Key phytochemicals such as alkaloids, flavonoids, phenolic compounds, saponins, steroids, tannins, and terpenoids are important for their industrial and medicinal applications. For the *Vigna radiata* extract, the phytochemical analysis detected the presence of flavonoids, phenolics, and other constituents known for their antimicrobial, antidiabetic, and antihyperlipidemic properties. Detailed results are summarized in Table 5.

Table 5: Phytochemical analysis results of the polyherbal extract

Constituents	Test	End Point	Results
Flavonoids	Ferric chloride Lead Acetate	Green to yellow precipitate	++
Protein	Xanthoprotein Ninhydrin	Yellow precipitate	++
Amino acids	Ninhydrin Tyrosine	Dark Red	++
Phenol	Ferric chloride	Blue or red yellow	++
Organic acid	Phosphoric acid	Light Yellow precipitate	++

3.2.1 Incompatibility study: The pre-formulation study was carried out by FTIR method. The results were shown below.



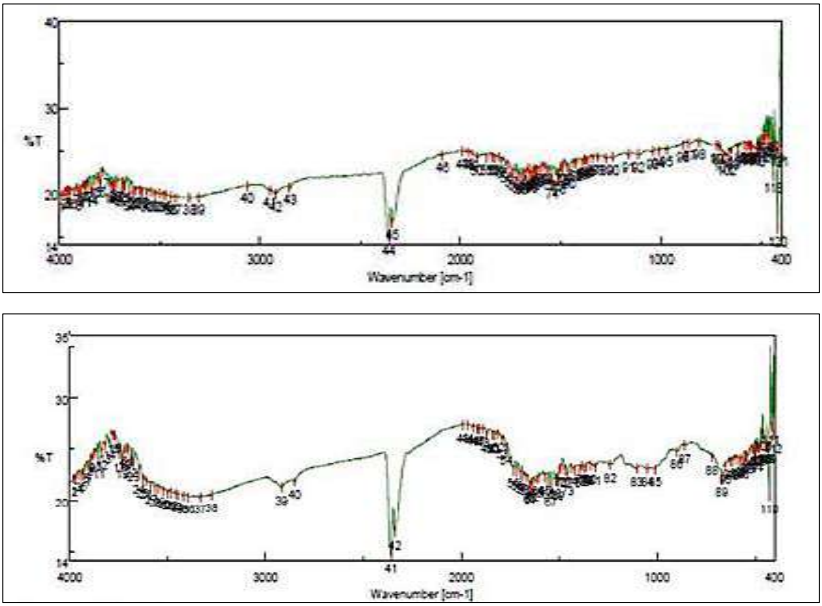


Fig 2: FTIR Graph (Poly Extract)

Antimicrobial Activity of the Extract

The antimicrobial activity of the gel was assessed by measuring the diameter of inhibition zones (in mm), which reflects the efficacy of the antimicrobial agents. The gel's effectiveness against acne-causing organisms, such as *Staphylococcus aureus* (ATCC-6538P), *Escherichia coli* (ATCC-8739), and *Candida albicans* (ATCC-18804), was evaluated and compared with standard antibiotics, including Gentamicin (10 µg) and Fluconazole (25 µg). The observed antimicrobial effects are likely attributed to the high flavonoid content in the extract, which contributes to the gel's efficacy. Additionally, the gel's antioxidant properties, which help prevent photodegradation and oxidative damage, further enhance its stability and effectiveness. The presence of polyphenols in the extract may also contribute to anti-acne activity by affecting mitochondrial permeability transition pores (mPTP). Furthermore, the antioxidant properties of the gel protect epidermal cells from damage induced by UVA radiation, partly due to the presence of orthophosphoric acid, detailed results are summarized in Table 6.

Table 6: Anti-microbial activity of the polyherbal extract

Sample	Staphylococcus aureus (ATTC-6538P)	Escherichia coli (ATCC-8739)	Candida albicans (ATCC-18804)
Polyherbal gel (F2)	12.3	13.5	12.6
Gentamicin (10 mcg)	22.5	22.6	-
Fluconazole (25 mcg)	-	-	22.5

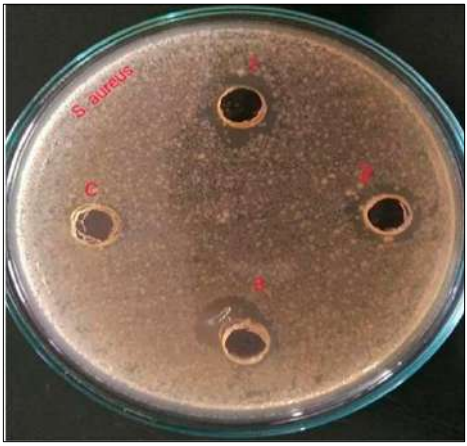


Fig 3: Zone of inhibition of *Momordica charantia* L., *Cassia fistula* L. extract towards Staphylococcus aureus (1) 12.4 mm, (2) 12.3 mm, (3) 12.1 mm and (c) control. Gels 2023, 9, x for Peer Review

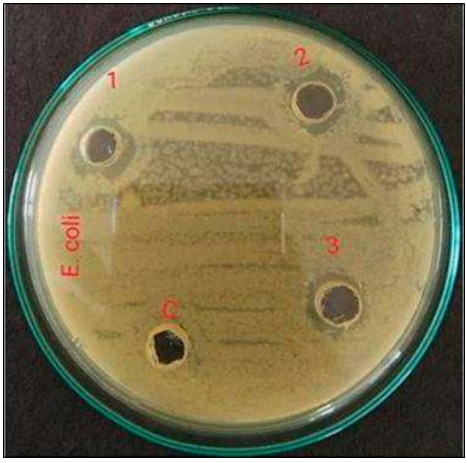


Fig 4: Zone of inhibition of *Calendula officinalis* L., *Abelmoschus moschatus* Medik., extract toward Escherichia coli (1) 13.2 mm, (2) 13.1 mm, (3) 13.1 mm and (c) control.

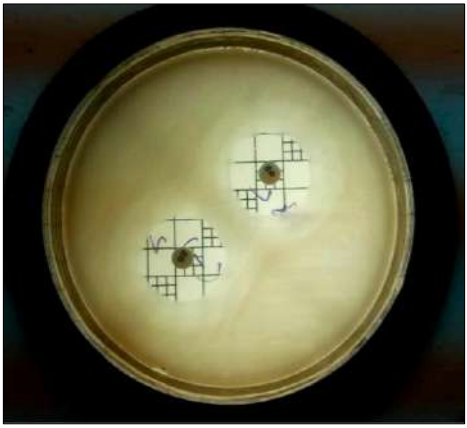


Fig 5: Standard Gentamycin on Staphylococcus aureus at 10 mcg in duplicate at ZOI of 22.2 mm.

Gel strength analysis

The development of products such as gels, capsules, and contact lenses relies on factors like strength, flexibility, and rupture force. Gel strength is a key parameter for assessing a colloidal dispersion's ability to form and maintain a gel. In the gelatin industry, this is referred to as Bloom strength, which measures the amount of force, in grams, needed to compress a gelatin gel's surface by 4 mm using a standard 0.5-inch diameter probe. This metric indicates the force required to break the gel. For the polyherbal gel developed, the Bloom strength is 0.0163 kg, as detailed in Tables6& 7 and Figures 3, 4 & 5. This characteristic impacts how effectively the drug can penetrate through the gel matrix.

Table 7: Test data of polyherbal gel strength

Gel Strength/ m value (g) Force 1	Force at target (cycle:1) (kg)	Radiant to positive peak (cycle:1) kg/s
0.696	0.015	0.003

Conclusion

A hydrogel formulation combining hydro-methanolic extracts of *Piper betle* (betel leaf) and *Piper nigrum* (black pepper) (1:1) was created using sodium carboxymethyl cellulose. This formulation exhibited satisfactory physicochemical properties. *Piper nigrum* demonstrated over 90% drug release within 24 hours, while *Piper betle* achieved over 70% drug release within the same period. Stability studies of the hydrogel formulations were

positive. Antifungal testing against *Candida albicans* indicated that both individual extracts and their combination exhibited antifungal activity. The observed antifungal effects are likely attributed to their alkaloid, phenol, and lignan content. Additionally, hydro-methanolic extracts of *Momordica charantia* (bitter melon), *Cassia fistula* (golden shower tree), *Calendula officinalis* (marigold), and *Abelmoschus esculentus* (okra) were also evaluated for their potential activities. *Momordica charantia* is known for its antiviral and antidiabetic properties, *Cassia fistula* has been recognized for its laxative and anti-inflammatory effects, *Calendula officinalis* is noted for its wound-healing and anti-inflammatory activities, and *Abelmoschus esculentus* is valued for its antioxidant and anti-diabetic properties. Further research is needed to elucidate the specific contributions of these phytoconstituents to the antifungal activity. This study represents the first scientific evaluation of a gel formulation combining *Piper betle* and *Piper nigrum* extracts for antifungal purposes. Overall, both extracts demonstrated strong antifungal properties, and their methanolic hydro extracts are suitable for formulation as hydrogels with desirable physicochemical characteristics.

Acknowledgment

We are very thankful to the respected principal and management of SOP, CEC, Bilaspur and the research laboratory. The authors (SL and PB) gratefully acknowledge support and research contribution from a research lab and guidance from colleagues (No. 511/34/100 PU).

Reference

1. Ahmadian E, Khosroushahi AY, Eftekhari A, Farajnia S, Babaei H, Eghbal MA. Novel angiotensin receptor blocker azilsartan induces oxidative stress and NF-kB-mediated apoptosis in the hepatocellular carcinoma cell line HepG2. Biomed Pharmacother. 2018;99:939-46. https://doi.org/10.1016/j.biopha.2018.01.117
2. Oon HH, Wong SN, Aw DC, Cheong WK, Goh CL, Tan HH. Acne management guidelines by the Dermatological Society of Singapore. J Clin Aesthet Dermatol. 2019;12:34.
3. Asthana N, Pal K, Aljabali AA, Tambuwala MM, de Souza FG, Pandey K. Optimization of polyvinyl alcohol (PVA) mixed green-clay and aloe vera based polymeric membranes: Peel-off mask formulation for skin care cosmeceuticals using green nanotechnology. J Mol Struct. 2021;1229:129592. https://doi.org/10.1016/j.molstruc.2020.129592

4. Kartikeyan A, Vasudevan V, Peter AJ, Krishnan N, Velmurugan D, Velusamy P, *et al.* Effect of incubation period on the glycosylated protein content in germinated and ungerminated seeds of mung bean (*Vigna radiata* (L.) Wilczek). Int J Biol Macromol. 2022;217:633-51. https://doi.org/10.1016/j.ijbiomac.2022.07.036

5. Qiu Y, Yu T, Wang W, Pan K, Shi D, Sun H. Curcumin-induced melanoma cell death is associated with mitochondrial permeability transition pore (mPTP) opening. Biochem Biophys Res Commun. 2014;448:15-21. https://doi.org/10.1016/j.bbrc.2014.04.024

6. Kanatt SR, Arjun K, Sharma A. Antioxidant and antimicrobial activity of legume hulls. Food Res Int. 2011;44:3182-7. https://doi.org/10.1016/j.foodres.2011.08.022

7. Bayan MF, Marji SM, Salem MS, Begum MY, Chidambaram K, Chandrasekaran B. Development of polymeric-based formulation as a potential smart colonic drug delivery system. Polymers. 2022;14:3697. https://doi.org/10.3390/polym14173697

8. Obaidat RM, Tashtoush BM, Bayan MF, Al Bustami RT, Alnaief M. Drying using supercritical fluid technology as a method for preparing chitosan aerogel microparticles. AAPS Pharm Sci. Tech. 2015;16:1235-44. https://doi.org/10.1208/s12249-015-0312-2

9. Ilango KB, Gowthaman S, Seramaan KI, Chidambaram K, Bayan MF, Rahamathulla M, *et al.* Mucilage of *Coccinia grandis* as an efficient natural polymer-based pharmaceutical excipient. Polymers. 2022;14:215. https://doi.org/10.3390/polym14010215

10. Heggset EB, Strand BL, Sundby KW, Simon S, Chinga-Carrasco G, Syverud K. Viscoelastic properties of nanocellulose-based inks for 3D printing and mechanical properties of CNF/alginate biocomposite gels. Cellulose. 2019;26:581-95. https://doi.org/10.1007/s10570-018-2142-3

11. Chen Y, Li Z, Chaves Figueiredo S, Çopuroğlu O, Veer F, Schlangen E. Limestone and calcined clay-based sustainable cementitious materials for 3D concrete printing: A fundamental study of extrudability and early-age strength development. Appl Sci. 2019;9:1809. https://doi.org/10.3390/app9091809

12. Supasatyankul B, Saisriyoot M, Klinkesorn U, Rattanaporn K, Sae-Tan S. Extraction of phenolic and flavonoid compounds from mung bean

(*Vigna radiata*) seed coat by pressurized liquid extraction. Molecules. 2022;27:2085. https://doi.org/10.3390/molecules27072085

13. Kang MC, Kim SY, Kim YT, Kim EA, Lee SH, Ko SC, *et al. In vitro* and *in vivo* antioxidant activities of polysaccharides purified from *Aloe vera* (*Aloe barbadensis*) gel. Carbohydr Polym. 2014;99:365-71. https://doi.org/10.1016/j.carbpol.2013.07.091
14. Al Aboody MS. Cytotoxic, antioxidant, and antimicrobial activities of celery (*Apium graveolens* L.). Bioinformation. 2021;17:147. https://doi.org/10.6026/97320630017147
15. Bayan MF, Salem MS, Bayan RF. Development and in vitro evaluation of a large-intestinal drug delivery system. Res J Pharm Technol. 2022;15:35-9. https://doi.org/10.52711/0974-360X.2022.00007
16. Bayan MF, Jaradat A, Alyami MH, Naser AY. Smart pellets for controlled delivery of 5-fluorouracil. Molecules. 2023;28:306. https://doi.org/10.3390/molecules28010306
17. Ourique AF, Melero A, Da Silva CD, Schaefer UF, Pohlmann AR, Guterres SS, *et al.* Improved photo stability and reduced skin permeation of tretinoin: Development of a semisolid nanomedicine. Eur J Pharm Sci. 2011;79:95-101. https://doi.org/10.1016/j.ejpb.2011.03.008
18. Shareen R, Kumar S, Gupta GD. Meloxicam carbopol-based gels: Characterization and evaluation. Curr. Drug Deliv. 2011;8:407-15. https://doi.org/10.2174/156720111795768013
19. Lu Z, Fassihi R. Influence of colloidal silicon dioxide on gel strength, robustness, and adhesive properties of diclofenac gel formulation for topical application. AAPS Pharm Sci. Tech. 2015;16:636-44.

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 3
Ancient Wisdom in *Shopha* (Inflammation) and *Granthi* (Cysts) Related to Gynaecology: Medicinal Plants in Ayurveda

Authors

Garima
Ph.D. Scholar, Department of Prasuti Tantra & Stri Roga, All India Institute of Ayurveda (AIIA), Sarita Vihar, New Delhi, India

Sujata Kadam
I/C Director, AIIA and Professor, Department of Prasuti Tantra & Stri Roga, All India Institute of Ayurveda, Sarita Vihar, New Delhi, India

Meenakshi Pandey
Associate Professor, Department of Prasuti Tantra & Stri Roga All India Institute of Ayurveda, Sarita Vihar, New Delhi, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 3

Ancient Wisdom in *Shopha* (Inflammation) and *Granthi* (Cysts) Related to Gynaecology: Medicinal Plants in Ayurveda

Garima, Sujata Kadam and Meenakshi Pandey

Abstract

Inflammation in our body is natural biological response to any form of injury, infection or irritation, characterized by redness, swelling, pain, and heat. Inflammation can occur in any part of the body and presents respective symptoms and disease. Similarly, in gynaecological disorders, it is reflected by conditions such as endometriosis, haemorrhagic cysts, PCOS and ovarian cysts. Conventional medical management includes anti-inflammatory drugs, hormonal therapy, and surgical interventions, associated with different adverse effects from nausea, hormonal imbalance, metabolic disturbances, neuro-degenerative disorders, dependency on synthetic medications and even cardiac arrest. Long term untreated inflammation may lead to ectopic pregnancy, infertility, chronic pain and other reproductive issues, while it may get life threatening when occurs in other major organ systems.

Considering these challenges along with increasing concerns over developing resistance and adverse effects of drugs, it is need of the hour to look for an alterbnative which is safe yet effective with least side effects non-invasive and is cost efficient. Ayurveda stands as a beacon of hope. It offers time-tested, sustainable, safe and effective solutions for inflammation and associated cystic conditions. Ayurveda understands and deeply explains inflammation in terms of '*shotha'* and its etiopathogenesis, imbalance of bodily constituents and probable solutions through various medicinal plants such as *Guduchi* (*Tinospora cordifolia*), *Varuna* (*Crataeva nurvala), Guggulu* etc. with proven anti-inflammatory, immunomodulatory, anti-tumour, and tissue-healing properties among others.

Medicinal plants mentioned in this chapter are research based and proven for their said properties. These act at removal of toxins, correction of

metabolic activities, maintain physiological balance and promote optimum quality *dhatu* formation. Thus, these not only help effectively pacify inflammation, help reduce cysts but also help maintain and bring overall health and well-being ensuring a safe, sustainable and natural way to reproductive health for females.

Keywords: Ayurveda, inflammation, gynaecological disorders, medicinal plants, cyst management

Introduction

Inflammation is a natural response of body to injury, infections or toxins, but chronic inflammation can lead to serious health issues such as arthritis, cardiovascular diseases, and metabolic disorders. While acute inflammation is essential for healing, chronic inflammation occurs when the body's immune response remains active for prolonged periods, leading to tissue damage, oxidative stress, and increased risk of degenerative diseases.

Chronic inflammation caused by poor diet, stress, pollution, and sedentary lifestyles are well capable of leading some of serious health issues including; Autoimmune disorders, Cardiovascular diseases, Diabetes and metabolic syndrome and even Neuro-degenerative diseases. Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) are most commonly used option for management of inflammation. NSAIDs, though effective, have been associated with adverse effects in different organ systems ranging from simple nausea, vomiting, gastric reflux, diarrhoea to serious cardiac risks, aseptic meningitis, aplastic anaemia, skin problems among others. Moreover, these drugs have also been linked to transcriptional adaptations that lead to increased antibiotic resistance [1]. Thus, there is need for an alternative that is effective, safe, having least adverse effects, preventive as well as curative and can be taken as a substitute by people found unfit for or allergic to above drugs.

Inflammation in ayurveda

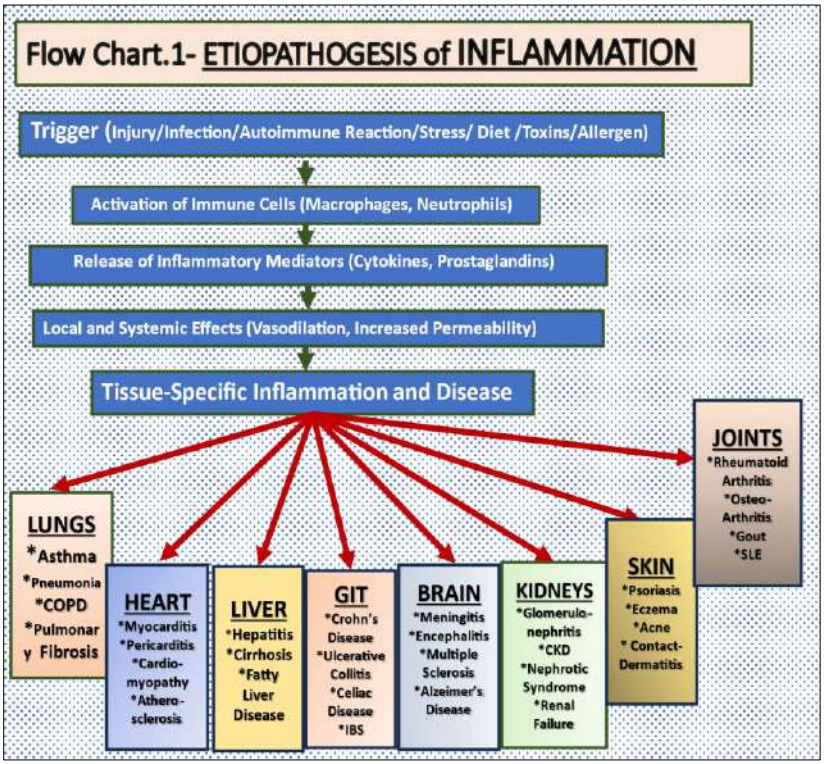
In Ayurveda, it can be understood with the term '*Shopha'* which has been described in detail by Acharya Charak mentioning that it can occur in different parts of the body, thus, can be of various types according to *sthana* (place), *dushya*, *aakriti* (signs and symptoms) and *naama* (name). And then he describes *shophas* including *Granthi* and that it can occur in any one part of the body due to three *doshas* namely, *vata, pitta* and *kapha* presenting their respective signs and symptoms. *Granthi* in Ayurveda is described as a rounded, protuberant, knotty and hard swelling, since it is knotty or glandular, so it is called as *Granthi*. Inflammation in body can be a huge impediment for

overall well-being. Ayurveda, the ancient Indian system of medicine, offers a natural approach through its various mentioned drugs in reducing inflammation.

Etiopathogenesis

Modern science

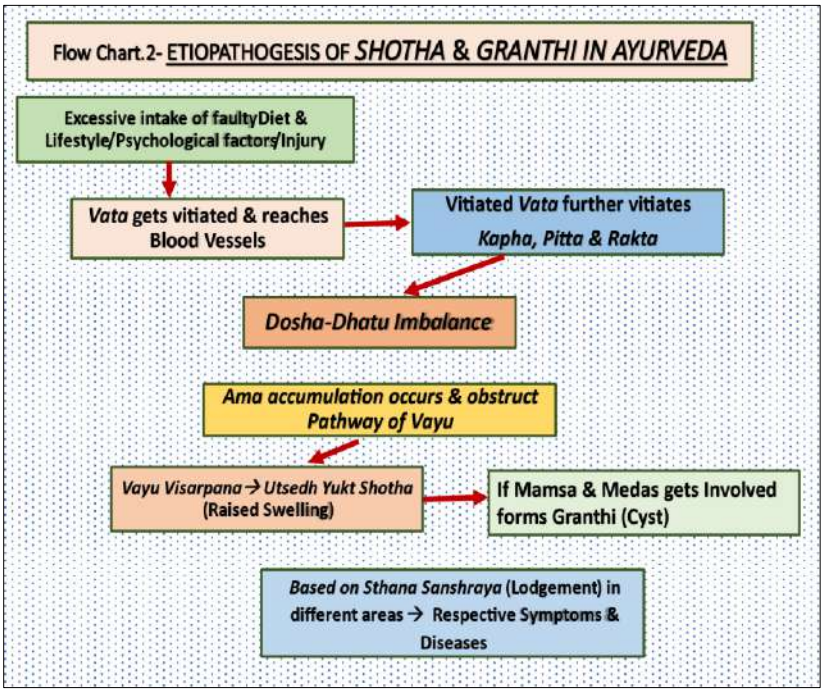
In simple words it is triggered by any injury, infection or autoimmune reaction which activates immune cells (Macrophages, Neutrophils) which release Inflammatory Mediators (for e.g. Cytokines, Prostaglandins) producing different local and systemic effects like vasodilatation, increased Permeability etc leading to the Tissue-Specific Inflammation and or disease.



Ayurveda

It is caused by disturbed body consituents *doshas* and *dhatus* in a specific way. The *vata* gets vitiated and reaches blood vessels. It vitiates the other two *doshas* and also *rakta* (vascular system). These *kapha*, *rakta* and *pitta* getting affected by *vata* and also increased in their amount due to different causative

factors or *ama* (toxin) accumulation obstruct path of *vayu*. This obstructed *vayu* moves and spreads leading to raised swelling or agitate body constituents *Mamsa* (muscular system), *Rakta* and *Medas* (fat and adipose), produce a round, oval or protuberant swelling referred to as *Granthi.*

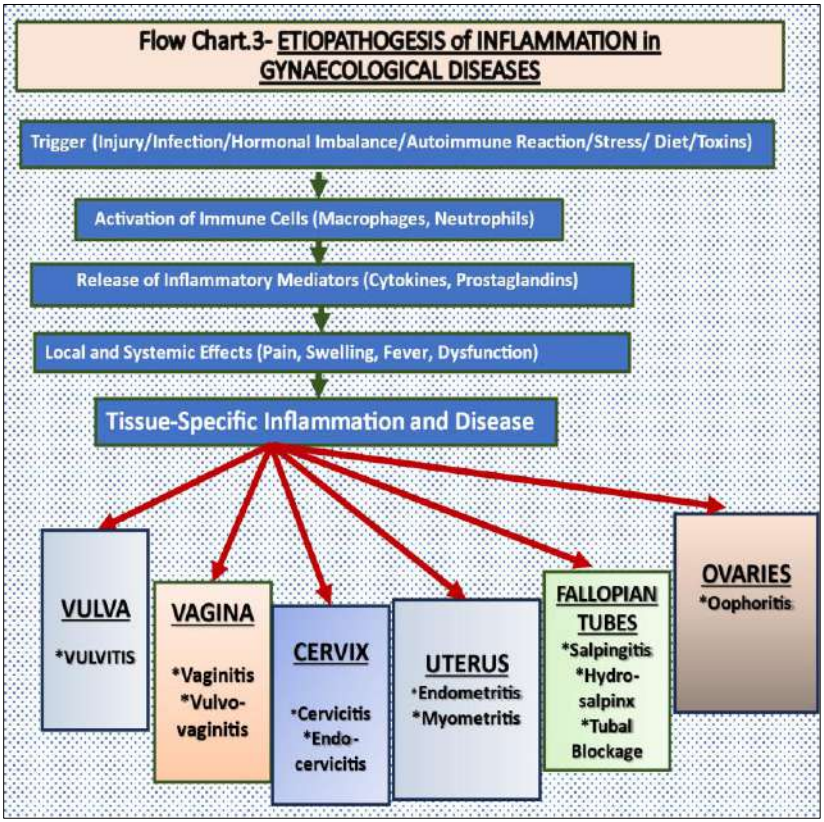


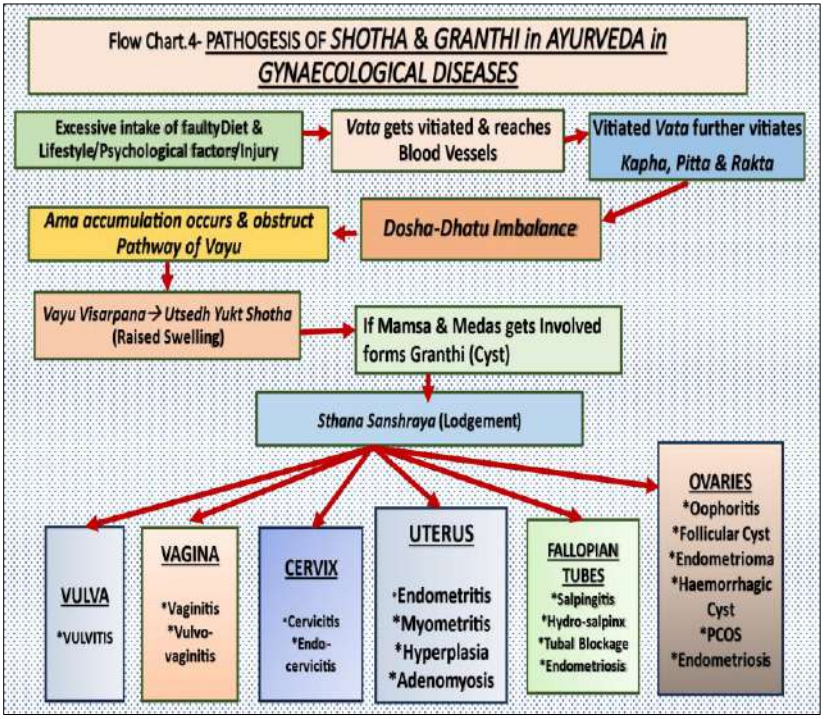
Inflammation in gynaecology

Inflammation according to Ayurveda as well as contemporary science can occur in any part of bodily tissues based on which different disease conditions may be seen. For example, if inflammation occurs in Lungs it may cause Asthma, Pneumonia, Pulmonary Fibrosis or Chronic Obstructive Pulmonary Disease (COPD), in Heart may lead to myocarditis, cardiomyopathy to Atherosclerosis. Similarly, Chron's disease, irritable bowel syndrome (IBS), gastritis in Gastrointestinal system, hepatitis, cirrhosis in Liver, multiple sclerosis, encephalitis, Alzeimer's disease in Brain and so on.

Thus, as per Ayurveda when these factors get logdement in reproductive system they cause Inflammation there and produce respective symptoms,i.e. if more *vata* and *kapha*, more chance for cyst formation. In the same context if *pitta* and *rakta* more vitiated, then more of endometriomas or haemorhhagic cyst or endometrial hyperplasia may occur. Therefore, the lodgement in uterus

might present as hyperplasia, in ovaries as follicular or haemorrhagic cysts, or endometrioma, endometriosis in ovaries or follicular tube or area it gets *sthanasanshraya* (placement), Pelvic Inflammatory Disease in pelvis and so on. Moreover, long term inflammation in reproductive tissues or organs may lead to serious complications that include scarring and adhesions in the reproductive tract causing ectopic pregnancy, infertility and chronic pelvic pain while, such long-term inflammation in other major organ systems can cause serious medical conditions and some could even be life threatening.





Why ayurveda for inflammation?

Ayurvedic drugs act at breaking the pathway of pathogenesis to cleanse vitiated doshas and toxins from the body to correct and restore the physiological balance of *dosha*, *dhatu* and *agni* at the cellular level. Thus, supports overall wellness by improving digestion, promoting detoxification and enhancing immune balance. These drugs, including various numerous drugs in Ayurveda pacify inflammation and provide a sustainable way of managing inflammation.

Recent researches have validated Ayurveda's wisdom in management of inflammation. Various studies confirm the effectiveness of plants in reducing inflammatory markers such as CRP (C-reactive protein), TNF-alpha, and IL-6. Most commonly used NSAIDs as discussed may found to be useful in suppressing symptoms but are associated with a wide range of adverse effects on different major organ systems, while Ayurvedic herbs work at a deeper level, enhancing the immune response and preventing any long-term damage.

Chronic inflammation and *Granthi*

In Ayurveda, Granthi refers to cysts, nodules, fibroids, or localized swellings that develop due to an imbalance of *Doshas (Vata, Pitta, and Kapha)* and vitiation of *Dhatus* (body tissues). Researchers have found direct link between chronic inflammation and the development of cysts and fibroids, particularly in conditions like PCOS (Polycystic Ovary Syndrome), uterine fibroids, and benign or malignant tumors.

Table 1: Ayurvedic and scientific correlation of inflammation and granthi

S. No.	Ayurvedic concept	Modern science
1	*Vata* and *Kapha dosha* lead to Granthi formation	Chronic inflammation triggers fibrosis, cyst formation, and abnormal tissue growth [2]
2	Accumulation of Ama (toxins) due to poor digestion (Agni dysfunction)	Oxidative stress and toxin accumulation contribute to abnormal cell growth and inflammation [4]
3	Vitiation of *Meda* and *Rakta* Dhatu	Insulin resistance and chronic inflammatory markers (IL-6, TNF-α, CRP) promote cystic and fibrotic changes [5]
4	*Vata* and *Kapha dosha* combining with equal amount of vitiated *pitta*	Inflammatory pathways like NF-kB and COX-2 drive fibrosis and tissue hyperplasia [6]

Scientific studies supporting the inflammation-granthi link

Inflammation and uterine fibroids: Research shows increased COX-2 and prostaglandin levels in fibroid tissue, indicating a direct link between inflammation and fibroid growth [6].

Cysts and PCOS: Women with PCOS have higher C-reactive protein (CRP) levels, suggesting a chronic inflammatory state that worsens cyst formation [7].

Breast fibroids and chronic inflammation: Elevated IL-6 and TNF-α in fibrocystic breast disease confirms inflammation as a key factor in fibrotic tissue changes [4].

Medicinal plants in ayurveda

There have been various plants and combinations mentioned in Ayurveda, among these, following given are research based proven medicinal plants that

not only have tremendous potential in pacifying inflammation from body but also help in correction of *agni*, which in turn, leads to correction of metabolic activities and maintenance of physiological balance promoting overall health and wellbeing. Below mentioned medicinal plants are being used for thousands of years by Ayurvedic Practitioners in various diseases and combinations. Though, no significant or serious adverse effects could be found, it is still advisable to use these in supervision of an Ayurvedic Physician as these are chosen as per individual person's requirements and no self-medication should be promoted.

1) Kanchnara (Picture 1)

Botanical name: *Bauhinia variegata* Linn.

Family: *Caesalpinioideae*

Classification according to classics: It belongs to *Vamanopaga* (Acharya Charak), *urdhwabhagahara* and *kashaya varga* (Acharya Su.).

Doshaghnata: *Kaphapittashamak Rogaghnata, Gandmalahara, granthi shotha, kushthaghna, krimighna, rakta pradar, prameha, vibandha, kasahara and vranahara* [8].

Part used: Leaves, Flower, Stem, Seeds and roots.

Karma: Kanchnara has necessary properties of *deepan, pachan, vata-kapha shamak, shothhara, lekhan* and *bhedan* which help to get rid of cardinal symptoms of granthi [9].

Action and uses [10]: Oedema, tumour, goiter, diarrhoea, dysentery, haemorrhoids, wound healing, dyspepsia, leprosy and as antivenom. Chemical Constituents: Its stem bark contains quercitroside, kaempferol-3-glucoside, lupeol and betasitosterol isoquercitroside, rutoside myricetol glucoside and kaempferol glucosides.

Pharmacological activities: Ethanolic extract of kanchanara has shown anti-tumour and cytotoxic effects [11]. These possess anti-inflammatory effects, antioxidant activity in form of quercitin and flavonoid along with free radical scavenging. It possesses anti-diabetic properties, anti-microbial activity, anti-obesity and anti-helminthic activity.

2) Guduchi (Picture 2)

Botanical name: *Tinospora cordifolia (Willd) Miers ex Hook.f and Thoms*.

Family: *Menispermaceae*

Classification according to classics: It belongs to *vayahsthapana, daahprashaman, trishnanigrahana, stanya shodhana, triptaghna* (Acharya Charak), *kakolyadi* and *vallipanchmoola* (Acharya Sushruta).

Doshaghnata: *Tridoshajhara Rogaghnata: Kushthaghna, chhardinigrahana, vatavikar, kasa, shukra daurbalya, madhumeha* [12].

Parts used: Stem.

Karma: *Vednasthapana, raktashodhaka, deepana, pachana, pittasarak, anulomana, hrdya* and *rasayana*.

Action and uses: Fever, jaundice, cancer, chronic diarrhoea, dysentery, emaciation of children, burning, bone fracture, debility, earache, cough, leucorrhoea and asthma [13].

Chemical constituents [14]: It is found to contain a host of chemical constituents including mainly, alkaloids, diterpinoids, steroids, flavanoids and lignans.

Pharmacological activities: It is found to be anti-inflammatory, anti-fibrotic, immune-modulatory, immuno-potentiating, anti-stress, antipyretic and adaptogenic activity [15].

3) Guggulu (Picture 3)

Botanical name: *Commiphora mukul (Hook ex Stocks)* Engl.

Family: *Burseraceae*

Classification according to classics: It belongs to *eladi* (Acharya Sushruta) gana.

Doshaghnata: *Tridosha shamak Rogaghnata: Medohara, shoth hara, amavathara, prameh hara, bhagna sandhan, kushtha* and *krimi*.

Part used: Resin

Karma: *Pachan, vata-kapha shamak, shothhara, lekhan* and *bhedan* which help to get rid of cardinal symptoms of granthi [16]. *Vrishya, rasayana, deepana, balya swarya, vranahara, varnya and brimhana* [17].

Action and uses: Hypercholestrolemia, obesity, atherosclerosis, rheumatism, inflammation and antioxidant [18].

Chemical constituents [19]: The plant contains essential oil, mainly consisting of myrecene, dimyrecene, polymyrecene, Z-guggulsterone, E-guggulsterone, guggulsterone-I, guggulsterone-II and guggulsterone-III.

Pharmacological activities [20]: It is useful in treatment and obesity and other disorders of fat including coating and obstruction of vessels. It has potent anti-inflammatory, hypo lipidemic activity, anti-platelet activity. An increase in serum fibrinolytic activity by 22% was seen after administration of guggulu. Its hypolipidemic action is considered to be due to high affinity binding anion exchange of guggulu and inhibition of hepatic cholesterol biosynthesis, increased fecal bile acid excretion and enhanced plasma lecithin: cholesterol acyl transferase activity.

4) Shunthi (Picture 4)

Botanical name: *Zingiber officinale Rosc*.

Family: *Zingiberaceae*

Classification according to classics: It belongs to a number of ganas such as *triptighna, arshoghna, deepaniya, shoolprashaman* and *trishna nigrahana* (Acharya Charak), in pippalayadi and trikatu by Acharya Sushruta and panchkola and shadushana (Acharya Bhavprakash)

Doshaghnata: *Kaphavatashamak Rogaghnata: Arshoghna, shwashara, vatavyadhi, agnimandya, aruchi, adhmana, udarashoola, shwas, kasa, hikka, vajikarana, pratishyaya* and *daurbalya*.

Part used: Rhizome

Karma: *Shothhara, vednasthapana, sheetprashamana, vatanulomana, shoolprashamana, raktashodhaka, deepana, pachana, rochana and vrishya* [21].

Action and uses: Appetizer, laxative, carminative, digestive disorders, coryza, dropsy, otalgia, asthma, inflammation, rheumatoid arthritis dyspepsia, flatulence and anorexia [22].

Chemical constituents: It's a mixture of constituents, consisting of monoterpenes (phellandrene, camphene, cineole, bornoel and citral) and sesquiterpenes such as zingiberol, zingiberene, zingiberenol, beta bisabolene, sesquiphellandrene and others along with aldehydes and alcohols [23].

Pharmacological activities: Besides nutritional importance (contains fats 0.9%, proteins-2.3%, minerals-1.2% and polyphenol compunds) [24], it exhibits anti-inflammatory and anti-coagulant. It has shown anti-tumour activity in mouse by elevating aryl hydrocarbon hydroxylase enzyme (related with activation and detoxification of foreign biotic compound including chemical, i.e. carcinogen and mutagen) and mild super scavenging property.

Its ethanolic extract inhibits 12-0-tetradecanolphorbol-13-acetate (TPA), induction of epidermal ornithine decaboxylase (ODC), cyclo-oxygenase and lipo-oxygenase activity and m-RNA expression [25].

5) Pippali (Picture 5)

Botanical Name: *Piper longum Linn*

Family: *Piperaceae*

Classification according to classics: It belongs to *kasahara, hikkanigrahana, shirovirechana, vaman, triptighna, deepaniya, shoolprashaman* (Acharya Charak), *pippalayadi, urdhwabhagahara* and *shirovirechana* by Acharya Sushruta.

Doshaghnata: *Rogaghnata: Swashhara, kasahara, jwarhara, pramehhara, arshoghna* [26], *hikkanigrahana*

Karma: *Deepana, vrishya, rechaka, shoolanashak, rakta shodhak, medhya, jantughna, vatanulomana* and *mridurechana* [27].

Part used: Fruit and root.

Action and uses [29]: Asthma, immunosuppressant, anti-inflammatory, hepatoprotective, anti-amoebic, bioavalability enhancer

Chemical constituents: It has been found to contain eleven compounds: longum, and were characterized as coumaperine, N-5-(4-hydroxy-3 methoxyphenyl)-2E-pentenoyl piperidine, piperolactam A, 1-[1-oxo-5 (3,4 methylenedioxyphenyl)-2E,4E-pentadienyl]-pirrolidine, 1-[1-oxo-5(3,4 methylenedioxyphenyl)-2E-pentenyl]-pirrolidine, 1-[1-oxo-9(3,4-methylene dioxyphenyl)-2E, 8E-nonadienyl] -pyrrolidine, (R)-(-)-turmerone, octahydro-4 hydroy-3alpha-methyl-7-methylene-alpha-(1-methylethyl)-1H-indene-1-methanol, (+) -aphanamol I, bisdemethoxycurcumin, demethoxycurcumin [30].

Pharmacological activities: It exhibits anti-inflammatory activity, enhances bio availability by improving Gastro-Intestinal absorption inducing thermogenesis. It strongly inhibits aryl hydrocarbon hydroxylation, ethylmorphine-n-demethylation, strongly inhibits aryl hydrocarbon hydrolase (AHH) and glucoronyl transferase activities [31]. It possesses anti-cancer, antioxidant, depressant, hypocholestrolemic and antiulcer activity [32].

6) Varuna (Picture 6)

Botanical name: *Crataeva nurvala Buch-Ham*

Family: *Capparadaceae*

Classification according to classics: It belongs to *varunadi,vatashmari nashan* and *kaphashmari nashan gana* (Acharya Sushruta)

Doshaghnata: *Kaphavata shamak, Vatahara Rogaghnata: Ashmari, mutrakrichha, bastishoola, jwar, krimi, agnimandya, rakta vikara and vidradhi* [33].

Parts used: Stem, root, bark, leaves and flowers

Karma: *Ashmaribhedana, raktadoshnashak, krimighna, vidhradhihara* and *agnideepaka*.

Conceptual review action and uses: Lithotripsic, used in vesicular calculi, lymphadenitis, wound healing, inferyility, diuretic, diabetes, anti-cancer and as cardioprotective [34].

Chemical constituents: Its main constituents are saponins and tannins [35]. It also contains flavanoids, glucosinolates, plant sterols including lupeols and terpenes are found [36].

Pharmacological activities [36]: It shows diverse activities; anti-inflammatory, anti-cancerous, anti-urolithic, anti-diabetic, cardio protective and anti-arthritic. Lupeols show potent lithotripsic and anti-goitre activity.

Picture 1: Kanchanara

Picture 2: Guduchi

Picture 3: Guggulu

Picture 4: Shunthi

Picture 5: Pippali

Picture 6: Varuna

Conclusion

Chronic inflammation plays a key role in the formation of Granthi (cysts and fibroids). Ayurveda has well understood the concept and explained about inflammation and its pathogenesis. In order to pacify inflammation and consequent problems, various medicinal plants have been mentioned in Ayurveda. Properties of above-mentioned drugs against inflammation and potential in overall wellbeing have been well established by various researches. Therefore, in a world of increasing resistance Ayurveda provides a natural and sustainable way to manage and prevent these conditions.

References

1. Umaru ML, Bello I, Danmalam UH, Maigari A. Phytochemical screening and antibacterial activity of the root extract of *Calotropis procera*. Afr J Biotechnol. 2009;8(25):7332-9. Available from: http://www.academicjournals.org/AJB
2. Furukawa S, Fujita T, Shimabukuro M, Iwaki M, Yamada Y, Nakajima Y, *et al*. Increased oxidative stress in obesity and its impact on metabolic syndrome. J Clin Invest. 2017;114(12):1752-61.
3. Chen J, Zheng Y, Tang G, Jin R. The role of oxidative stress in the development of uterine fibroids. Biomed Res Int.; 2019. p. 1-7.
4. Guo S. Insulin resistance in polycystic ovary syndrome and breast cancer. World J Diabetes. 2017;8(6):81-90.
5. Reinhold-Keller E, Zeidler A, Gutfleisch J, Peter HH, Gross WL. Cyclooxygenase-2 in chronic inflammatory diseases: A potential target for treatment. Rheumatology (Oxford). 2003;42(3):315-21.

6. Morales Roselló J, García González M, Perales Marín A, Sánchez Martínez P, Torrejon Cardoso R. Prostaglandins and inflammation in uterine fibroids: A possible therapeutic target? Eur J Obstet Gynecol Reprod Biol. 2015;194:1-6.
7. Shorakae S, Jona E, de Courten B, Lambert G, Lambert E, Teede H, *et al*. Increased inflammation and oxidative stress in polycystic ovary syndrome: A systematic review and meta-analysis. Clin Endocrinol (Oxf). 2018;89(6):744-57.
8. Pandey G. Dravyaguna Vijnana. 4th ed. Varanasi: Chaukhamba Krishnadas Academy. 2015;1:59-67.
9. Verma A, *et al*. Effect of Kanchnar Guggulu in the management of Mansaja Granthi W.S.R. to Fibroadenoma breast. Int J Green Pharm. 2015;9(4):S20-3.
10. Singh R, *et al*. Multidimensional uses of medicinal plant Kachnar (*Bauhinia variegata* Linn.). AJPCT. 2016;4(2):58-72.
11. Singh R, *et al*. Multidimensional uses of medicinal plant Kachnar (*Bauhinia variegata* Linn.). AJPCT. 2016;4(2):58-72.
12. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 761-3.
13. Upadhyay A, *et al*. *Tinospora cordifolia* (Willd.) Hook.f. and Thoms. (Guduchi) - validation of the Ayurvedic pharmacology through experimental and clinical studies. Int J Ayurveda Res. 2010;1(2):112-21.
14. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 338.
15. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 338.
16. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 338.
17. Hegde PL, Harini A. A Textbook of Dravyaguna Vijnana. Vol. II. 1st ed. 2014. p. 319-32.
18. Deng R. Therapeutic effects of Guggulu and its constituent guggulsterone: cardiovascular benefits. Cardiovasc Drug Rev. 2007;25(4):375-90.

19. Jain A, Gupta VB. Chemistry and pharmacological profile of Guggulu: A review. Indian J Tradit Knowl. 2006;5(4):478-83.
20. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 162.
21. Sharma P. Dravyaguna Vigyan. Vol. II. Reprint ed. Varanasi: Chaukhamba Bharti Academy; 2015. p. 331-4.
22. Chaudhary A, *et al*. Mahoshadha (*Zingiber officinale* Rosc.) of Brihatrasi - A review. Int Ayurvedic Med J. 2017;5(4):1300-5.
23. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 392.
24. Banerjee S, *et al*. Zingiber officinale: A natural gold. Int J Pharma Bio Sci. 2011;2(1):283-94.
25. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 392.
26. Hegde PL, Harini A. A Textbook of Dravyaguna Vijnana. 1st ed. 2014;2:656-65.
27. Hegde PL, Harini A. A Textbook of Dravyaguna Vijnana. 1st ed. 2014;2:656-65.
28. Sharma P. Dravyaguna Vigyan. Vol. II. Reprint ed. Varanasi: Chaukhamba Bharti Academy; 2015;2:275-6.
29. Chauhan K, *et al*. Phytochemical and therapeutic potential of *Piper longum* Linn.: A review. Int J Res Ayurveda Pharm. 2011;2(1):157-61.
30. Liu W, *et al*. Chemical constituents from *Piper longum*. PubMed. 2009;34(22):2891-4.
31. Sabnis M. Chemistry and Pharmacy of Ayurvedic Medicinal Plants. Reprint ed. Varanasi: Chaukhamba Amarabharti Prakashan; 2006. p. 281.
32. Zaveri M, *et al*. Chemistry and pharmacology of *Piper longum* L. Int J Pharm Sci Rev Res. 2010;5(1):67-76.
33. Hegde PL, Harini A. A Textbook of Dravyaguna Vijnana. Vol. II. 1st ed. 2014. p. 865-70.
34. Pansare T, *et al*. Review on *Varuna* (Crataeva nurvala Buch-Ham) with special reference to Ayurvedic, phytochemical and pharmacological aspects. Int J Res AYUSH Pharm Sci. 2017;1(3):128-36.

35. Sharma P. Dravyaguna Vigyan. Reprint ed. Varanasi: Chaukhamba Bharti Academy. 2015;2:653.

36. Pansare T, *et al*. Review on *Varuna* (*Crataeva nurvala* Buch-Ham) with special reference to Ayurvedic, phytochemical and pharmacological aspects. Int J Res AYUSH Pharm Sci. 2017;1(3):128-36.

Chapter - 4
Mulethi (*Glycyrrhiza glabra*): A Potential Medicinal Herb

Authors

Rahul Kashid
Department of Botany, Mrs. K.S.K. College, Beed, Maharashtra, India

Navnath Kashid
Department of Botany, Baburaoji Adaskar Mahavidyalaya, Kaij, Beed, Maharashtra, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 4

Mulethi (*Glycyrrhiza glabra*): A Potential Medicinal Herb

Rahul Kashid and Navnath Kashid

Abstract

In biosphere medicinal plants are of great importance to the health of individuals and communities. Plant having bioactive constituents, play vital, physiological action on the human body. The most important of these bioactive constituents of plants are triterpenoid saponin, flavonoids, tannins, alkaloids and phenolic compounds. Many of these indigenous medicinal plants are used as a spices and food plant. They are also sometimes added to foods meant for pregnant and nursing mothers for medicinal purposes.

Glycyrrhiza glabra Linn is a plant used in traditional medicine across the world for its ethanopharmacological value. It is found to contain important phytoconstituent such as glycyrrhizin, glycyrrhizinic acid, glabrin A and B and isoflavones. It is effectively used as anti-inflammatory, anti-bacterial, anti-fungal, anti-diabetic, antiviral, anti-ulcer, antitussive, anti-oxidant, skin whitening, anti-diuretic agent. This review is an effort to compile the available literature on *Glycyrrhiza glabra* with respect to its traditional uses, bioactive constituents and pharmacologic activities. This may be useful in discovering potential therapeutic effects and developing new formulations.

Keywords: *Glycyrrhiza glabra*, phytoconstituent, antimicrobial activity, traditional uses

Introduction

The plants have been major source of medicine in all cultures, practices from ancient times. In the traditional system, various indigenous plants are being used in the diagnosis, prevention and elimination of acute and chronic disease. Recently there is an increasing demand for herbal medicines, health products, pharmaceuticals across the world as herbs have stood the trial of time for their positive safety, efficacy, cultural acceptability and lesser side effect. Now day medicinal plants have been a part of modern life style and source of important therapeutic aid for alienating human ailments.

Glycyrrhiza glabra Linn is one of important traditional medicinal plant used in various ancient medicine systems and documented across the globe for its ethanopharmacological value to cure varieties of ailments. Glycyrrhizin is the major active constituent obtained from liquorice roots, one of the most widely used in herbal preparations for the treatment and management of chronic diseases.

Glycyrrhiza glabra Linn, commonly known as 'liquorice' and 'sweet wood' belongs to Leguminosae family. The vernacular names for liquorice are Jeshthamadh (Marathi), Jothi-madh (Hindi), Yashtimadhu, Madhuka (Sanskrit), Jashtimadhu, Jaishbomodhu (Bengali), Atimadhuram, Yashtimadhukam (Telugu), Jethimadhu (Gujarati) and Atimadhuram (Tamil).

Glycyrrhiza glabra (Liquorice or Mulethi) is a perennial herb or under shrub about 1m high. Its dried peeled or unpeeled underground stems and roots constitute the drug which is an important constituent of all cough and catarrh syrups, throat lozenges and pastilles. This has been used in medicine for more than 4000 years. Hippocrates (400 BC) mentioned its use as a remedy for ulcers and quenching of thirst. Dioscorides, the father of Greek medicine described this drug in detail and considered it useful for maintaining shape of arteries and in burning stomach, trouble of liver and kidney, scabies, healing of wounds and as a remedy for eye diseases. It has been used in Arab system of medicine for more than 600 years from where it has been adopted to modern medicine.

The dried rhizome and root of Liquorice or Mulethi plant were employed medicinally by the Egyptian, Chinese, Greek, Indian, and Roman civilizations as an expectorant and carminative. In modern medicine, licorice extracts are often used as a flavoring agent to mask bitter taste in preparations, and as an expectorant in cough and cold preparations. Licorice extracts have been used for more than 60 years in Japan to treat chronic hepatitis, and also have therapeutic benefit against other viruses, including Human Immunodeficiency Virus (HIV), cytomegalovirus (CMV), and Herpes simplex.

Glycyrrhiza glabra (Mulethi) is a plant used in herbalism and traditional medicine across the world for its ethanopharmacological value. Mulethi or Licorice roots are used for its demulcent property; it is used internally for Addison's disease asthma, bronchitis, peptic ulcer, arthritis, allergic complaints and steroid therapy. Externally, liquorices are used for eczema,

herpes and shingles. Since, liquorice extract is used in auto-immune conditions and has therapeutic benefit in immunodeficiency conditions like AIDS. Components of licorice root have both estrogenic and anti-estrogenic activity.

Distribution

Liquorice is native to Mediterranean region, South Europe and Middle East. It is widely distributed in Spain, Italy, Greece, Syria, Iraq, Afghanistan, Turkey, parts of USSR and China. However, its cultivation is limited to small areas in USSR, UK, and USA. In India, it grows in Punjab and Jammu and Kashmir. Semi-arid areas of Haryana, Rajasthan and Gujarath states are suitable for the cultivation of Liquorice. However, its commercial cultivation has not yet been possible and the domestic requirement is largely met through imports.

Glycyrrhiza is a genus of about 20 species and a member of the family Fabaceae, with a sub-cosmopolitan distribution in Asia, Australia, Europe, and the Americas. Its scientific name is taken from the Greek for sweet root (glykys, meaning sweet, and rhiza, meaning root). 2-3 Glycyrrhiza glabra (known as Liquorice in English, Mulethi in Hindi and also called Yashtimadhu in Ayurveda), is an important herb used in Indian medicines, home remedies, folk medicines and Ayurveda. Liquorice (British English) or licorice (American English) is the root of *Glycyrrhiza glabra* from which a sweet flavour can be extracted.

Botany

Glycyrrhiza glabra Linn. belongs to the family Fabaceae, The word *Glycyrrhiza* is of Greek origin meaning '*sweet*' and glabra means '*smooth*' which refers to smooth fruit of the species. This is a tall perennial, self-pollinated herb or under shrub about 1m high with long cylindrical burrowing rootstock and horizontal creeping stolons which reach 1.5-1.8m in length. Leaves are alternate, pinnate with 9-17 leaflets. Leaflets are yellowish-green, 2.5-5cm long, ovate and obtuse. Flowers are pale blue arranged in a raceme and 1.25cm long. Calyx is glandular and pubescent. The pods are glabrous, red to brown having 3-4 seeds. Rhizome is soft, flexible and fibrous with light yellow colour and a characteristic sweet taste.

Fig 1: *Glycyrrhiza glabra* plants and dried rhizome

Secondary metabolites (Bioactive compounds)

The earlier studies have been reported describing the different secondary metabolites of the *Glycyrrhiza* species. The commercial name of the dried rhizome and root of the *Glycyrrhiza glabra* plant is liquorice which is used as flavouring agent and the taste coorigent in pharmaceutical and confectionery industries and its products are widely reported to be useful in ulcer therapy. It is found to contain important phytoconstituents, which are effectively used as anti-inflammatory, anti-bacterial, anti-fungal, anti-diabetic, antiviral, antiulcer, antitussive, and anti-oxidant, skin whitening, anti-diuretic agent. Its roots were also demonstrated to have antidepressant, hypotensive hepatoprotective, spasmolytic, memory strengthening activity.

Glycyrrhiza glabra contains more than 20 triterpenoids and nearly 300 flavonoids. The secondary metabolites are triterpenoid saponin, glycosides, glycyrrhizin, prenylated biaurone, licoagrone, 7-acetoxy-2-methyl-isoflavone, 7-methoxy-2-methylisoflavone, and 7-hydroxy-2 methyl isoflavone, 4-methyl coumarin, liqcoumarin, glyzaglabrin, quercetin, quercetin-3-glucoside, liquiritigenin, isoliquiritigenin. Other constituents reported include a flavanone rhamnoglucoside, isoliquiritin, licuraside, liquiritoside, liquoric acid, liquiritic acid, isoglabrolide, 18α-hydroxy glycyrrhetic acid, glabrolide, glycyrrhizic acid, glabridin, glabrol, liquiritin, glycyrrhetinic acid; licoflavonol, glyzarin, glyzaglabrin, licoisoflavones A, B and licoisoflavon (Yang *et al*., 2015).

Properties and Activity

Liquorice gave a number of compounds the most important bieng a glucoside, glycyrrhizin which gave glycyrrhetinic acid on enzyme

hydrolysis. Root also contains flavans, flavones, iso-flavanoes and coumarins including a 4-methyl coumarin, liqcoumarin, glabridin, glabrene, 4'-0-methyl and 3'-methoxyglabridin, formononetin, salicylic acid, 0-acetyl salicylic acid which has been isolated first time from nature, hispaglabridins A and B and 4'0-methylglabridin. On hydrolysis it also gave two molecules of d-glucuronic acid, each linked with 1-2 linkage to 3-hydroxyl of the sapogenin (Elgamal *et al.*, 1969). Glycyrrhizin is antidiuretic, antiinflammatory, expectorant, antiulcerous, antihistamine. Glycyrrhizic acid is antiviral. The roots are emetic, tonic, diuretic, demulcent, mild laxative, aphrodisiac, trichogenous, expectorant, emmenagogue, alexipharmic, alterant and intellect promoting.

Glycyrrhiza glabra (Mulethi) is an important herb for treating hormone-related female problems. It is used as an energy tonic, particularly for the spleen and stomach, and the root is added to many formulae. Roots of *Glycyrrhiza glabra* being tonic, demulcent laxative emollient are used in genito-urinary diseases.

Traditional uses

In traditional medicine, liquorice has been recommended as a prophylactic agent for gastric and duodenal ulcers. It is employed in dyspepsia as an anti-inflammatory agent during allergenic reactions (Ammosov S, Litvinenko, 2003). It is used as a contraceptive, laxative, anti-asthmatic, emmenagogue, galactagogue, antiviral agent in folk therapy (Saxena S., 2014). *Glycyrrhiza* roots are useful for treating cough because of its demulcent and expectorant property. It is also effective against anemia, gout, sore throat, tonsillitis, flatulence, sexual debility, hyperdypsia, fever, skin diseases and swellings. Liquorice is effectively used in acidity, leucorrhoea, bleeding, jaundice, hiccough, hoarseness, bronchitis, vitiated conditions of *Vata dosha*, *gastralgia*, diarrhea, fever with delirium and anuria (Sheth A. 2005, Kaur *et al*., 2013). It is a vital ingredient in medicinal oils used for the treatment of rheumatism, hemorrhagic diseases, epilepsy and paralysis. It has been proved by several years of research that, glycyrrhizin breaks down in the gut and exerts anti-inflammatory action similar to hydrocortisone and other corticosteroid hormones. The effect is due to stimulation of hormone production by adrenal glands and reduction in the breakdown of steroids by the liver and kidneys. Effectiveness of glycyrrhizin in the treatment of chronic hepatitis and liver cirrhosis is proved (Khare, 2004).

Pharmacological activities

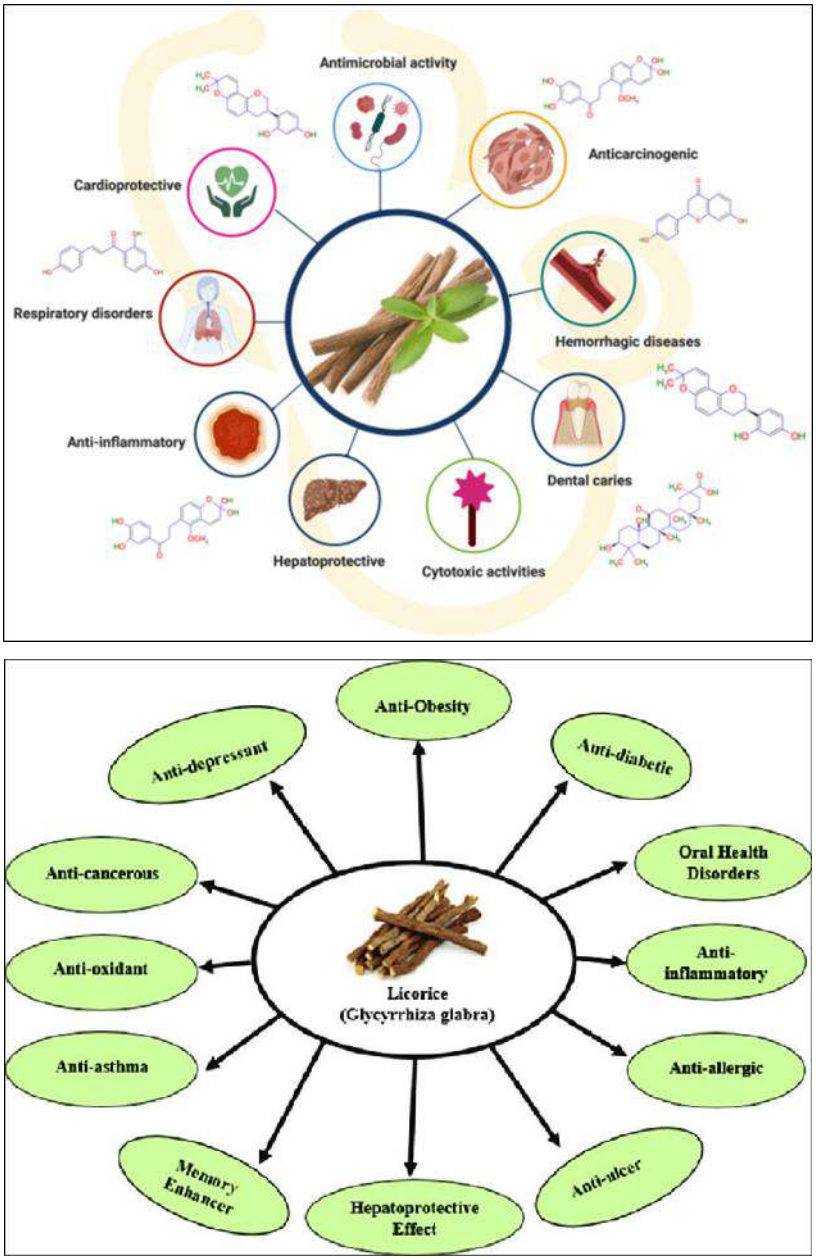


Fig 2: Therapeutic activities and traditional uses of *Glycyrrhiza glabra* Linn

1. Anti-jussive & expectorant

The *Glycyrrhiza glabra* (Mulethi) root or liquorice powder and extract was found to be effective in treatment of sore throat, cough and bronchial catarrh. Liquorice has been shown to work as efficiently as codeine in sore throat. It decreases irritation and produces expectorant effects. Carbenoxolone stimulates gastric mucus secretion. Glycyrrhizin is responsible for demulcent action of liquorice. Liquiritin apioside, an active compound present in the methanolic extract of liquorice which inhibits capsaicin induced cough (Kamei *et al,* 2003). Ethanolic extract of *G. glabra* was found to be responsible for inhibition of 35.62% SO_2 gas induced cough in experimental animals (mice) (Jahan & Siddique, 2012).

2. Antioxidant activity

Liquorice (*Glycyrrhiza glabra* L) having high content of phenolic content in ethanolic extracts is responsible for its powerful antioxidant activity by means of significant free radical scavenging, hydrogen-donating, metal ion chelating, anti-lipid peroxidative and reducing abilities (Visavadiya *et al.,* 2009). Liquorice flavonoids have exceptionally strong antioxidant activity. Antioxidant activity of liquorice flavonoids was found to be over 100 times stronger than that of antioxidant activity of vitamin E. Flavonoids from liquorice are currently the strongest natural antioxidants known (Ju HS *et al*., 1989).

3. Skin lightening and skin tightening activity

The liquorice extract is reported to be an effective pigment lightening agent. It is the safest pigment-lightening agent known with least side effects. Liquorice extract with other active compounds like glabrene, Licochalcone A, Isoliquiritin are also responsible for inhibition of tyrosinase activity. Liquiritin present in liquorice extract disperse melanin, thereby inducing skin lightening (Cronin & Draelos, 2010). It is reported to show improvement in the viscoelastic and hydration properties of the skin by ethanolic extract of *Glycyrrhiza glabra*. Synergistic effect of UV protective, antioxidant and anti-inflammatory properties of liquorice extract might be responsible for giving beneficial effects on skin (Ahshawat *et al*., 2008).

4. Anti-inflammatory

Liquorice root extract promotes the healing of ulcers of the stomach and mouth. It is reported that glycyrrhetinic acid in liquorice extract gives anti-inflammatory effect similar to glucocorticoids and mineralocorticoids

(Baker, 1994). According to *In vitro* studies, glycyrrhizic acid inhibits all factors responsible for inflammation. It inhibits cyclooxygenase activity and prostaglandin formation (specifically prostaglandin E2). It is also responsible for indirectly inhibiting platelet aggregation (Okimasu *et al.*, 1983).

5. Anti-viral

Glycyrrhizin does not allow the virus cell binding, while it is found to have a prominent antiviral activity. It has been previously employed in the treatment of HIV-1 and chronic hepatitis C. Recent study on two clinical isolates of SARS virus (Severe Acute Respiratory Syndrome virus) (FFM-1 and FFM-2) gave valuable insight about anti-viral activity of glycyrrhizin. The study was carried out on patients with SARS, admitted to clinical center of Frankfurt University, Germany. This study on antiviral activities of ribavirin, 6-azauridine, pyrazofurin, mycophenolic acid and glycyrrhizin proved that glycyrrhizin was the most efficient in controlling viral replication. Thus, it can be a good prophylactic measure (Adam, 1997, Cinatl *et al*., 2003). Glycyrrhizic acid was found to have a distinctive effect against Kaposi sarcoma-associated herpes virus (KSHV) as found in *In vitro* studies.

6. Anti-fungal

The methanolic extract of liquorice was shows fungicidal activity against *Arthrinium sacchari* M001 and *Chaetomium funicola* M002. Glabridin was found to be the active compound giving anti-fungal activity (Hojo & Sato, 2002). Isoflavonoids such as glabridin, glabrol and their derivatives are responsible for *in vivo* inhibition of *Mycobacterium smegmatis* and *Candida albicans*. Thus, liquorice extract has a great potential in formulating cosmetic products with antiseptic activities.

7. Anti-bacterial

Liquorice contains secondary metabolites such as; saponins, alkaloids, flavonoids in hydro-methanolic root extract. The extract exhibits potent antibacterial activity (Sharma *et al.*, 2013). *In vitro* studies have proved that aqueous and ethanolic extracts of liquorice show inhibitory activity on cultures of *Staphylococcus aureus* and *Streptococcus pyogenes*.

8. Anti-malarial

Liquorice having Licochalcone has reported to possess very good antimalarial activity. All *Glycyrrhiza* species have this compound in different amounts and it can be isolated from them. *In vivo* studies against *P. yoelii* in mice with oral doses of 1000 mg kg-1 have shown to eradicate

malarial parasite completely. Also, no toxicity was observed (Sianne &Fanie RVH. 2002).

9. Anti-hyperglycemic

Root extract of *Glycyrrhiza glabra* was found to have anti-lipidemic and antihyper glycemic activity at low doses (Revers FE, 1956).

10. Immunostimulatory

Glycyrrhiza glabra showed Immunostimulatory effects. It increases production of TCD69 lymphocytes and macrophages from human granulocytes. According to *in vivo* studies, liquorice root extract prevent the rise in the amount of immune-complexes related to autoimmune diseases like systemic lupus erythematosus (Alonso *et al*, 2004).

11. Memory enhancing

The effects of *Glycyrrhiza glabra* on learning and memory was investigated in mice. Elevated plus-maze and passive avoidance paradigm were used to test learning and memory. Three doses of aqueous extract of liquorice were administered (75, 150 and 300 mg/kg p.o.) (Dhingra *et al*., 2004).

12. Hepatoprotective

Glycyrrhizin significantly inhibits the CCl4- induced release of AST and LDH at concentrations of 25-200 μg/ml. Alteration of membrane fluidity by the glycyrrhizin or inhibition of CCl4-induced membrane lipid peroxidation might be responsible for the activity. 18β-glycyrrhetic acid (an aglycone of glycyrrhizic acid) shows hepatoprotective activity by inhibiting both free radical generation and lipid peroxidation (Jeong *et al*, 2002). Glycyrrhizin is useful in treating acetaminophen-induced hepatotoxicity. Liquorice extract is proved to show hepatoprotective activity against diclofenac induced hepatotoxicity in rats (Alaaeldin, 2007).

13. Anticoagulant

A Glycyrrhizin is the first plant based inhibitor of thrombin, is found to prolong the thrombin and fibrinogen clotting time. It also increases plasma recalcification duration. Glycyrrhizin causes inhibition in thrombin induced platelet aggregation. But there was no effect of glycyrrhizin on Platelet Aggregating Factor (PAF) and Collagen induced agglutination (Mendes-Silva *et al.*, 2003).

14. Hair growth stimulatory

The liquorice hydro-alcoholic extract showed good hair growth promoting activity. Comparison between liquorice extract and the standard drug used (Minoxidil 2%) showed that, 2% concentration of liquorice extract showed better hair growth stimulatory activity than 2% Minoxidil. After efficacy and safety analysis, it has been concluded that, liquorice has a significant hair growth activity and it can be safely used in herbal formulations in treatment of various types of Alopecia (Roy *et al*., 2014).

Conclusion

In present review of *Glycyrrhiza glabra* Linn plants summarized the distribution, ethnobotany, major secondary metabolites, ethnopharmacology, antimicrobial activity and potential medicinal uses. As per clinical efficacy and toxicity the more exploration of *Glycyrrhiza glabra* plants needed. Liquorice (*Glycyrrhiza glabra* Linn) is a plant with ethanopharmacological importance. This review would help in further studies on *Glycyrrhiza glabra* Linn for exploring its potential in preventing and treating diseases.

References

1. Adam L. *In vitro* antiviral activity of indigenous glycyrrhizin, licorice and glycyrrhizic acid (Sigma) on Japanese encephalitis virus. J Commun Dis. 1997;29(2):91-9.
2. Ahshawat MS, Saraf S, Saraf S. Preparation and characterization of herbal creams for improvement of skin viscoelastic properties. Int J Cosmet Sci. 2008;30(3):183-93.
3. Alaaeldin AH. *Curcuma longa*, *Glycyrrhiza glabra* Linn and *Moringa oleifera* ameliorate diclofenac-induced hepatotoxicity in rats. Am J Pharmacol Toxicol. 2007;2(2):80-8.
4. Alonso J. Tratado de Fitofármacos y Nutracéuticos. Barcelona: Corpus; 2004. p. 905-11.
5. Ammosov S, Litvinenko VI. Triterpenoids of plants of *Glycyrrhiza* L. and *Meristotropis* Fisch. et Mey genuses. Pharm Chem J. 2003;37:83-94.
6. Baker ME. Licorice and enzymes other than 11-hydroxysteroid dehydrogenase: An evolutionary perspective. Steroids. 1994;59:136-41.
7. Cinatl J, Morgenstern B, Bauer G, Chandra P, Rabenau H, Doerr HW. Glycyrrhizin, an active component of liquorice roots, and replication of SARS-associated coronavirus. Lancet. 2003;361(9374):2045-6.

8. Cronin H, Draelos ZD. Top 10 botanical ingredients in 2010 anti-aging creams. J Cosmet Dermatol. 2010;9(3):218-25.

9. Dhingra D, Parle M, Kulkarni SK. Memory enhancing activity of *Glycyrrhiza glabra* Linn in mice. J Ethnopharmacol. 2004;91(2-3):361-5.

10. Hojo H, Sato J. Antifungal activity of licorice (*Glycyrrhiza glabra* Linn) and potential applications in beverage foods. J Food Ingredients Jpn. 2002;203.

11. Jahan Y, Siddique HH. Study of antitussive potential of *Glycyrrhiza glabra* & *Adhatoda vasica* using a cough model induced by SO_2 gas in mice. Int J Pharm Sci Res. 2012;3:1668-74.

12. Dhingra D, Parle M, Kulkarni SK. Memory enhancing activity of *Glycyrrhiza glabra* in mice. J Ethnopharmacol. 2004;91(2-3):361-5.

13. Jeong HG, You HJ, Park SJ, Moon AR, Chung YC, Kang SK, *et al*. Hepatoprotective effects of 18β-glycyrrhetinic acid on carbon tetrachloride-induced liver injury: inhibition of cytochrome P450 2E1 expression. Pharmacol Res. 2002;46:221-7.

14. Ju HS, Li XJ, Zhao BL, Han ZW, Xin WJ. Effects of *Glycyrrhiza* flavonoids on lipid peroxidation and active oxygen radicals. Acta Pharm Sin. 1989;24(11):807-12.

15. Kaur R, Kaur, Dhinds AS. *Glycyrrhiza glabra*: a phytopharmacological review. Int J Pharm Sci Res. 2013;4(7):2470-7.

16. Khare CP. Encyclopedia of Indian Medicinal Plants. New York: Springer-Verlag; 2004. p. 233.

17. Kamei J, Nakamura R, Ichiki H, Kubo M. Antitussive principles of *Glycyrrhiza* radix, a main component of Kampo preparations Bakumondo-to (*Mai-men-dong-tang*). Eur J Pharmacol. 2003;69:159-63.

18. Mendes-Silva W, Assafim M, Ruta B, Monteiro RQ, Guimaraes JA, Zingali RB, *et al*. Antithrombotic effect of glycyrrhizin, a plant-derived thrombin inhibitor. Thromb Res. 2003;112:93-8.

19. Okimasu E, Moromizato Y, Watanabe S. Inhibition of phospholipase A_2 and platelet aggregation by glycyrrhizin, an anti-inflammatory drug. Acta Med Okayama. 1983;37:385-91.

20. Roy SD, Karmakar PR, Dash S, Chakraborty J, Das B. Hair growth stimulating effect and phytochemical evaluation of hydro-alcoholic extract of *Glycyrrhiza glabra*. Glob J Res Med Plants Indig Med. 2014;3(2):40-7.
21. Saxena S. *Glycyrrhiza glabra*: Medicine over the millennium. Nat Prod Radiance. 2005;4(5):358-67.
22. Sharma V, Agrawal RC, Pandey S. Phytochemical screening and determination of anti-bacterial and antioxidant potential of *Glycyrrhiza glabra* root extracts. J Environ Res Dev. 2013;7(4A):1552-8.
23. Sianne S, Fanie RVH. Antimalarial activity of plant metabolites. Nat Prod Rep. 2002;19:675-92.
24. Sheth A. The Herbs of India. 1st ed. Vol. 2. Gujrat: Hi Scan Pvt Ltd; 2005. p. 566.
25. Revers FE. Clinical and pharmacological investigations on extract of licorice. Acta Med Scand. 1956;154:749-51.
26. Visavadiya NP, Soni B, Dalwadi N. Evaluation of antioxidant and anti-atherogenic properties of *Glycyrrhiza glabra* root using *in vitro* models. Int J Food Sci Nutr. 2009;60(2):135-49.
27. Yang R, Wang LQ, Yuan BC, *et al*. The pharmacological activities of licorice. Planta Med. 2015;81(18):1654-69.
28. Zadeh JB, Kor ZM, Goftar MK. Licorice (*Glycyrrhiza glabra* Linn) as a valuable medicinal plant. Int J Adv Biol Biomed Res. 2013;1(10):1281-5.

Chapter - 5
Pharmacological Insights into Ashwagandha (Withania Somnifera): A Traditional Herb with Exceptional Modern Therapeutic Potential

Authors

Veerapuram Harika
Department of Entomology, CCS Haryana Agriculture University (CCSHAU), Hisar, Haryana, India

U. Jaya Surya
Department of Agricultural Entomology, Tamil Nadu Agriculture University (TNAU), Coimbatore, Tamil Nadu, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 5

Pharmacological Insights into Ashwagandha (*Withania somnifera*): A Traditional Herb with Exceptional Modern Therapeutic Potential

Veerapuram Harika and U. Jaya Surya

Abstract

Ashwagandha (*Withania somnifera*) is a highly regarded herb in traditional Ayurvedic medicine, known for its remarkable therapeutic potential backed by modern pharmacological research. This comprehensive review examines the herb's botanical, phytochemical, and pharmacological profiles, as well as its various therapeutic applications. Ashwagandha possesses neuroprotective, adaptogenic, anti-inflammatory, and immunomodulatory properties, making it effective for managing stress, enhancing cognitive function, and treating neurodegenerative diseases such as Alzheimer's and Parkinson's. Its benefits include supporting reproductive health, improving sleep disorders, and offering anti-cancer and cardioprotective effects. The herb's primary bioactive constituents-including withanolides, alkaloids, and saponins-work together to produce a wide range of biological activities. Advanced analytical techniques have helped clarify the roles these compounds play in anti-inflammatory, antioxidant, and neuroprotective processes. Ashwagandha also shows promise in combating bacterial resistance, enhancing athletic performance, and addressing hormonal imbalances such as hypothyroidism. Despite its potential benefits, there are some safety concerns, and sporadic cases of hepatotoxicity. This highlights the importance of caution when using the herb, especially in vulnerable populations or alongside other medications. This review emphasizes the need for rigorous clinical trials to confirm Ashwagandha's efficacy, optimal dosing, and long-term safety. This positions Ashwagandha as a key component in integrative medicine and pharmacotherapy for chronic diseases. Future research should focus on its role in neurodegenerative diseases, cancer therapy, and advanced drug delivery systems.

Paperback ISBN: 978-93-6135-630-8 E- Book ISBN: 978-93-6135-161-7

Keywords: Ashwagandha, *Withania somnifera*, adaptogenic properties, neurodegenerative diseases, alzheimer's disease, parkinson's disease, withanolides, hypothyroidism

Introduction

Ashwagandha (*Withania somnifera*), a small shrub from the Solanaceae family, has been used for over 3,000 years in Ayurveda for its restorative and adaptogenic properties. The plant's roots and leaves are particularly valued for their medicinal properties. Ashwagandha has a long history of use in traditional Indian medicine, dating back to 1000-1500 BC, and it is recognized for its diverse pharmacological properties, including adaptogenic, immunomodulatory, rejuvenating, and aphrodisiac effects. Ayurvedic writings frequently refer to it as a Rasayana, a term used to describe compounds that promote lifespan, immunological support, and rejuvenation. It has also been used to treat several ailments, such as problems of the musculoskeletal, neurological, dermatological, respiratory, and reproductive systems. These conventional assertions have been further supported by contemporary research in recent years [1-3]. Ashwagandha, Indian winter cherry, and the plant *Withania somnifera* are other names for Indian ginseng. The root is the portion of the plant that is employed in medication. The word "ashwa," which means horse, is the source of the name "ashwagandha," and it is thought that eating the root can give you power comparable to that of a horse. "Gandha," the second component of the name, signifies fragrance and alludes to the distinct scent of the fresh root. Ayurvedic medicine has always utilized ashwagandha to support the neurological system since ancient times. Its adaptogenic qualities and therapeutic uses-often grouped under the label "rasayana" [3].

Fig 1: Ashwagandhapowder

Fig 2: Ashwagandha plant

Botanical Description

Taxonomy and Morphology [1-6]

Ashwagandha is a small, woody shrub belonging to the Solanaceae family, native to India, the Middle East, and parts of Africa. Its scientific classification is as follows:

Kingdom: Plantae

Subkingdom: Tracheobionta

Super division: Spermatophyta

Division: Magnoliophyta

Class: Magnoliopsida

Subclass: Rosidae

Order: Solanales

Family: Solanaceae

Genus: Withania

Species: Somnifera

Major compounds

Withaferin A: The most potent withanolide, noted for its anticancer and anti-inflammatory properties.

Withanolide A: Known for its adaptogenic and neuroprotective activities.

Withanoside IV: Demonstrates cognitive enhancement and anti-stress effects.

Key alkaloid

Withanine: Acts on the neurotransmitter pathways, specifically gamma-aminobutyric acid.

Saponins

Role: These are glycoside compounds that facilitate adaptogenic and neuroprotective activity.

Mechanisms: Stress resistance and improved mitochondrial health reduce oxidative cell death in brain cells.

Flavonoids

Role: The strong antioxidants in Ashwagandha eliminate reactive oxygen species (ROS) and thereby protect the cells from damage due to oxidative stress.

Benefits

Prevents lipid peroxidation in cell membranes.

Pro-inflammatory: Synergism with withanolides potentiates their anti-inflammatory effects.

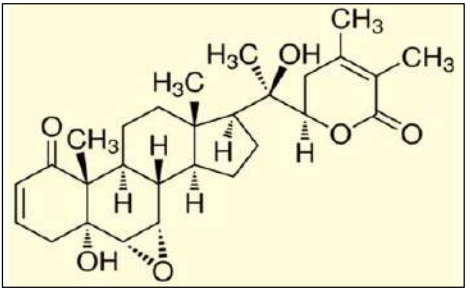


Fig 9: Withanolide

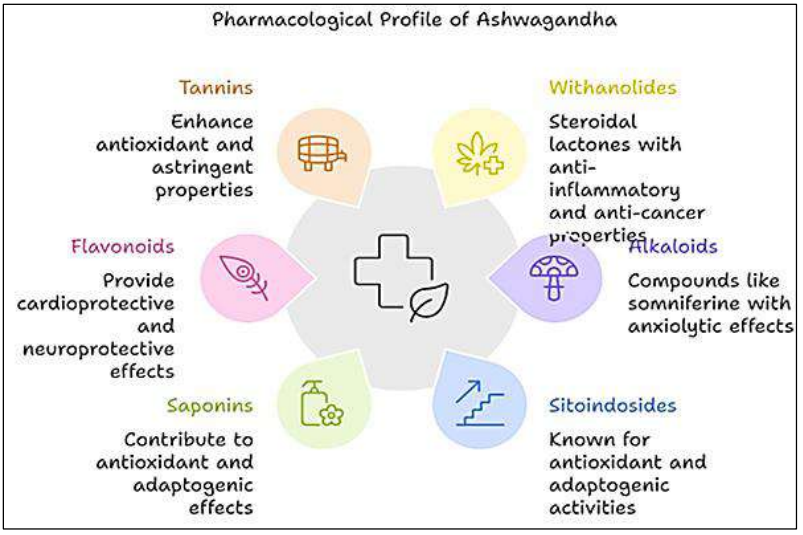


Fig 10: Pharmacological effects

Traditional applications of Ashwagandha

Ayurveda, the ancient medical system originating in India, can be dated to 6000 BC (Charak Samhita, 1949). For the majority of these 6000 years, Ashwagandha has been utilized as a Rasayana. The root of Ashwagandha is considered a tonic, aphrodisiac, narcotic, diuretic, anthelmintic, astringent, thermogenic, and stimulant. The root emits an odor reminiscent of a horse

("ashwa"), which is the reason it is named Ashwagandha (because consumption imparts the strength of a horse). It is frequently utilized in the emaciation of children (when administered with milk, it serves as the optimal tonic for children), debility associated with aging, rheumatism, aberrant vata conditions, leucoderma, constipation, sleeplessness, neurological breakdown, goiter, etc. (Sharma, 1999).A paste created by crushing roots with water is utilized to alleviate joint irritation (Bhandari, 1970). It is also administered topically to carbuncles, ulcers, and painful swellings (Kritikar and Basu, 1935). The root, in conjunction with other medications, is used for snake venom and scorpion stings. It is also beneficial for leucorrhoea, boils, acne, flatulent colic, intestinal worms, and hemorrhoids (Misra, 2004). The Nagori Ashwagandha is the preeminent kind among all Ashwagandha types. Optimal benefits are shown when utilizing fresh Ashwagandha powder (Singh, 1983).The leaves possess a bitter taste and are advised for use in cases of fever and uncomfortable swellings. The flowers possess astringent, depurative, diuretic, and aphrodisiac properties. The seeds possess anthelmintic properties and, when mixed with astringent and rock salt, eliminate white spots from the cornea. Ashwagandharishta, derived from it, is utilized for hysteria, anxiety, memory impairment, syncope, and similar conditions. It also functions as a stimulant and enhances sperm count (Sharma, 1938).

Pharmacological actions

1. Using Ashwagandha to treat Alzheimer's

Alzheimer's disease and the Use of Ashwagandha The aging population issue has been noted for many years, and as a result, the proportion of persons with dementia disorders has significantly increased. A multifactorial illness, dementia is typified by a variety of symptoms brought on by brain disease and usually progresses over time. Memory, cognitive skills, orientation, understanding, learning, and emotional regulation are among the higher cortical processes that are impacted by this disorder. Neurodegenerative disorders cause irreparable harm by destroying the central nervous system. Abnormal β-amyloid protein buildup in the brain is seen with Alzheimer's disease. The neurotoxic impact of fibrillar β-amyloid is caused by the production of free radicals and the disruption of glucose transport in neurons, which results in cell death and damage. Additionally, the β-amyloid core of the senile plaque is surrounded by clusters of hyperphosphorylated τ proteins in Alzheimer's disease. Together with other proteins, τ proteins help to stabilize microtubules in a physiological sense. Microglia, inflammatory response cells, accompany the buildup of senile plaques and try to eliminate

and degrade both the senile plaques and injured and dead neurons. However, the inflammatory response in the brain is exacerbated by the poisons produced by microglial cells, which kill both healthy and sick cells. Research on human nerve cells has demonstrated that ashwagandha can counteract the harmful effects of β-amyloid, indicating that it may be useful in treating neurocognitive impairment, including that seen in HIV infection. Significant gains in cognitive performance were seen in animal trials with rats given vitanol, a component extracted from the root of *Withania somnifera*. This was explained by a decrease in pro-inflammatory cytokines such as TNF-α, IL-1β, IL-6, and MCP-1, as well as nitric oxide and lipid peroxidation, and a suppression of amyloid β-42 [8]. The β and γ-secretase enzymes, which cause neurotoxic β-amyloid aggregates, also showed a decline in activity. Furthermore, ashwagandha's withaferin A shows promise in the treatment of Alzheimer's disease. It inhibits τ protein accumulation and decreases β-amyloid aggregation. Furthermore, it is well known that withaferin A controls the production of heat shock proteins (HSPs), which rise in response to cellular stresses, and inhibits oxidative and pro-inflammatory chemicals. However, further research is required to evaluate withaferin A's safety and validate its neuroprotective benefits in the treatment of Alzheimer's disease. Withaferin A has been shown to dramatically decrease both the gene expression of neuroinflammatory molecules linked to NF-κB and the generation of amyloid β. According to one study, ashwagandha lessened the adverse symptoms of Alzheimer's disease in transgenic mice given a half-purified extract of *Withania somnifera* root, which mostly contained withanolides, for 30 days. By raising the liver's levels of LDL receptor-related protein 1 (LRP1), it achieved this. Increased LRP1 levels were linked to reversed behavioral impairments in Alzheimer's disease and decreased amyloid β. According to research, LRP1 functionally alters the mechanisms required for the β-amyloid precursor protein (APP) to develop, which is essential for the synthesis of amyloid β and the processing of APP. Furthermore, LRP1 is recognized as a crucial modulator of τ protein proliferation. The impact of derivatives of *Withania somnifera* on the development of β-amyloid 42 deposits in Alzheimer's disease has been investigated. It was found that the hydrophobic core of β-amyloid 1-42 in its oligomeric form interacts with withanolide A, withanolide B, witanoside IV and witanoside V. Its contact with monomers is inhibited by this interaction, which stops more aggregation. The fungus Beauveria bassiana bioconverted *Withania somnifera* extract in a different study, producing withaferin a byproducts cysteine and glutathione. The glutathione derivative CR-777 showed promise as a barrier against a range of

neuronal stresses and showed neuroprotective benefits. Withanolide A, one of ashwagandha's most significant constituents, has demonstrated efficacy against neurodegenerative processes in Parkinson's and Alzheimer's. Further research has shown that it can also cross the blood-brain barrier (BBB). Three distinct dosages of withanolide A were given intranasally to adult mice in one experiment (1 mg/kg, 5 mg/kg, and 10 mg/kg). The drug was able to enter both the brain and the cerebellum thanks to this mode of delivery. Significant improvements in general brain health and a decrease in cerebral infarction were observed after withanolide A treatment [7-21].

2. Ashwagandha use in parkinson's disease

Parkinson's disease is characterized by the degeneration of dopaminergic neurons in the nigrostriatal system, leading to an imbalance between dopamine's inhibitory effects and the excitatory actions of acetylcholine and glutamic acid. Several factors may contribute to the degeneration of nigrostriatal cells, including:

- Genetic conditions
- Endogenous and exogenous toxic factors
- Neuroinfections
- Oxidative stress
- Reduced growth factors

A combination of the above factors the disease is slightly more prevalent in men than in women; however, the exact cause is unknown. This difference may be due to the protective role of estrogen. Research involving rats with Parkinson's disease induced by 6-hydroxydopamine revealed interesting findings. Before administering 6-hydroxydopamine into the striatum, the rats received oral doses of a *Withania somnifera* extract at 100, 200, and 300 mg/kg body weight for three weeks [21]. The study indicated that Ashwagandha significantly reduced lipoperoxidation and led to an increase in glutathione concentration. Additionally, it enhanced the activity of enzymes such as glutathione S-transferase, glutathione reductase, glutathione peroxidase, superoxide dismutase and catalase. There was also an increase in catecholamines and dopamine D2 receptor binding, along with elevated expression of tyrosine hydroxylase. While *Withania somnifera* shows promise in improving biochemical parameters in Parkinson's disease, its effects are dose-dependent. In a study involving fruit flies, a standardized methanol extract of Ashwagandha root was found to counteract deficits associated with

Parkinson's disease. Furthermore, in mice with the disease, the administration of Ashwagandha extract not only improved biochemical indicators but also reduced motor impairment compared to the control group. Oral administration of *Withania somnifera* extract (100 mg/kg, i.p.) in mice led to increased levels of dopamine (DA), 3,4dihydroxyphenylacetic acid (DOPAC), and homovanillic acid (HVA) while also normalizing the levels of lipoperoxidation markers in the striatum [22-27].

3. Use of Ashwagandha in the treatment of huntington's disease

Huntington's disease is a disorder that cannot be cured, and the drugs that are now available mostly target the symptoms and attempt to delay the course of the disease. This particular genetic illness is passed down through generations in an autosomal dominant fashion, which means that statistically speaking, fifty percent of the kids will receive the allele that causes the disease. There is a mutation in the IT15 gene, which is situated on chromosome 4 and is responsible for encoding the huntingtin (htt) protein. This mutation causes the condition. Because of this mutation, huntingtin undergoes a structural shift, which ultimately results in the protein's insoluble state. The N-terminal portion of the mutant huntingtin protein, which is distinguished by enlarged polyglutamine repeats, accumulates and contributes to the acceleration of neuronal death. An imbalance of neurotransmitters, such as dopamine, GABA, serotonin, and acetylcholine, is brought about as a consequence of this buildup. It is a powerful neurotoxin that is composed of the chemical known as 3-Nitropropionic acid (3-NP). It produces biochemical and neurobehavioral alterations that are very similar to those that are found in Huntington's disease. It also causes oxidative and nitrosative stress, inhibits complex II of the mitochondrial electron transport chain, which results in an energy deficit, and increases the risk of developing Huntington's disease. Through the use of an animal model, researchers were able to produce signs of Huntington's disease by injecting 3-NP intraperitoneally. A favorable effect on biochemical parameters and motor function was shown to be brought about by the administration of Ashwagandha extract over an extended period of time. This effect is most likely attributable to the antioxidant characteristics of the plant. According to the findings, there was a reduction in the amount of lipoperoxidation, a drop in the levels of lactate and nitrate dehydrogenase, and an increase in the levels of superoxide dismutase and catalase. In addition, the mitochondrial complex was unblocked, which resulted in the restoration of ATP production in a dose-dependent manner at dosages of 100 mg/kg and 200 mg/kg. The favorable benefits of withaferin A, an active component isolated

from ashwagandha, were demonstrated in a different investigation using mice. The failure of cells to maintain proteostasis is a characteristic feature of the aging process and a prevalent feature of many neurological illnesses, including Huntington's disease. As a result of triggering the heat shock response in this mouse model, withaferin A was able to repair defective proteostasis, which in turn delayed the onset of the associated illness. Withaferin A treatment resulted in considerably extended lifespans for mice and improvements in behavioral and motor impairments, including a reduction in body weight. Additional benefits included a reduction in body weight. The activation of the heat shock response, the decrease of mutant huntingtin aggregates, and the increase of striatal function in the brains of the mice were all validated by biochemical studies. Furthermore, withaferin A was shown to considerably diminish inflammatory processes, as demonstrated by a decrease in the activity of microglia [28-31].

4. Treatment of obsessive-compulsive disorder and alcohol withdrawal syndrome

Obsessive-compulsive disorder, sometimes known as OCD, is a persistent mental health disease that is characterized by intrusive thoughts and imagery that patients regard to be undesired and unreasonable. Individuals can experience varying degrees of severity in these cognitive disturbances; nonetheless, obsessive-compulsive disorder (OCD) can considerably impede everyday functioning, particularly in its more severe manifestations, which can have a considerable impact on psychological well-being. A number of elements, including structural and functional abnormalities within the central nervous system, as well as genetic and psychological factors, have been linked to the development of obsessive-compulsive disorder (OCD), according to research. Dysregulation of the serotonergic system is frequently associated with the condition it brings about. Recent research suggests that the use of ashwagandha root extract as a complementary treatment to selective serotonin reuptake inhibitors (SSRIs) for persons who suffer from obsessive-compulsive disorder (OCD) offers potential benefits. Using a mouse model that exhibited behaviors that were similar to those reported in obsessive-compulsive disorder (OCD), a recent study revealed that both aqueous and methanolic extracts of *Withania somnifera* (Ashwagandha) dramatically alleviated behavioral abnormalities without compromising motor performance. The effects that were seen were equivalent to those that were induced by conventional medications such as fluoxetine, ritanserin, and para-chlorophenylalanine. Research conducted on rats has shown that the oral administration of

ashwagandha can relieve withdrawal-related anxiety that is caused by extended alcohol intake. This research was conducted in connection to Alcohol Withdrawal Syndrome (AWS). Taking this into consideration, it appears that the plant may have a protective function in the management of the symptoms that are linked with ethanol withdrawal. In addition, research has demonstrated that ashwagandha has the ability to positively influence behavioral changes, anxiety, and seizures that occur during the withdrawal process from alcohol, while also boosting locomotor activity in individuals who are affected by this condition [32-38].

5. Anti-inflammatory and Immunomodulatory Effects

Withania somnifera, or Ashwagandha, is presently under investigation for its possible therapeutic effects on several inflammation-related illnesses, including as cardiovascular, pulmonary, autoimmune disorders, diabetes, malignancies, and neurodegenerative ailments. Preclinical studies indicate that this plant can modulate mitochondrial function, induce apoptosis, and diminish inflammation by lowering inflammatory indicators such as cytokines (including IL-6 and TNF-α), nitric oxide, and reactive oxygen species. Ashwagandha root powder shown a possible inhibitory impact on proteinuria and nephritis in a mouse model of lupus. Furthermore, a research examined the efficiency of Ashwagandha root powder in treating rheumatic disorders by administering it orally to rats for three days, one hour before to the induction of inflammation by an injection of complete Freund's adjuvant (CFA). The control group administered phenylbutazone exhibited alterations in the levels of many blood proteins, including α2 glycoprotein, acute phase protein α1, and prealbumin, as well as a notable decrease in inflammation. A research utilizing the HaCaT human keratinocyte cell line demonstrated that an aqueous extract from Ashwagandha root inhibits the NF-κB and MAPK (mitogen-activated protein kinase) pathways. This suppression led to a reduction in the expression of pro-inflammatory cytokines, such as IL-8, IL-6, TNF-α, IL-1β, and IL-12, while enhancing the expression of anti-inflammatory cytokines. The results indicate that the anti-inflammatory characteristics of Ashwagandha may be beneficial in reducing skin irritation. A preclinical study investigating the anti-neuroinflammatory properties of Ashwagandha water extract (ASH-WEX) in the context of lipopolysaccharide-induced systemic neuroinflammation revealed that subjects administered ASH-WEX demonstrated diminished reactive gliosis, reduced levels of inflammatory cytokines including TNF-α, IL-1β, and IL-6, and lower expression of nitro-oxidative stress enzymes. The molecular

mechanisms behind the anti-inflammatory actions of ASH-WEX seem to involve the suppression of lipopolysaccharide (LPS)-activated NFκB, P38, and JNK/SAPK MAPK pathways. The findings indicate that *Withania somnifera* may aid in mitigating nervous system inflammation linked to many neurological diseases. A research by Kanjilal *et al*. shown that Ashwagandha extract, administered over 8 to 12 weeks, may aid in alleviating arthritic symptoms in individuals. A study verified the immunomodulatory effects of *Withania somnifera* on immunological function in immunodeficient mice. The administration of *Withania somnifera* was seen to elevate the total count of white blood cells and bone marrow cells, enhance the levels of circulating antibodies and antibody-producing cells, and promote the synthesis of immune cells and the phagocytic activity of macrophages. A randomized, double-blind, placebo-controlled experiment with an open-label extension evaluated the impact of Ashwagandha extract on the immune systems of healthy individuals. Results demonstrated that Ashwagandha extract markedly enhanced natural killer cell activity and cytokine levels in comparison to the placebo group [39-45].

6. Antibacterial properties

The issue posed by drug resistance in microorganisms is one that is becoming increasingly recognized as being important and expanding. Over the past several years, there has been a discernible rise in the number of illnesses that are brought on by drug-resistant strains, which has become a significant reason for worry in terms of public health. The use of antibiotics in a careless and sometimes inappropriate manner has been a contributing factor in the creation of drug-resistant strains, which has rendered certain treatments utterly worthless. This suggests that ashwagandha might be an advantageous supplement to the treatment of bacterial infections by the use of pharmaceuticals. In spite of the fact that they are effective, many of the medications that are now used to treat bacterial infections come with potentially harmful side effects because of their toxicity. As opposed to this, ashwagandha is a herb that is completely harmless, non-toxic, and has very little adverse effects. Staphylococcus aureus and Enterococcus species that are resistant to methicillin have been proven to be efficiently inhibited by this substance, according to clinical studies. Additionally, it has been established that the root extract of *Withania somnifera* has the ability to suppress the development of a number of Gram-negative bacteria. These bacteria include *Escherichia coli*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Citrobacter freundii* and *Klebsiella pneumoniae*. It is believed that

Ashwagandha possesses a number of features that contribute to its antimicrobial activity. These properties include immunomodulatory effects, which are responsible for increasing immunological reactivity (immunopotentiation), cytotoxic effects, and the ability to silence genes. Based on research conducted on animal models, it has been demonstrated that *Withania somnifera* is an effective therapy for salmonellosis, greatly reducing the severity of the infection symptoms. Furthermore, depending on the doses that are utilized, *Withania somnifera* has the potential to function as an efficient anti-caries therapeutic drug. The growth of oral cavity bacteria such as *Streptococcus mutans* and *Streptococcus sobrinus* is significantly and significantly slowed down by it. Additionally, it inhibits the creation of bacterial acid and the formation of biofilm. It has been demonstrated that the plant is particularly effective against *Salmonella typhi*. Through the stimulation of apoptosis, which entails the release of reactive oxygen species (ROS) from mitochondria and the breakdown of the mitochondrial membrane potential, witanolides that have been isolated from ashwagandha are able to cause cell death in *Leishmania donovani*. In addition, research suggests that Ashwagandha possesses significant antifungal capabilities, notably against *Candida albicans*. However, it appears that *Aspergillus flavus* and *Aspergillus niger* are resistant to the chemicals that Ashwagandha contains. Nevertheless, glycoproteins that have been isolated from the root tubers of *Withania somnifera* have been shown to possess antibacterial capabilities against *Clavibacter michiganensis* subsp. Michiganensis, in addition to possessing antifungal activity against *Aspergillus flavus*, *Fusarium oxysporum* and *Fusarium verticilloides*. A study conducted by Murugan and colleagues discovered that the extract of *Withania somnifera* had improved antibacterial activity against P. aeruginosa. Ashwagandha extract was shown to cause damage to the cell membrane of *P. aeruginosa*, according to the findings of a research that investigated the mechanism of antibacterial action by morphological analysis and membrane stability experiments. *Withania somnifera* extracts, when administered in greater quantities, have been shown to be beneficial in treating malaria, resulting in a considerable reduction in parasitemia, according to studies conducted on mice [46-49].

7. Support for infertility treatment

According to the World Health Organization (WHO), infertility is the inability to conceive within one year, despite engaging in sexual activity on a regular basis (3-4 times per week) and not using contraception. The number of individuals seeking assistance has increased in recent years, and this issue

effects approximately 1.5 million couples in Poland. Infertility is a substantial demographic, emotional, and social issue. Research has demonstrated that the administration of *Withania somnifera* (commonly referred to as Ashwagandha) to men with oligospermia for a period of 90 days led to an increase in sperm count, semen volume, and sperm motility. Furthermore, testosterone and luteinizing hormone levels increased, while prolactin (PRL) and follicle-stimulating hormone (FSH) levels decreased. Ashwagandha root powder significantly enhanced semen parameters in men with normozoospermia, including sperm count, morphology, volume, and motility, thereby increasing the probability of pregnancy in women. Semen plasma also exhibited an increase in antioxidant enzymes and vitamins A, C, and E, as well as improvements in the hormonal profile, with no reported adverse effects. Not only were reproductive hormone levels and semen quality improved in men who consumed Ashwagandha root orally, but lipid peroxidation was inhibited, and protein carbonyl groups (CO) were decreased. The presence of CO in blood and tissues is a reliable indicator of protein peroxidation, with elevated levels being associated with a variety of diseases. Despite the fact that the precise relationship between oxidative stress, disease, and CO groups is still uncertain, the use of CO as a biomarker is advantageous, as these groups are relatively stable and manifest early in the progression of the disease. Ashwagandha has been demonstrated to enhance sperm parameters in males with idiopathic infertility without causing any adverse effects. It may also function as an alternative treatment to pentoxifylline. Nevertheless, the absence of sufficient data necessitates additional research, despite the promising results. The precise molecular mechanisms of action of *Withania somnifera* and its active constituents in the treatment of male infertility are still not completely comprehended. A study found that the sexual function of healthy women was enhanced by the supplementation of high-concentration Ashwagandha root extract (HCARE). Significant improvements in sexual arousal, lubrication, climax, and the number of successful sexual intercourses were observed in comparison to a placebo study. Additionally, Chauhan et al. verified that the total scores of the Derogatis Interview for Sexual Functioning – Male (DISF-M) increased statistically significantly in the Ashwagandha root extract group compared to the placebo group [50-53].

8. Anticancer effects of Ashwagandha

Cancer encompasses a diverse group of diseases characterized by uncontrolled cell division, which often arises from mutations in genes that encode proteins critical for regulating the cell cycle. These include proto-

oncogenes, which promote cell growth, and anti-oncogenes, which suppress it. The prevalence of cancer poses a significant health challenge globally, becoming one of the leading causes of mortality despite extensive research efforts concentrated on developing effective treatments and prevention strategies. Research has identified various bioactive compounds extracted from different parts of the Ashwagandha plant-namely the root, stem, and leaves-that exhibit notable anticancer properties. These compounds show promise for treating cancer as standalone therapies or in synergistic combinations with established chemotherapeutic agents. One of the primary classes of compounds found in Ashwagandha, known as witanolides, belong to a group of alkaloids that have demonstrated significant potential in combatting various forms of cancer. Witanolides, particularly, are recognized for their capacity to induce apoptosis, effectively triggering programmed cell death in cancerous cells. This is crucial in the treatment of several cancer types, including but not limited to breast, colon, lung, prostate, and hematological cancers. Research particularly emphasizes Ashwagandha's efficacy against breast cancer subtypes, notably estrogen receptor (ER) and progesterone receptor (PR)-positive breast cancer, as well as triple-negative breast cancer. These targeted properties suggest that Ashwagandha not only facilitates treatment but may also play a preventative role in the development of breast cancer. Furthermore, studies indicate that Ashwagandha could enhance the quality of life for patients undergoing treatment for breast cancer, which underscores its potential ancillary benefits. Among the noteworthy compounds derived from Ashwagandha is Withaferin A. This specific alkaloid has garnered attention for its effectiveness in treating melanoma, where it promotes apoptosis while concurrently impeding the proliferation of melanoma cells and curbing their migratory capabilities. Investigations into the antitumor mechanisms of Withaferin A within glioblastoma multiforme (GBM) have employed advanced techniques-including RNA sequencing, Western blotting, immunofluorescence staining, quantitative reverse transcription PCR (qRT-PCR), and small interfering RNA (siRNA) gene silencing. These studies revealed that Withaferin A significantly hinders GBM growth both in laboratory settings (*in vitro*) and in living organisms (*in vivo*), as well as activating intrinsic apoptotic pathways in GBM cells. Notably, the compound causes cell cycle arrest at the G2/M phase by dephosphorylating CDK1 at Thr161, which sheds light on optimizing therapeutic regimens centered around Withaferin A for either the prevention or treatment of glioblastoma multiforme. Moreover, a study by Jawarneh et al. explored the combined effect of Ashwagandha extract and intermittent fasting as a viable

therapeutic approach for breast cancer treatment, particularly when used alongside cisplatin, a commonly used chemotherapeutic drug. This combination therapy proved effective in reducing cancer cell proliferation through the induction of apoptosis, while also mitigating the toxic side effects associated with cisplatin, particularly in the liver and kidneys. Further emphasizing the protective properties of Ashwagandha, research conducted by Azab et al. demonstrated its capability to safeguard against the adverse effects of radiation exposure. The findings revealed that Ashwagandha extract could significantly lower oxidative stress and inflammation within liver and spleen tissues, suggesting its valuable role in defending vital organs from damage induced by radiotherapy [54-58].

9. Antidiabetic Activity

The potential antidiabetic effects of Ashwagandha are of significant interest; however, the existing literature on this topic is limited. A review conducted by Durg et al. elucidates the antidiabetic properties of this material, highlighting preclinical studies that yielded promising results. Animal research has demonstrated the capability of Ashwagandha to reduce blood glucose levels. Furthermore, Tekula *et al*. established that Withaferin A effectively regulates induced type 1 diabetes in rat models through modulation of Nrf2/NFκB signaling pathways, underscoring its potential therapeutic applications. In silico investigations have corroborated the efficacy of Withaferin A through molecular docking studies. Notably, only one clinical trial from the year 2000 has documented a direct hypoglycemic effect. Conversely, numerous studies indicate a beneficial impact of Ashwagandha on the lipidemic profile. In a study involving white albino rats that exhibited hypercholesterolemia, researchers observed a significant reduction in cholesterol levels and an enhancement of antioxidant effects attributed to *Withania somnifera*. While clinical trials focusing on diabetes did not demonstrate effects on blood glucose levels, intriguing improvements in the lipidemic profile, body weight, and blood pressure have been reported in a study by Agnihotri *et al*. In addition, Nayak et al. indicated an enhancement in the lipidemic profile and overall patient evaluation utilizing the DDS17 distress scale. Usharani *et al*. noted that administration of a standardized Ashwagandha extract, named SENSORIL, led to improvements in antioxidant parameters and the lipidemic profile while also confirming the tolerability and safety of this material. Despite its noted tolerability and safety, Usharani et al. demonstrated an observable impact on the lipidemic profile and a modification of the reflection index (RI) [59-63].

10. Anxiolytic and Anti-Stress effects

Stress is the body's biological response to stimuli, and its effects can disturb homeostasis, leading to various health issues. Anxiety disorders are among the most common psychiatric conditions, and many patients discontinue pharmacotherapy due to side effects, resulting in relapses. This emphasizes the need for new treatments with fewer adverse effects. In a study on patients with Generalized Anxiety Disorder (GAD) who took SSRIs and one capsule of Ashwagandha extract daily for six weeks, results suggested that *Withania somnifera* could support SSRI therapy. Ashwagandha significantly reduced scores on the Hamilton Anxiety Rating Scale (HAM-A) and the Depression, Anxiety and Stress Scale (DASS-21), as well as morning cortisol and DHEA-S levels. Men's testosterone levels increased, while women's remained unchanged, and there was a significant decrease in perceived stress. Ashwagandha's anxiolytic effects may result from decreased activity of the hypothalamic-pituitary-adrenal (HPA) axis and its anti-inflammatory and antioxidant properties. DHEA plays a role in sexual health and is affected by stress levels. While beneficial in moderation, high DHEA levels indicate stress or HPA overactivity. In another study, participants taking a sustained-release Ashwagandha capsule for 90 days reported significant improvements in memory, attention, sleep quality, and overall psychological well-being, with a noted reduction in stress levels. Research in female rats indicated that Ashwagandha could inhibit stress-induced immune responses and apoptosis while enhancing immune factor expression. Additional studies included participants with schizophrenia, depression, and anxiety, highlighting Ashwagandha’s potential in stress management [64-67].

11. Adaptogenic effect

Herbal remedies known as adaptogens are substances that improve a person's capacity to deal with stress and adjust to new circumstances. In accordance with the most recent definition, an adaptogen is defined as "a class of metabolic regulators that improves the body's ability to adjust to environmental factors and mitigate the potential damage that they may cause." An ideal adaptogen should be able to mitigate the harmful effects that are brought on by stress, be safe even when taken in greater dosages, and not generate any unpleasant side effects. This means that it should not interfere with the functioning of the body in a manner that is beyond what is required. Ashwagandha is a plant that may be classed as an adaptogen due to the properties that it provides. An investigation was carried out on a certain group of horses that were given an extract of ashwagandha root. These horses were

subjected to a variety of stressors, such as strenuous exercise, being separated from their companions, and loud noises. In the course of the experiment, the researchers investigated a variety of characteristics, including haematological, biochemical, hormonal, and immunological. In the group that was given the treatment, there was a statistically significant reduction in the levels of cortisol, epinephrine, glucose, triglycerides, creatinine, IL-6, alanine aminotransferase, and aspartate aminotransferase after a period of 21 days. A conclusion may be drawn from this that ashwagandha possesses adaptogenic, antioxidant, and immunostimulating properties. In addition, the Footshock technique was utilized in order to assess the adaptogenic effects of standardized extracts of *Withania somnifera* (Ashwagandha) and Panax ginseng on rats who were subjected to chronic stress. The effects of chronic stress included hyperglycemia, glucose intolerance, higher plasma corticosterone levels, a rise in the number of stomach ulcers, sexual dysfunction, cognitive impairments, immunosuppression, and mental despair. A considerable reduction in the severity of all of these illnesses was observed after the administration of extracts of *Withania somnifera* and Panax ginseng prior to the stressor. During the course of another investigation, an aqueous fraction of ashwagandha that was free of withanolides was investigated. In this study, the adaptogenic activity of this new fraction was investigated, and it was discovered that it caused considerable anti-stress benefits, such as better swimming endurance and reduced adrenal gland weight, without creating any detrimental consequences [68-69].

12. Increase muscle strength

Supplementation with ashwagandha has been demonstrated to increase muscular strength by a substantial amount and to boost the processes of muscle repair. Oral administration of 300 milligrams of root extract from *Withania somnifera* was given to young males who were in good health for a period of eight weeks during the course of the trial. A systematic resistance training program that was based on standards from the National Strength and Conditioning Association (NSCA) was also an activity that these men engaged in. Not only did the individuals in the research who took Ashwagandha have a considerable gain in muscular mass in their arms and chest, but they also saw a significant boost in their muscle strength. It was also noted that people who supplemented with Ashwagandha suffered much less exercise-induced muscle damage compared to the placebo group. This was demonstrated by the fact that plasma creatine kinase levels remained stable throughout the study. The group who took ashwagandha also showed a large reduction in body fat

and a significant increase in testosterone levels. Those who were given ashwagandha supplements shown substantial gains in a variety of cardiorespiratory endurance measures when compared to the group that was given a placebo, according to additional study carried out by Shenoy and colleagues. With regard to the maximum aerobic capacity, duration to exhaustion, and ventilatory threshold, the Ashwagandha group shown a notable improvement in all three of these areas. In addition to this, they had lower amounts of the hormone cortisol, which is connected with times of stress. In a different trial that involved adult athletes, a comparison was made between a group that received a determined dose of ashwagandha and a group that received a placebo. A considerable increase in VO2 max (maximum aerobic capacity) was observed in the athletes who had been taking Ashwagandha prior to the conclusion of the trial. They also got higher Total Quality Recovery Scores (TQR), which is an international standard. Based on the results of the Daily Analysis of Life Demands for Athletes (DALDA) questionnaire, it was shown that athletes who were treated with Ashwagandha had an increase in their quality of life. In comparison to the placebo group, the athletes who were treated with the Recovery Stress Questionnaire (RESTQ) reported feeling less weary and having more energy after their workouts. This showed that the athletes recovered from their workouts more quickly overall. In addition to this, the group that was treated showed a notable rise in the levels of antioxidants. Throughout the course of the research, there were no negative effects seen, which indicates that ashwagandha may be utilized without risk for the aforementioned goals. *Withania somnifera* aqueous extracts were also shown to be useful in increasing muscular strength and inducing muscle development. In comparison to individuals in the placebo group, those who took Ashwagandha supplements for a period of eight weeks showed considerably better gains in both their muscular strength and power capacity. With regard to the recovery of muscular strength following strenuous activity, those who took ashwagandha had a quicker recovery than the placebo group [70-71].

Safety and Tolerability

The long-standing history of Ashwagandha's medicinal use underscores its effectiveness and the body's good tolerance for this herb. However, recent concerns have emerged about its safety, particularly regarding its association with liver damage. Given the increasing popularity of herbal supplements in both national and international pharmaceutical markets, the importance of rigorously monitoring the safety of these products has never been more crucial.

The first documented case linking Ashwagandha to liver disease surfaced in Japan in 2004. This incident involved a 20-year-old male who developed congestive liver damage after consuming Ashwagandha. Remarkably, he recovered without complications following the discontinuation of the herb and two months of symptomatic treatment that included ursodeoxycholic acid and phenobarbital. Furthermore, research by Björnsson et al. highlighted an alarming trend, identifying that Ashwagandha could be the underlying cause of five distinct cases of liver damage. These instances highlight the hepatotoxic potential of this herb. Typically, liver damage associated with Ashwagandha manifests as cholestatic or mixed liver injury, often characterized by severe jaundice and pruritus (itching). The good news is that this type of liver damage tends to be self-limiting, usually resulting in the normalization of liver function tests within 1 to 5 months after the cessation of the supplement.

In another case reported in the UK, a 39-year-old woman experienced significant jaundice and nausea after using an over-the-counter herbal supplement that included Ashwagandha root extract. Additionally, there was a concerning report involving a 41-year-old woman who, during her treatment with Ashwagandha extract and progesterone, became severely ill and eventually qualified for a liver transplant due to her deteriorating liver condition. While these reports of hepatotoxic effects are currently few and far between, they underscore the necessity for continued monitoring and research to clarify any risks associated with Ashwagandha consumption.

In contrast to these alarming reports, a study conducted in India involving 80 healthy participants provided some reassurance about the safety of Ashwagandha. In this trial, individuals received doses of 300 mg of Ashwagandha root extract orally, twice daily over a period of 8 weeks. Researchers carefully monitored various health parameters, including body weight, blood pressure (systolic and diastolic), hemoglobin levels, and liver enzyme activity (specifically alkaline phosphatase, alanine transaminase, and aspartate transaminase), as well as plasma neutrophil and platelet counts. The findings revealed no significant differences between the group taking Ashwagandha and the control group receiving a placebo, indicating no apparent toxic effects. Thyroid function was also evaluated through blood tests measuring levels of triiodothyronine, thyroxine, and TSH (thyroid-stimulating hormone), all of which remained stable without significant variation.

Another smaller-scale study involving 18 volunteers corroborated the findings regarding Ashwagandha's safety profile. This study assessed various

blood parameters and confirmed a lack of significant changes in red blood cell counts, white blood cell percentages, and erythrocyte sedimentation rate (ESR), bilirubin levels, and plasma protein concentrations. Notably, an increase in serum creatinine levels and a decrease in blood urea nitrogen levels were observed. Researchers suggested that these alterations could be attributed to an observed increase in muscle mass among participants due to the herb's adaptogenic properties, which may promote physical performance and recovery.

Despite Ashwagandha's numerous benefits, caution is advised, particularly for women who are pregnant or breastfeeding. There remains insufficient evidence to definitively establish the safety of Ashwagandha-based preparations during these crucial periods.

Some insights into this issue have come from studies examining the effects of Ashwagandha on pregnant rats. These studies predominantly focused on the window of embryonic development between days 5 and 19 of pregnancy, a critical time characterized by significant organ and tissue formation in the developing fetus. In these animal studies, Ashwagandha doses as high as 2000 mg/kg/day were administered orally. Remarkably, no toxic effects were noted in the treated rats, with no adverse effects observed in terms of body weight changes in the pregnant females, the number of corpus luteum, or embryo implantation rates. Furthermore, no observable external, skeletal, or visceral deformities were found in the fetuses, suggesting a lack of teratogenic effects from Ashwagandha in these studies.

Overall, while the historical and emerging evidence around Ashwagandha is promising, ongoing investigation and careful consideration of its use in sensitive populations remain essential [72-73].

Contradictions

Phytotherapy utilizing Ashwagandha root has been increasingly recognized for its potential health benefits; however, it is crucial to understand that these preparations may not be suitable for all patients without careful consideration of their health conditions and concurrent therapies. Specifically, patients diagnosed with hyperthyroidism who exhibit a range of symptoms-including irritability, restlessness, nervousness, anxiety, hand tremors, palpitations, psychomotor agitation, muscle weakness, fatigue, and decreased libido-should proceed with caution.

While Ashwagandha preparations have demonstrated effectiveness in alleviating some of these symptoms, their use is contraindicated in individuals

suffering from hyperthyroidism due to the risk of exacerbating the condition. Research indicates that Ashwagandha can elevate levels of 3, 3', 5-triiodothyronine (T3) and tetraiodothyronine (T4), both of which can lead to adverse outcomes in patients with hyperthyroidism. In addition, Indian ginseng root extract, which is derived from Ashwagandha, has been employed in the management of male infertility.

However, men diagnosed with hormone-sensitive prostate cancer should avoid this treatment. Studies suggest that Ashwagandha can increase testosterone production, which may contribute to the progression of this type of cancer. Furthermore, pregnant individuals or those planning to conceive should strictly avoid using Ashwagandha root extract, as higher doses have been linked to an increased risk of miscarriage. When considering the use of Ashwagandha, extreme caution is warranted, particularly for those who are taking medications that target GABA-A receptors. This is especially relevant for individuals prescribed benzodiazepines and barbiturates. The concurrent use of Ashwagandha may enhance the sedative and muscle-relaxing effects of these medications, potentially leading to serious side effects. Specifically, Ashwagandha has been shown to interact with a variety of drugs used to manage anxiety, sleep disorders, muscle spasticity, and seizures. This interaction could result in heightened adverse effects, such as impaired motor coordination, muscle weakness, persistent headaches, decreased libido, muscle tremors, and excessive drowsiness.

Furthermore, preliminary studies suggest that Ashwagandha root extracts may function as a CYP3A4 inducer or a CYP2B6 inhibitor. This characteristic could lead to clinically relevant interactions between Ashwagandha and various other medications. For instance, such interactions could amplify the adverse effects of certain drugs or render them ineffective in ongoing treatment regimens. Patients who are taking hypoglycemic agents, antihypertensive medications, or immunosuppressive drugs, as well as those with autoimmune conditions, should consult with their healthcare provider before beginning Ashwagandha therapy to discuss potential risks and benefits.

Current research involving both human and animal studies indicates that Ashwagandha is a safe herbal remedy for short-term as well as long-term use. Significant adverse effects linked to the ingestion of the raw material or its preparations have not been identified to date. However, individuals who exhibit hypersensitivity reactions to other plants within the Solanaceae family, or specifically to Ashwagandha, are advised to avoid this herb. Additionally, patients suffering from autoimmune diseases should exercise caution with

Ashwagandha supplementation due to its potential immunostimulant effects. Such effects could aggravate conditions like multiple sclerosis (MS), systemic lupus erythematosus (SLE), and rheumatoid arthritis (RA). Consequently, it is advisable that Ashwagandha preparations not be used in conjunction with immunosuppressive agents, as the two can produce antagonistic effects, undermining the intended therapeutic outcomes.

In summary, while Ashwagandha may offer various health benefits, careful consideration and professional guidance are essential to ensure its safe and effective use, especially in vulnerable populations or those on complex medication regimens [74-79].

Future directions

Further research is warranted to:

- Explore the potential of Ashwagandha in treating neurodegenerative disorders (e.g., Alzheimer's, Huntington's disease).
- Conduct large-scale, multicenter trials to validate its anti-cancer efficacy.
- Investigate synergistic effects when combined with other pharmacological agents.

Conclusion

Ashwagandha (*Withania somnifera*) exhibits a diverse range of pharmacological actions, making it a versatile therapeutic agent in modern medicine. Its neuroprotective, anti-inflammatory, and adaptogenic properties are supported by growing clinical evidence, while its immunomodulatory and anti-cancer potentials hold promise for future applications. As research progresses, Ashwagandha may become a cornerstone of integrative pharmacotherapy for chronic diseases and stress-related conditions.

Ashwagandha, scientifically known as *Withania somnifera*, is a medicinal herb that has been a cornerstone of traditional medicine, especially within the Ayurvedic system, for thousands of years. Its roots and leaves are utilized for their purported health benefits, and recent scientific investigations have begun to substantiate many of these claims, revealing a wide array of beneficial effects on various bodily systems. Research has demonstrated that Ashwagandha may help reduce stress and anxiety, improve cognitive function, and enhance physical performance and endurance. Additionally, it has been studied for its potential anti-inflammatory and antioxidant properties, which could contribute to better overall health and a reduced risk of chronic diseases.

Despite the promising findings, it is important to emphasize that research on Ashwagandha remains ongoing. More rigorous studies, particularly well-designed clinical trials, are crucial to solidify its potential therapeutic uses. These studies should focus not only on confirming the efficacy of Ashwagandha in treating specific conditions but also on determining the optimal dosages and treatment durations necessary to achieve the desired health outcomes. Safety is another critical aspect to consider when using Ashwagandha, especially in conjunction with other medications or dietary supplements. Potential interactions can occur, and individuals with specific health conditions, such as autoimmune disorders, thyroid issues, or those who are pregnant or breastfeeding, should exercise caution and consult healthcare professionals before starting any new supplement regimen involving Ashwagandha. As the body of research continues to grow, it becomes increasingly essential to keep our knowledge about Ashwagandha current. This includes examining its various applications in disease treatment while also ensuring user safety through appropriate guidelines. Preliminary findings suggest that Ashwagandha may hold significant promise for a range of neurological disorders, such as stress-related conditions and neurodegenerative diseases. However, the precise mechanisms through which Ashwagandha exerts its effects, including its influence on neurotransmitters and neuroprotective pathways, require further investigation. Understanding these mechanisms is critical for the development of more tailored therapeutic strategies that can maximize the benefits of Ashwagandha while minimizing potential risks. In conclusion, while Ashwagandha shows great potential as a therapeutic agent, continuing research is essential to fully understand its benefits, establish safety protocols, and uncover the underlying action mechanisms contributing to its effectiveness.

References

1. Mikulska P, Malinowska M, Ignacyk M, Szustowski P, Nowak J, Pesta K, et al. Ashwagandha (*Withania somnifera*)—Current research on the health-promoting activities: A narrative review. Pharmaceutics. 2023;15(4):1057.
2. Dar NJ, Hamid A, Ahmad M. Pharmacologic overview of *Withania somnifera*, the Indian Ginseng. Cell Mol Life Sci. 2015 Dec;72(23):4445-60.
3. John J. Therapeutic potential of *Withania somnifera*: A report on phyto-pharmacological properties. Int J Pharm Sci Res. 2014;5:2131–48.

4. Dutta R, Khalil R, Green R, Mohapatra SS, Mohapatra S. *Withania somnifera* (Ashwagandha) and Withaferin A: Potential in integrative oncology. Int J Mol Sci. 2019;20(21):5310.

5. Abbas SS, Singh N. Anti-stress agents (herbs) of Indian origin. In: Herbal drugs, a twenty first century perspective. Delhi: DRDO, Govt. of India; 2006. p. 578–91.

6. Singh N, Bhalla M, de Jager P, Gilca M. An overview on Ashwagandha: A Rasayana (rejuvenator) of Ayurveda. Afr J Tradit Complement Altern Med. 2011;8(Suppl 5):208–13.

7. Tiwari S, Atluri V, Kaushik A, Yndart A, Nair M. Alzheimer's disease: Pathogenesis, diagnostics, and therapeutics. Int J Nanomedicine. 2019;14:5541–54.

8. Kurapati KRV, Atluri VSR, Samikkannu T, Nair MPN. Ashwagandha (*Withania somnifera*) reverses β-amyloid1-42 induced toxicity in human neuronal cells: Implications in HIV-associated neurocognitive disorders (HAND). PLoS One. 2013;8(10):e77624.

9. Pandey A, Bani S, Dutt P, Satti NK, Suri KA, Qazi GN. Multifunctional neuroprotective effect of Withanone, a compound from *Withania somnifera* roots in alleviating cognitive dysfunction. Cytokine. 2018;102:211–21.

10. Das R, Rauf A, Akhter S, Islam MN, Emran TB, Mitra S, et al. Role of Withaferin A and its derivatives in the management of Alzheimer's disease: Recent trends and future perspectives. Molecules. 2021;26(12):3696.

11. Atluri VSR, Tiwari S, Rodriguez M, Kaushik A, Yndart A, Kolishetti N, et al. Inhibition of amyloid-beta production, associated neuroinflammation, and histone deacetylase 2-mediated epigenetic modifications prevent neuropathology in Alzheimer's disease in vitro model. Front Aging Neurosci. 2020;11:342.

12. Sehgal N, Gupta A, Valli RK, Joshi SD, Mills JT, Hamel E, et al. *Withania somnifera* reverses Alzheimer's disease pathology by enhancing low-density lipoprotein receptor-related protein in liver. Proc Natl Acad Sci USA. 2012;109(9):3510–5.

13. Zlokovic BV, Deane R, Sagare AP, Bell RD, Winkler EA. Low-density lipoprotein receptor-related protein-1: A serial clearance homeostatic

mechanism controlling Alzheimer's amyloid β-peptide elimination from the brain. J Neurochem. 2010;115(5):1077–89.

14. Lillis AP, Van Duyn LB, Murphy-Ullrich JE, Strickland DK. LDL receptor-related protein 1: Unique tissue-specific functions revealed by selective gene knockout studies. Physiol Rev. 2008;88(3):887–918.
15. Rauch JN, Luna G, Guzman E, Audouard M, Challis C, Sibih YE, et al. LRP1 is a master regulator of tau uptake and spread. Nature. 2020;580(7803):381–5.
16. Dubey S, Kallubai M, Subramanyam R. Improving the inhibition of β-amyloid aggregation by withanolide and withanoside derivatives. Int J Biol Macromol. 2021;173:56–65.
17. Kuboyama T, Tohda C, Komatsu K. Withanoside IV and its active metabolite, sominone, attenuate Aβ(25–35)-induced neurodegeneration. Eur J Neurosci. 2006;23(6):1417–26.
18. Rabhi C, Arcile G, Le Goff G, Da Costa Noble C, Ouazzani J. Neuroprotective effect of CR-777, a glutathione derivative of Withaferin A, obtained through the bioconversion of *Withania somnifera* (L.) Dunal extract by the fungus Beauveria bassiana. Molecules. 2019;24(24):4599.
19. Mukherjee S, Kumar G, Patnaik R. Withanolide A penetrates brain via intra-nasal administration and exerts neuroprotection in cerebral ischemia reperfusion injury in mice. Xenobiotica. 2020;50(8):957–66.
20. Singh M, Ramassamy C. In vitro screening of neuroprotective activity of Indian medicinal plant *Withania somnifera*. J Nutr Sci. 2017;6:e54.
21. Bhargava P, Malik V, Liu Y, Ryu J, Kaul SC, Sundar D, et al. Molecular insights into Withaferin-A-induced senescence: Bioinformatics and experimental evidence to the role of NFκB and CARF. J Gerontol A Biol Sci Med Sci. 2019;74(2):183–91.
22. Zając M, Jelińska A, Muszalska IC. Chemia leków z elementami chemii medycznej dla studentów farmacji i farmaceutów. Poznan: Uniwersytet Medyczny im. Karola Marcinkowskiego; 2018.
23. Ahmad M, Saleem S, Ahmad AS, Ansari MA, Yousuf S, Hoda MN, et al. Neuroprotective effects of *Withania somnifera* on 6-hydroxydopamine induced Parkinsonism in rats. Hum Exp Toxicol. 2005;24(3):137–47.

24. Wongtrakul J, Thongtan T, Kumrapich B, Saisawang C, Ketterman AJ. Neuroprotective effects of *Withania somnifera* in the SH-SY5Y Parkinson cell model. Heliyon. 2021;7(7):e08172.

25. RajaSankar S, Manivasagam T, Sankar V, Prakash S, Muthusamy R, Krishnamurti A, et al. *Withania somnifera* root extract improves catecholamines and physiological abnormalities seen in a Parkinson's disease model mouse. J Ethnopharmacol. 2009;125(3):369–73.

26. De Rose F, Marotta R, Poddighe S, Talani G, Catelani T, Setzu MD, et al. Functional and morphological correlates in the Drosophila LRRK2 loss-of-function model of Parkinson's disease: Drug effects of *Withania somnifera* (Dunal) administration. PLoS One. 2016;11:e0146140. doi:10.1371/journal.pone.0146140.

27. RajaSankar S, Manivasagam T, Surendran S. Ashwagandha leaf extract: A potential agent in treating oxidative damage and physiological abnormalities seen in a mouse model of Parkinson's disease. Neurosci Lett. 2009;454(1):11–5. doi:10.1016/j.neulet.2009.02.044.

28. Rojas NG, Cesarini ME, Peker G, Da Prat GA, Etcheverry JL, Gatto EM. Review of Huntington's Disease: From Basics to Advances in Diagnosis and Treatment. J Neurol Res. 2022;12(4):93–113. doi:10.14740/jnr721.

29. Kumar P, Kumar A. Possible neuroprotective effect of *Withania somnifera* root extract against 3-nitropropionic acid-induced behavioral, biochemical, and mitochondrial dysfunction in an animal model of Huntington's disease. J Med Food. 2009;12(3):591–600. doi:10.1089/jmf.2008.0028.

30. Joshi T, Kumar V, Kaznacheyeva EV, Jana NR. Withaferin A Induces Heat Shock Response and Ameliorates Disease Progression in a Mouse Model of Huntington's Disease. Mol Neurobiol. 2021;58(8):3992–4006. doi:10.1007/s12035-021-02397-8.

31. Fakhri S, Piri S, Moradi SZ, Khan H. Phytochemicals Targeting Oxidative Stress, Interconnected Neuroinflammatory, and Neuroapoptotic Pathways Following Radiation. Curr Neuropharmacol. 2022;20(5):836–56. doi:10.2174/1570159X19666210809103346.

32. Leder S, Siwiak-Kobayashi M, Nerwice WBA. Psychiatria. Podręcznik dla Studentów Medycyny. Warszawa: Wydawnictwo Lekarskie PZWL; 2016.

33. Borkowska A. Znaczenie zaburzeń funkcji poznawczych i możliwości ich oceny w chorobach psychicznych. Psychiatr Prakt Klin. 2009;2(1):30–40.

34. Borkowska A. Dysfunkcje poznawcze w zaburzeniu obsesyjno-kompulsyjnym. Psychiatr Psychol Klin. 2005;5(2):66–78.

35. Jahanbakhsh SP, Manteghi AA, Emami SA, Mahyari S, Gholampour B, Mohammadpour AH, et al. Evaluation of the efficacy of *Withania somnifera* (Ashwagandha) root extract in patients with obsessive-compulsive disorder: A randomized double-blind placebo-controlled trial. Complement Ther Med. 2016;27:25–9. doi:10.1016/j.ctim.2016.03.018.

36. Kaurav BPS, Wanjari MM, Chandekar A, Chauhan NS, Upmanyu N. Influence of *Withania somnifera* on obsessive compulsive disorder in mice. Asian Pac J Trop Med. 2012;5(5):380–4. doi:10.1016/S1995-7645(12)60063-7.

37. Gupta GL, Rana AC. Effect of *Withania somnifera* Dunal in ethanol-induced anxiolysis and withdrawal anxiety in rats. Indian J Exp Biol. 2008;46(6):470–5.

38. Haque IM, Mishra A, Kalra BS, Chawla S. Role of Standardized Plant Extracts in Controlling Alcohol Withdrawal Syndrome—An Experimental Study. Brain Sci. 2021;11(7):919. doi:10.3390/brainsci11070919.

39. Dar NJ, Hamid A, Ahmad M. Pharmacologic overview of *Withania somnifera*, the Indian Ginseng. Cell Mol Life Sci. 2015;72(23):4445–60. doi:10.1007/s00018-015-2012-1.

40. Rasool M, Varalakshmi P. Immunomodulatory role of *Withania somnifera* root powder on experimental induced inflammation: An in vivo and in vitro study. Vascul Pharmacol. 2006;44(6):406–10. doi:10.1016/j.vph.2006.01.015.

41. Sikandan A, Shinomiya T, Nagahara Y. Ashwagandha root extract exerts anti-inflammatory effects in HaCaT cells by inhibiting the MAPK/NF-κB pathways and by regulating cytokines. Int J Mol Med. 2018;42(1):425–34. doi:10.3892/ijmm.2018.3608.

42. Gupta M, Kaur G. *Withania somnifera* as a potential anxiolytic and anti-inflammatory candidate against systemic lipopolysaccharide-induced

neuroinflammation. Neuromol Med. 2018;20(3):343–62. doi:10.1007/s12017-018-8497-7.

43. Kanjilal S, Gupta AK, Patnaik RS, Dey A. Analysis of Clinical Trial Registry of India for Evidence of Anti-Arthritic Properties of *Withania somnifera* (Ashwagandha). Altern Ther Health Med. 2021;27(3):58–66.

44. Davis L, Kuttan G. Immunomodulatory activity of *Withania somnifera*. J Ethnopharmacol. 2000;71(1–2):193–200. doi:10.1016/S0378-8741(99)00206-8.

45. Tharakan A, Shukla H, Benny IR, Tharakan M, George L, Koshy S. Immunomodulatory effect of *Withania somnifera* (Ashwagandha) extract—A randomized, double-blind, placebo controlled trial with an open label extension on healthy participants. J Clin Med. 2021;10(16):3644. doi:10.3390/jcm10163644.

46. Rawat V, Bisht P. Antibacterial activity of *Withania somnifera* against Gram-positive isolates from pus samples. Ayu. 2014;35(3):330. doi:10.4103/0974-8520.153757.

47. Kumari M, Gupta RP. In vitro antibacterial effect of *Withania somnifera* root extract on Escherichia coli. Vet World. 2015;8(1):57–60. doi:10.14202/vetworld.2015.57-60.

48. Singh G, Kumar P. Evaluation of antimicrobial efficacy of flavonoids of *Withania somnifera* L. Indian J Pharm Sci. 2011;73(4):473–6. doi:10.4103/0250-474X.95656.

49. Alam N, Hossain M, Mottalib MA, Sulaiman SA, Gan SH, Khalil MI. Methanolic extracts of *Withania somnifera* leaves, fruits and roots possess antioxidant properties and antibacterial activities. BMC Complement Altern Med. 2012;12:175. doi:10.1186/1472-6882-12-175.

50. Łukaszuk K, Kozioł K, Jakiel G, Jakimiuk A, Jędrzejczak P, Kuczyński W, et al. Diagnostyka i leczenie niepłodności—Rekomendacje Polskiego Towarzystwa Medycyny Rozrodu i Embriologii (PTMRiE) oraz Polskiego Towarzystwa Ginekologów i Położników (PTGP). Ginekol Perinatol Prakt. 2018;3(3):112–40.

51. Mahdi AA, Shukla KK, Ahmad MK, Rajender S, Shankhwar SN, Singh V, *et al*. *Withania somnifera* improves semen quality in stress-related male fertility. Evid Based Complement Alternat Med. 2011;2011:576962. doi:10.1093/ecam/nep138.

52. Nasimi Doost Azgomi R, Nazemiyeh H, Bazargani HS, Fazljou SMB, Nejatbakhsh F, Jazani AM, et al. Comparative evaluation of the effects of *Withania somnifera* with pentoxifylline on the sperm parameters in idiopathic male infertility: A triple-blind randomised clinical trial. Andrologia. 2018;50:e13041. doi:10.1111/and.13041.

53. Gupta A, Mahdi A, Shukla KK, Ahmad MK, Bansal N, Sankhwar P, et al. Efficacy of *Withania somnifera* on seminal plasma metabolites of infertile males: A proton NMR study at 800 MHz. J Ethnopharmacol. 2013;149:208–14. doi:10.1016/j.jep.2013.06.024.

54. Mehta V, Chander H, Munshi A. Mechanisms of anti-tumor activity of *Withania somnifera* (Ashwagandha). Nutr Cancer. 2021;73:914–26. doi:10.1080/01635581.2020.1778746.

55. Singh N, Yadav SS, Rao AS, Nandal A, Kumar S, Ganaie SA, et al. Review on anticancerous therapeutic potential of *Withania somnifera* (L.) Dunal. J Ethnopharmacol. 2021;270:113704. doi:10.1016/j.jep.2020.113704.

56. Vashi R, Patel BM, Goyal RK. Keeping abreast about Ashwagandha in breast cancer. J Ethnopharmacol. 2021;269:113759. doi:10.1016/j.jep.2020.113759.

57. Nagy Z, Cheung BB, Tsang W, Tan O, Herath M, Ciampa OC, et al. Withaferin A activates TRIM16 for its anti-cancer activity in melanoma. Sci Rep. 2020;10:1–9. doi:10.1038/s41598-020-76722-x.

58. Azab KS, Maarouf RE, Abdel-Rafei MK, El Bakary NM, Thabet NM. *Withania somnifera* (Ashwagandha) root extract counteract acute and chronic impact of γ-radiation on liver and spleen of rats. Hum Exp Toxicol. 2022;41:9603271221106344. doi:10.1177/09603271221106344.

59. Jain S, Pandhi P, Singh AP, Malhotra S. Efficacy of standardised herbal extracts in type 1 diabetes—An experimental study. Afr J Tradit Complement Altern Med. 2006;3:23–33. doi:10.4314/ajtcam.v3i4.31174.

60. Kyathanahalli CN, Manjunath MJ. Oral supplementation of standardized extract of *Withania somnifera* protects against diabetes-induced testicular oxidative impairments in prepubertal rats. Protoplasma. 2014;251:1021–9. doi:10.1007/s00709-014-0612-5.

61. Khalil M, Ahmmed I, Ahmed R, Tanvir EM, Afroz R, Paul S, et al. Amelioration of isoproterenol-induced oxidative damage in rat myocardium by *Withania somnifera* leaf extract. Biomed Res Int. 2015;2015:624159. doi:10.1155/2015/624159.

62. Guo R, Gan L, Lau WB, Yan Z, Xie D, Gao E, et al. Withaferin A prevents myocardial ischemia/reperfusion injury by upregulating AMP-activated protein kinase-dependent B-cell lymphoma2 signaling. Circ J. 2019;83:1726–36. doi:10.1253/circj.CJ-18-1391.

63. Woods A, Vertommen D, Neumann D, Turk R, Bayliss J, Schlattner U, et al. Identification of phosphorylation sites in AMP-activated protein kinase (AMPK) for upstream AMPK kinases and study of their roles by site-directed mutagenesis. J Biol Chem. 2003;278:28434–42. doi:10.1074/jbc.M303946200.

64. Yaribeygi H, Panahi Y, Sahraei H, Johnston TP, Sahebkar A. The impact of stress on body function: A review. EXCLI J. 2017;16:1057–72. doi:10.17179/excli2017-480.

65. Fuladi S, Emami SA, Mohammadpour AH, Karimani A, Manteghi AA, Sahebkar A. Assessment of the efficacy of *Withania somnifera* root extract in patients with generalized anxiety disorder: A randomized double-blind placebo-controlled trial. Curr Rev Clin Exp Pharmacol. 2021;16:191–6. doi:10.2174/1574884715666200413120413.

66. Chengappa KNR, Brar JS, Gannon JM, Schlicht PJ. Adjunctive use of a standardized extract of *Withania somnifera* (Ashwagandha) to treat symptom exacerbation in schizophrenia: A randomized, double-blind, placebo-controlled study. J Clin Psychiatry. 2018;79:22496. doi:10.4088/JCP.17m11826.

67. Remenapp A, Coyle K, Orange T, Lynch T, Hooper D, Hooper S, et al. Efficacy of *Withania somnifera* supplementation on adult's cognition and mood. J Ayurveda Integr Med. 2022;13:100510. doi:10.1016/j.jaim.2021.08.003.

68. Panossian A, Wikman G. Evidence based efficacy of adaptogens in fatigue, and molecular mechanisms related to their stress-protective activity. Curr Clin Pharmacol. 2009;4:198–219. doi:10.2174/157488409789375311.

69. Bhattacharya SK, Muruganandam AV. Adaptogenic activity of *Withania somnifera*: An experimental study using a rat model of chronic stress.

Pharmacol Biochem Behav. 2003;75:547–55. doi:10.1016/S0091-3057(03)00110-2.

70. Sharma AK, Basu I, Singh S. Efficacy and safety of Ashwagandha root extract in subclinical hypothyroid patients: A double-blind, randomized placebo-controlled trial. J Altern Complement Med. 2018;24:243–8. doi:10.1089/acm.2017.0183.

71. Ziegenfuss TN, Kedia AW, Sandrock JE, Raub BJ, Kerksick CM, Lopez HL. Effects of an aqueous extract of *Withania somnifera* on strength training adaptations and recovery: The STAR trial. Nutrients. 2018;10:1807. doi:10.3390/nu10111807.

72. Balkrishna A, Pokhrel S, Singh H, Joshi M, Mulay VP, Haldar S, et al. Withanone from *Withania somnifera* attenuates SARS-CoV-2 RBD and host ACE2 interactions to rescue spike protein induced pathologies in humanized zebrafish model. Drug Des Devel Ther. 2021;15:1111–33. doi:10.2147/DDDT.S292805.

73. Ziauddin M, Phansalkar N, Patki P, Diwanay S, Patwardhan B. Studies on the immunomodulatory effects of Ashwagandha. J Ethnopharmacol. 1996;50:69–76. doi:10.1016/0378-8741(95)01318-0.

74. Kamal HI, Patel K, Brdak A, Heffernan J, Ahmad N. Ashwagandha as a unique cause of thyrotoxicosis presenting with supraventricular tachycardia. Cureus. 2022;14:e23494. doi:10.7759/cureus.23494.

75. Brar GK, Malhotra M. Ashwagandha (*Withania somnifera*)—A herb with versatile medicinal properties empowering human physical and mental health. J Pre-Clin Clin Res. 2021;15:129–33.

76. Bassareo V, Porru S, Rosas M, Frau R, Talani G, Sanna E, et al. New insights on the effects of *Withania somnifera* on the motivational properties of addictive drugs. Proc XVII-Natl Congr Ital Neurosci Soc; Turin, Italy. 4 May 2017.

77. Akhgarjand C, Asoudeh F, Bagheri A, Kalantar Z, Vahabi Z, Shabbidar S, et al. Does Ashwagandha supplementation have a beneficial effect on the management of anxiety and stress? A systematic review and meta-analysis of randomized controlled trials. Phytother Res. 2022;36:4115–24. doi:10.1002/ptr.7598.

78. Savai J, Varghese A, Pandita N, Chintamaneni M. Investigation of CYP3A4 and CYP2D6 interactions of *Withania somnifera* and Centella

asiatica in human liver microsomes. Phytother Res. 2015;29:785–90. doi:10.1002/ptr.5308.

79. Chandrasekhar K, Kapoor J, Anishetty S. A prospective, randomized double-blind, placebo-controlled study of safety and efficacy of a high-concentration full-spectrum extract of Ashwagandha root in reducing stress and anxiety in adults. Indian J Psychol Med. 2012;34:255–62. doi:10.4103/0253-7176.106022.

Chapter - 6
Plants used as Antimicrobial Agents

Authors

Dinesh Kumar
Faculty of Pharmacy, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Navneet Verma
Faculty of Pharmacy, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Sushil Kumar
Faculty of Pharmacy, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Anesh Sagar
Faculty of Pharmacy, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Kavya Vishnoi
Assistant Professor, Prathviraj Chauhan Institute of Medical Sciences, Dhampur, Bijnor, Uttar Pradesh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 6

Plants used as Antimicrobial Agents

Dinesh Kumar, Navneet Verma, Sushil Kumar, Anesh Sagar and Kavya Vishnoi

Abstract

The increase incidence of resistance to synthetic antimicrobial has prompted the hunt for new antimicrobial agents, notably from natural sources such as medicinal plants. Traditional medicine has made extensive use of plants' antibacterial qualities, and research has shown that several plant extracts are beneficial against viral, bacterial, and fungal illnesses. Several medicinal plants' antibacterial properties, bioactive chemicals, and their uses in contemporary medicine are examined in this article.

Keywords: Antimicrobial, traditional medicine, alkaloids, phenolics, flavonoids etc.

Introduction

Plants are unquestionably one of the most important sources of antimicrobials. Plants derived phytoconstituents are very active against numerous infectious diseases for many years and saved millions of lives. Synthetic drugs produce many adverse effects due to this reason scientist going to the natural antimicrobial because natural antimicrobial produced less adverse effects as compare to synthetic antimicrobial. It is estimated that there are 2,50,000 to 5,00,000 species of plants on earth [1].

Alternative natural antimicrobial agents are being investigated as a result of the growing resistance of microorganisms to traditional antibiotics. Alkaloids, flavonoids, tannins, and essential oils are just a few of the many secondary metabolites that are known to be produced by plants and have strong antibacterial qualities. Discussing the antibacterial properties of specific medicinal plants and their bioactive components is the aim of this review.

Relatively small percentage (1 to 10%) of these are used as foods by both humans and other animal species. It is possible that even more are used for medicinal purposes [2].

Major classes of antimicrobial compounds from plants

Plant-derived antimicrobials belong to various chemical classes, each with distinct mechanisms of action against bacteria, fungi, and viruses. The major classes include:

Phenolics and polyphenols

Phenolics and polyphenols are the large class of compounds with strong antimicrobial properties. Phenolics are phytoconstituents having single substituted phenolic rings (Fig.1) Cinnamic acid and caffeic acids are common example of phenolics.

Phenolic compounds are naturally found in plants, where they serve as a defense mechanism against pathogens. Natural phenolic compounds are secondary metabolites produced by plants for numerous functions including antimicrobial defence. Different types of phenolic compounds, including phenolic acids (like gallic acid), flavonoids, and stilbenes, tannins, can inhibit the growth and activity of many microorganisms, including food-related pathogens as well as clinically important bacteria, fungi and protozoa [3, 4]. Some examples of phenolics and polyphenols as antimicrobial are listed in table 1.

Mechanism of action

Membrane disruption: Phenolics can interact with the cell membrane of microbes, causing damage and leakage of cellular components.

Enzyme inhibition: They can inhibit key enzymes necessary for microbial survival, disrupting metabolic processes.

Biofilm disruption: Some phenolic compounds can interfere with the formation of bacterial biofilms, which are important for microbial colonization.

Potential applications

Food preservation: Due to their antimicrobial activity, phenolic compounds can be used as natural preservatives in food products.

Wound care: Topical applications of phenolic compounds might be beneficial in wound healing by inhibiting microbial growth.

Drug development: Research is ongoing to develop new antimicrobial drugs based on phenolic compounds, particularly to address antibiotic resistance issues [4].

Table 1: Examples of phenolics and polyphenols as antimicrobials

Plant source	Phenolics	Active against
Coffee	Caffeic Acid	*Salmonella species*
Green tea, grapes	Gallic Acid	*Listeria monocytogenes*
Tea, grapes, pomegranates	Tannins	*E. coli*, *S. aureus*

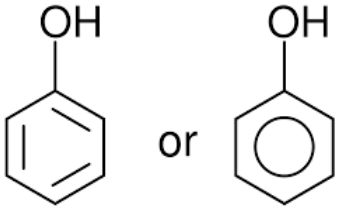


Fig 1: Basic structure of phenolics

Quinones

Quinones from plants have antimicrobial properties and are also used as anticancer, antioxidant, antimalarial, and anti-inflammatory agents. Quinones are aromatic ring compounds with two ketone substitutes (Fig. 2). These are extensively found in plants and produce antibacterial, antifungal and antiviral activities [5, 6, 7]. Some examples of quinone as antimicrobial are listed in table 2.

Major types of quinones in plants

Benzoquinones: Found in *Tectona grandis* (teak) and *Plumbago* species.

Naphthoquinones: Present in *Juglans regia* (walnut), *Lawsonia inermis* (henna), and *Diospyros* species.

Anthraquinones: Found in *Aloe vera*, *Rheum palmatum* (rhubarb), and *Cassia* species.

Table 2: Examples of quinone as antimicrobials

Plant source	Quinone	Active against
Aloe vera	Aloin	*E. coli* and *Salmonella*
Rheum palmatum (rhubarb)	Rhein	*H. pylori*
Lawsonia inermis (henna)	Lawsone	*Aspergillus* and *Candida* species
Juglans regia (walnut)	Juglone	*Pseudomonas aeruginosa*, *Bacillus subtilis*
Plumbago zeylanica	Plumbagin	*Staphylococcus aureus*, *E. coli*, *Candida albicans*

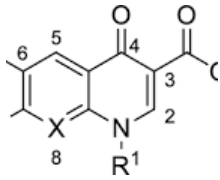


Fig 2: Basic structure of quinones

Flavonoids

Flavones, flavanols and flavonols all are flavonoids. These are polyphenolics that have C_6-C_3- C_6 structure (Fig. 3). These are found in plants and produce numerous pharmacological activities especially antimicrobial activity.

Major classes and their antimicrobial properties

Flavones: Found in parsley, celery, and chamomile, flavones such as apigenin and luteolin exhibit antibacterial properties against *Staphylococcus aureus* and *Escherichia coli*.

Flavanols (Catechins): Present in green tea, cocoa, and grapes, catechins have been shown to inhibit *Helicobacter pylori* and *Candida albicans*.

Flavonols: Found in onions, kale, and berries, flavonols like quercetin and kaempferol act against *Pseudomonas aeruginosa* and *Bacillus subtilis* by disrupting bacterial membranes and inhibiting biofilm formation [8, 9, 10]. Some examples of flavonoids as antimicrobial are listed in table 3.

Table 3: Examples of flavonoids as antimicrobials

Plant source	Flavonoids	Active against
Onions, Kala, Berries	Quercetin	*P. aeruginosa, B. subtilis*
Green tea, cocoa	Catechin	*H. pylori, c. albicans*
Spinach, broccoli	Kaempferol	*E. coli, S. aureus*
Green peppers, Celery	Luteolin	*Salmonella species*
Chamomile	Apigenin	*S. aureus, E. coli*

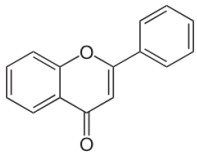


Fig 3: Basic structure of flavonoids

Tannins

Tannins are complex compounds and are founds in many plants. These are derivatives of Gallic acid (Fig. 4). Tannins have various biological activities such as antibacterial, antioxidant, antitumor etc. Some examples of tannins as antimicrobial are listed in table 4.

Table 4: Examples of tannins as antimicrobial

Plant source	Tannins	Active against
Pomegranates, walnuts	Ellagitannins	*E. coli, S. aureus*
Grapes, tea	Condensed Tannins	*Candida albicans, Listeria monocytogenes*
Oak bark, sumac	Gallotannins	*Salmonella species, Pseudomonas aeruginosa*

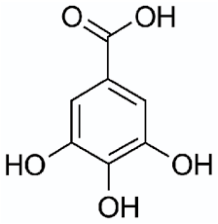


Fig 4: Basic structure of tannins

Coumarins

Chemically, coumarins are aromatic organic compounds that are made of benzene and α-pyrone rings. The chemical formula for coumarin is C9H6O2 (Fig. 5). Coumarins are found in many plants, including tonka beans, strawberries, cinnamon, and lavender oil. They are very useful as antimicrobial [11]. Some examples of coumarins as antimicrobial are listed in table 5. (Borges *et al*., 2013).

Table 5: Examples of coumarin as antimicrobials

Plant source	Coumarin	Active against
Tonka beans	Warfarin	*Pseudomonas aeruginosa*
Clove, Cinnamon	Umbelliferone	*Candida albicans*, *Aspergillus species*
Angelica archangelica	Scopoletin	*E. coli*, *S. aureus*

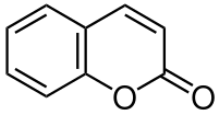


Fig 5: Basic structure of coumarin

Terpenoids and essential oils

Terpenoids and Essential oils are a class of naturally occurring organic compounds. They are known for their strong odors. They are derived from isoprene, a 5-carbon molecule (Fig. 6). They are classified into monoterpenes, sesquiterpenes, diterpenes, triterpenes, and more. They have many biological activities, including anti-inflammatory, antibacterial, and antiviral properties [12, 13]. Some examples of terpenoids and essential oils as antimicrobial are listed in table 6.

Table 6: Examples of terpenoids and essential oils as antimicrobial

Plant source	Phytoconstituents	Active against
Peppermint (*Mentha piperita)*	Menthol	*P aeruginosa, L monocytogenes*
Clove (*Syzygium aromaticum*)	Eugenol	*Aspergillus species*
Oregano (*Origanum vulgare*)	Carvacrol	*Escherichia coli, Salmonella species*
Thyme (*Thymus vulgaris*)	Thymol	*Staphylococcus aureus, Candida albicans*

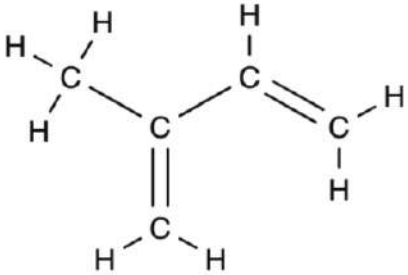


Fig 6: Basic structure of terpenoids

Alkaloids

Alkaloids are a group of naturally occurring organic compounds that contain nitrogen atoms. They are mainly found in plants and are the most biologically active group of compounds in plants [14]. Basic structure of some alkaloidal compounds (Fig. 7). Some examples of alkaloids as antimicrobial are listed in table 7.

Table 7: Examples of alkaloids as antimicrobial

Plant source	Alkaloids	Active against
Hydrastis canadensis	Berberine	*Staphylococcus aureus*, *Escherichia coli*
Sanguinaria canadensis	Solanine	*Streptococcus mutans*, *Candida albicans*
Nightshade	Sanguinarine	Fungus and Bacteria
Cinchona	Quinoline Alkaloids	*Plasmodium species, Mycobacterium tuberculosis*

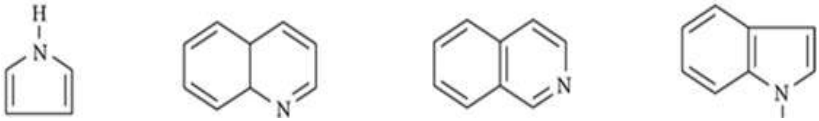


Fig 7: Basic structure of some alkaloidal compounds

Lectins and Polypeptides

Lectins and polypeptides, particularly antimicrobial peptides (AMPs), can both act as antimicrobial agents by binding to specific molecules on the surface of pathogens, disrupting their cell membranes, and ultimately inhibiting their growth; with lectins primarily targeting carbohydrates on microbial surfaces while AMPs interact with the cell membrane through various mechanisms depending on their structure and sequence [15]. Some examples of lectins and polypeptides as antimicrobial are listed in table 8 and list of some well-established plants as antimicrobial is listed in table 9.

Table 8: Examples of Lectins and polypeptides as antimicrobial

Plant source	Lectins and polypeptides	Active against
Rubiaceae family	Cyclotides	*Staphylococcus aureus*
Jack bean	Concanavalin A	*E. coli* and *Candida albicans*
Various plants	Defensins	Bacteria and Fungus

Table 9: List of Some well-established Plants Having Antimicrobial activity

Scientific name	Common name	Class	Compounds	Active against	Reference
Withania somniferum	Ashwagandha	Lactone	Withaferin A	Bacteria, Fungi	[16]
Aegle marmelos	Bael Tree	Terpenoids	Essential oil	Fungi	[17]
Malus sylvestris	Apple	Flavonoids	Phloretin		[16]
Piper nigrum	Black pepper	Alkaloids	Piperine	*Fungi, E. coli, Lacto bacillus*	[18]
Carum carvi	Caraway	Coumarin		Bacteria, Fungi, Viruses	[19]

Anacardium pulsatilla	Cashew	Polyphenol	Salicylic acids	Bacteria, Fungi	[20]
Syzygium aromaticum	Clove	Terpenoids	Eugenol	Genereal	[21]
Anethum graveolens	Dill	Terpenoids	Essential Oil	Bacteria	[21]
Eucalyptus globulus	Eucalyptus	Polyphenolics	Tannins	Bacteria, Virus	[21]
Allium sativa	Garlic	Terpenoids	Allicin	General	[21]
Panax Ginseng	Ginseng	Saponins		*E. coli, Staphylocus*	[21]
Citrus paradisa	Grapefruit peel	Terpenoids		Fungi	[21]
Camellia sinensis	Green Tea	Flavonoids	Catechin	General	[21]
Lawsonia inermis	Henna	Phenolics	Gallic acid	*S. aureus*	[21]
Glycyrrhiza globra	Liquorice	Phenolics	Glabrol	*S. aureus, M. tuberculosis*	[21]
Quercus rubra	Oak	Tannins	Tannins		[21]
Allium cepa	Onion	Sulfoxide	Allicin	Bacteria	[21]
Carica papaya	Papaya	Terpenoids, Alkaloids	Latex	General	[21]
Mentha piperita	Peppermint	Terpenoids	Menthol	General	[21]
Vinca minor	Periwinkle	Alkaloids	Reserpine	General	[21]
Cinchona Sp.	Quinine	Alkaloids	Quinine	Plasmodium	[21]
Cassia augustifolia	Senna	Anthraquinone	Rhein	*S. aureus*	[21]
Hypericum perforatum	St. John's wort	Anthraquinone	Hypericin		[21]
Curcuma longa	Turmeric	Terpenoids	Curcumin	Bacteria, protozoa	[21]
Rosmarinus officinalis	Rosemary	Terpenoids	Essential oil	General	[21]
Rauvolfia serpentina	Rauvolfia	Alkaloids	Reserpine	General	[21]

Conclusion

Plant-derived antimicrobials represent a promising alternative to synthetic antibiotics, particularly in combating antibiotic resistance. Their diverse mechanisms of action and broad-spectrum activity make them valuable for future drug development.

References

1. Borris RP. Natural products research: perspectives from a major pharmaceutical company. J Ethnopharmacol. 1996;51(1-3):29-38.

2. Moerman DE. An analysis of the food plants and drug plants of native North America. J Ethnopharmacol. 1996;52(1):1-22.

3. Lobiuc A, Pavăl NE, Mangalagiu II, Gheorghiță R, Teliban GC, Amăriucăi-Mantu D, *et al*. Future antimicrobials: Natural and functionalized phenolics. Molecules. 2023;28(3):1114.

4. Daglia M. Polyphenols as antimicrobial agents. Curr Opin Biotechnol. 2012;23(2):174-81.

5. Millanao AR, Mora AY, Villagra NA, Bucarey SA, Hidalgo AA. Biological effects of quinolones: A family of broad-spectrum antimicrobial agents. Molecules. 2021;26(23):7153.

6. Haraguchi H. Antioxidative plant quinones and their antimicrobial activity. Phytomedicine. 2001;8(2):121-6.

7. Goel S, Parihar PS, Meshram V. Plant-derived quinones as a source of antibacterial and anticancer agents. In: Singh J, Meshram V, Gupta M, editors. Bioactive natural products in drug discovery. Singapore: Springer; 2020.

8. Cushnie TP, Lamb AJ. Antimicrobial activity of flavonoids. Int. J Antimicrob Agents. 2005;26(5):343-56.

9. Daglia M. Polyphenols as antimicrobial agents. Curr. Opin. Biotechnol. 2012;23(2):174-81.

10. Maddela NR, Garcia GA, Kaur J, editors. Antimicrobials for sustainable food storage. Boca Raton: CRC Press; 2024.

11. Borges A, Abreu AC, Dias C, Saavedra MJ, Borges F, Simões M. New perspectives on the use of coumarins as antimicrobial agents. J Med Chem. 2013;56(23):7466-79.

12. Ali IA, Neelakantan P. Antibiofilm activity of phytochemicals against *Enterococcus faecalis*: A literature review. Phytother Res. 2022;36(7):2824-38.

13. Guimarães AC, Meireles LM, Lemos MF, Guimarães MC, Endringer DC, Fronza M, *et al*. Antibacterial activity of terpenes and terpenoids present in essential oils. Molecules. 2019;24(13):2471.

14. Cushnie TT, Cushnie B, Lamb AJ. Alkaloids: An overview of their antibacterial, antibiotic-enhancing and antivirulence activities. Int. J Antimicrob Agents. 2014;44(5):377-86.

15. Breitenbach Barroso Coelho LC, Marcelino Dos Santos Silva P, Felix de Oliveira W, De Moura MC, Viana Pontual E, Soares Gomes F, *et al*. Lectins as antimicrobial agents. J Appl. Microbiol. 2018;125(5):1238-52.
16. Hunter MD, Hull LA. Variation in concentrations of phloridzin and phloretin in apple foliage. Phytochemistry. 1993;34(5):1251-4.
17. Rana BK, Singh UP, Taneja V. Antifungal activity and kinetics of inhibition by essential oil isolated from leaves of *Aegle marmelos*. J Ethnopharmacol. 1997;57:29-34.
18. Ghoshal S, Krishna Prasad BN, Lakshmi V. Antiamoebic activity of *Piper longum* fruits against *Entamoeba histolytica in vitro* and *in vivo*. J Ethnopharmacol. 1996;50:167-70.
19. Scheel LD. The biological action of the coumarins. Microbiol Toxins. 1972;8:47-66.
20. Himejima M, Kubo I. Antibacterial agents from the cashew *Anacardium occidentale*. J Agric Food Chem. 1991;39:418-21.
21. Cowan MM. Plant products as antimicrobial agents. Clin Microbiol Rev. 1999;12(4):564-82.

Chapter - 7
Introduction, History, Present status of Pharmacognosy, Scope of Pharmacognosy & Agriculture

Authors

Anesh Sagar
Faculty of Pharmacy, IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Navneet Verma
Faculty of Pharmacy, IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Sushil Kumar
Faculty of Pharmacy, IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Dinesh Kumar
Faculty of Pharmacy, IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Raj Kumar Singh Bharti
Faculty of Pharmacy, IFTM University, Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 7

Introduction, History, Present status of Pharmacognosy, Scope of Pharmacognosy & Agriculture

Anesh Sagar, Navneet Verma, Sushil Kumar, Dinesh Kumar and Raj Kumar Singh Bharti

Abstract

Pharmacognosy is the study of natural products from plants, animals, mineral, fungi, and other sources, including their biological, chemical, and physical properties. It plays a role in agriculture by helping to develop quality standards for drugs, identify drugs, and improve the safety and effectiveness of traditional medicines. In recent years, there has been a resurgence of interest in traditional medicinal plants, plant-based systems continue to play an essential role in healthcare, and there are traditionally used for treating several diseases particularly dysmenorrheal, dieresis, paralysis, jaundice, amenorrhea, skin disorders of many varieties, renal stone and blood detoxification, hypertension, neurodegenerative diseases, ulcers, high blood pressure, epilepsy, vomiting, diabetes, bleeding, chronic bronchitis, asthma, constipation, gonorrhea and paralysis. The present status of traditional medicine, phytochemicals and their source of compounds with biological activity, supply and demand in herbal and pharma industries and new cultivation methods for traditional medicinal plants. The recent WHO report, about 80% of the world population is still using natural products for their primary healthcare needs. Pharmacognosy can provide safe & effective drugs in combination with the modern medicine system.

Keywords: Traditional medicinal plants, phytochemistry, cultivation methods, traditional medicine systems, health care, agriculture

1. Introduction

Pharmacognosy is the study of crude drugs derived from natural sources, like plants, animals, minerals, and marines. Seydler, a German scientist, used the phrase in his work "Analecta Pharmacognostica" in 1815. It is also called as study of crude drugs.

Plants, animals, microbes, and minerals have all been used by medical science as possible sources of medications to treat and prevent illnesses in

humans and animals. The ancient usage of natural remedies to treat primary health issues in various parts of the world is supported by a number of historical indications.

The word comes from two Latin words: Gignosco, which means "knowledge," and Pharmakon, which means "drug."

Pharmacognosy is the study of the therapeutic applications of different naturally occurring medications, including their origins, distributions, growing methods, active ingredients, medicinal applications, identification tests, preservation techniques, substitutes, and adulterants.

Pharmacognosy is defined as the "science which has the task to learn everything about drugs originating from plants or animals in all aspects, except the physiological effect". Minerals, marine organisms, bacteria, fungi, and animals are all used as potential sources of medications, both modern and traditional. However, pharmacognostic research has become more engaging and instructive due to the rapid advancement of analytical techniques in pharmacology, phytochemistry, drug discovery, and biotechnology. The old botanical approach to Pharmacognosy has been expanded and suitably adjusted to modern scientific methods in order to meet the demands of the advances in pharmaceutical education and research.

The fields of pharmacology, chemistry, and botanicals are all involved in the study of medications derived from plants. Botany includes the study of plant identification (taxonomy), genetics, and cultivation. Chemical characterization of includes the isolation, identification and analysis of constituents in plant materials.

About 80% of people worldwide still get their primary medical treatment from natural products, according to a recent WHO survey. When used in conjunction with the current medical system, pharmacology can produce safe and efficient medications.

Here are some ways pharmacognosy is used in agriculture

- **Drug standardization:** Pharmacognosy helps develop quality standards for drugs and drug formulations.
- **Drug identification:** Pharmacognosy helps identify drugs and their botanical aspects.
- **Phytochemical isolation and analysis:** Pharmacognosy involves isolating and analyzing phytochemicals.

- **Molecular biological techniques:** Pharmacognosy uses molecular biological techniques like DNA fingerprints to study natural products.
- **Research areas:** Pharmacognosy research areas include phytochemistry, biosynthesis, biotransformation, and chemotaxonomy.
- **Improving quality of traditional medicines:** Pharmacognosy helps improve the quality, safety, and effectiveness of traditional medicines.

The following are some general rules for growing medicinal plants

- **Site selection:** Select a location that is appropriate for the kind of herb you plan to grow, taking drainage, soil composition, and sunlight into account.
- **Soil preparation:** Assess the pH and nutrient levels of the soil and make any necessary amendments.
- **Seed selection:** Make use of premium seeds or plant cuttings from reliable suppliers.
- **Crop rotation:** Rotate your crops to reduce the danger of pests and diseases and to stop soil erosion.
- **Watering:** Depending on the particular herbs' water requirements, give them regular, suitable watering.

In Pharmacognosy a systemic complete study of crude drug is done by following categories

1. Common name
2. Biological source
3. Family
4. Geographical source
5. Cultivation, collection & preparation
6. Morphological characters
7. Microscopic characters
8. Chemical constituents
9. Adulterant
10. Therapeutic efficacy

The following categories comprise the study of modern pharmacognosy

1. **Medical ethnobotany:** This field examines how plants have historically been used medicinally.
2. **Ethno pharmacology:** This field investigates the pharmacological characteristics of conventionally used medications.
3. **Phytotherapy:** This field investigates the therapeutic application of plant extracts.
4. **Phytochemistry:** This field examines compounds derived from plants. The identification of novel medications derived from plants is another aspect of this area.
5. **Zoopharmacognosy:** This field examines how animals use plants, soils, and insects to treat and prevent illnesses as a form of self-medication.
6. **Pharmacognosy biotechnology:** This field uses biotechnology to study the synthesis of naturally occurring bioactive compounds.
7. **Herbal interactions:** This field examines how the body reacts to herbs and other medications.
8. **Marine pharmacognosy:** This field examines compounds derived from marine organisms.

1.2 Regulatory concerns in traditional medicines

Numerous historical indicators have demonstrated that a significant body of traditional medical knowledge has been developed globally as a result of the careful selection and traditional usage of medicinal ingredients. In indigenous medicine systems, traditional remedies are typically combined with witchcraft, mysticism, astrology, and religious beliefs. Strict conventional regulatory standards are also used for the selection and prescription of traditional remedies, which are actually the continuation of successful practices from the past (Dewick, 2002). Many diagnostic techniques to the selection and administration of natural substances to treat certain health disorders have been demonstrated by the long-standing usage of traditional medicines, as documented in the Vedas, Materia Medica, Medical Papyri, and other ancient inscriptions.

Traditional regulatory procedures are still widely used in ethno medical practices to identify a specific remedy, mode of use, doses, timing of administration, toxicity, adverse effects, contraindications, and other issues related to the safety and efficacy of natural medicines. The geography and

ecological conditions of the areas where medicinal plants are grown are also taken into consideration by traditional medical practices to guarantee the quality of the therapies. Numerous traditional methods pertaining to the gathering, processing, storing, mixing, and prescribing of natural remedies have been eloquently depicted in Ayurvedic literatures, such as the Vedas and other literary works (Misra and Rastogi, 2005). To ensure the quality, safety, and effectiveness of traditional treatments and procedures, traditional herbal practitioners undoubtedly carefully created, developed, and upheld regulatory norms (Nissen and Evans, 2012). Therefore, ancient religious texts, writings, incantations, beliefs, customs, and folklore served as the foundation for traditional indigenous medical practices. These practices in turn inspired contemporary pharmaceutical science to ensure the efficacy, safety, and quality of natural remedies.

1.3 History of pharmacognosy

The history of herbal medicines continues since human civilization. Some documents of ancient times showed that in China, India, Egypt, and Greece, plants were used for medicinal purposes a long time before the Christian era began. The contribution of scientist and its old writings is the key part of Pharmacognosy below mentions the different scientist and its contribution.

1) Papyrus EBERS

It is an old document written in 1550 B.C. It is Egyptian medical papyrus of herbal knowledge. It currently kept at library of university of Leipzig in Germany. The scroll contains 700 magical formulas and remedies having Medicinal use of several plant animals and also about human anatomy.

2) Hippocrates (460-360 B.C)

Hippocrates is a Greek Physician. He deals with the anatomy and Physiology of human beings. For his contribution Hippocrates is known as father of medicine. Hippocrates gives the Hippocrates oath for establishing several principles of medical ethics. Hippocrates is a Practional of medicine.

3) Aristotle (384-322)

Aristotle is a Greek Philosopher and scientist. He is well known for his studies on Animal kingdom. He known as father of zoology for his work on animal. He is also known as father of Embryology.

4) Theophrastus (370-287)

Theophrastus is a student of Aristotle known for writing plant kingdom. Theophrastus is Greek native. Theophrastus known for his plant study. The interest of Theophrastus in Botany, Physics, Metaphysics, natural history. For his contribution he known as father of Botany.

5) Diascorides (40-80 A.D.)

De materia media (on medicinal material) is important document written by dioscorides having information about different medicinal plants. De materia media covers about 600 medicinal plant along with some animal and mineral substance and around 1000 medicine from them.

6) Galen (131-200 A.D.)

- Galen describe the various method of preparation containing active constituent of crude drugs and of present branch dealing with the extraction of plant and animal drug is known as galenical pharmacy.
- Galen contributes to the medicine anatomy and surgery etc.
- For his contribution he is known as first pharmacist of world

7) Charak

- Charak has a man Contribution in Ayurveda for collections of different information's of medicinal plant their preparation and uses.
- Charak gathered this information in a book is known as charak samhita.
- Charak divided medicinal plants into 50 groups (10 herbs in each group) for particular illness.
- For his contribution he is known as father of Indian medicine.

8) Sushrutha

- Sushrutha 760 herbs in 7 group based on their common properties.
- Sushrutha contribution in Ayurveda known as Sushrutha samhita.
- Sushrutha is the founder of surgery.
- World first surgeries handle by Sushrutha so is known as father of surgery.

9) Seydler

- The term Pharmacognosy was first used in 1815 by a German scientist named Seydler.

- The work of "C.A. Seydler" in title ANALECTA PHARMACOGNOSTICA which containt the meaning of Pharmacognosy.

10) G. Mendel

- In 1865, G. Mendel reported some significant findings about factory mongrels.
- A significant advance in botanical exploration was the preface of the microscope as a pivotal logical instrument, particularly as a result of the development of styles for cleaning, mounting, and staining the medications.
- Berg released the Anatomical Atlas of Crude medicines in 1865.

11) Other important discoveries during the period were isolation of nicotine from tobacco by scientist Reimann. Isolation of Ergometrine, Reserpine, Quinine and Quinidine, are the significant discoveries of the 20th century. In the 19th century the term Materia Medica was used for the subject who is now known as Pharmacognosy.

1.4 Present status of pharmacognosy

1) The Herbal drug has gained significance in recent times because of their effectuality and cost effectiveness.
2) Pharmacognosy is important for developing natural drugs, which are getting more important in ultramodern drug.
3) At present time, the people have realized that the use of natural being medicines is n't only provident but indeed safer too.
4) Active ingredients from naturally being medicines have lead to rapid-fire developments in Pharmacognosy and Phytochemistry.
5) Pharmacognosy exploration uses a variety of ways, including botanical, natural, molecular, computational, and phytochemical styles.
6) In present script, ultramodern state of art installation like structure determination and pharmacological webbing are available.
7) Rapid developments in the fields of Chemistry Biochemistry and Pharmacology have further supported advancements in Pharmacognosy.
8) The methodical study of Pharmacognosy provides a new space of analysis, starting from work the biologically active principles of

phytomedicine and their mode of action and implicit medicine relations, to internal control and involvement in clinical trials.

9) From the history numerous times colorful new composites are insulated from marine organism that shows effective natural conditioning.
10) Pharmacognosy has led to the discovery of new medicines for a number of conditions, including cancer, HIV/ AIDS, Alzheimer's, malaria and pain.
11) As per AYUSH, some important herbals similar as; Curcuma longa, *Emblica officinalis*, *Terminalia chebula*, *Terminalia billerica*, *Glycyrrhiza glabra*, *Zingiber officinale*, *Coriandrum sativum*, *Withania somnifera*, *Piper longa* etc. Are important for COVID- 19 contagion operation.
12) Not only marine or factory species, indeed microorganisms also play vital part in medicine discovery as antibiotics. Lately, Black fungus infection spreaded in 2021 which is treated with Amphotericin B, was insulated from Streptomyces nodosus.

1.5 Scope of pharmacognosy in agriculture

The use of Natural products for Agricultural purposes is one of the many applications of Pharmacognosy in agriculture:

Plant cultivation

Pharmacognosy involves the cultivation, classification, & identification of medicinal plants. This knowledge can be used to improve the cultivation of medicinal & aromatic plants.

Natural pesticides

Natural materials have the potential to be employed as both insecticides and insect repellents.

Plant breeding

Plant breeding is a component of pharmacology that can enhance agricultural techniques.

Plant genetics

Plant genetics is a branch of pharmacology that can aid in the advancement of farming techniques.

Plant pathology

Plant pathology is a subfield of Pharmacognosy that can enhance cultivation techniques.

The study of natural materials for their therapeutic qualities, especially plants, is known as Pharmacognosy. There are numerous uses for it, such as:

- Drug development and discovery.
- Natural product quality assurance.
- Researching native cultures' customary methods of treatment.
- Being aware of how supplements function.
- Finding and analyzing naturally occurring substances with potential for use in medicine or commerce.
- Examining the functional characteristics and safety of chemicals found in food, consumer goods, and new foods.
- Applying chemicals or natural extracts to cosmetics.
- Modifying and investigating genetic biosynthesis routes to boost production.

1.6 Scope of pharmacognosy

Pharmacognosy is an applied science, which play crucial role in the development of different discipline of science. A pharmacognosist should have sound knowledge of plant taxonomy, plant pathology, plant breeding and plant genetics. This is helpful in the development of cultivation technology for medicinal and aromatic plant. Phytochemistry is concerned with variety of substance, which are synthesized and accumulated by plant and deal with structural elucidation of this substance

Technology, involving extraction, purification and characterization of pharmaceuticals obtained from natural sources, significant contribution to the advancement of natural and physical science.

We can say that Pharmacognosy is an important link between Pharmacology and medicinal chemistry. It is a vital link between Allopathic and Ayurvedic system of medicine.

Scope of pharmacognosy is discussed below

1) Pharmacology is essential to the advancement of several scientific fields. The creation of cultivation techniques for aromatic and

medicinal plants benefits from an understanding of plant taxonomy, plant breeding, plant pathology, and plant genetics.

2) Pharmacognosy is a significant area of pharmacy that uses natural items to play a major role in the development of new drugs.
3) A crucial connection between medicinal chemistry and pharmacology is Pharmacognosy.
4) Natural products can be synthesized, packaged, and administered in dose forms that are acceptable to the current medical system through the use of Pharmacognosy.
5) The oldest pharmacy has thousands of plants that are used to heal illnesses.
6) Over 80% of people on the planet still get their primary medical care from natural products. Pharmacology also contributes to the modern medical system by producing safe and efficient medications.
7) Pharmacognosy increases the efficacy of contemporary medicine by incorporating knowledge about the safe use of herbal medications, including toxicity, side effects, and drug interactions.
8) The foundation for the creation of novel medication is Pharmacognosy.
9) India is the richest source of medicinal plants because they are present in practically every region of the country. Herb collectors and small dealers supply the substances used to make Ayurvedic and Unani remedies.
10) Botany, taxonomy, plant biotechnology, plant genetics, plant pathology, pharmaceutics, pharmacology, phytochemistry, and other scientific fields are all influenced by the advancement of Pharmacognosy.

Lastly, Crude drugs and their byproducts are valuable commodities and lucrative business ventures. These could only be gathered in limited quantities from wild sources, and the price they were sold at was outrageously high. Now, everything is different. Enormous-scale crop production involves the cultivation of numerous industrially significant species that yield equally enormous economic profits.

In the global trade, drug plants, standardized extracts, and the pure, therapeutically active ingredients have grown to be important commodities.

Given these wonderful facts, pharmacology appears to have a wide range of applications in the fields of medical, bulk medications, dietary supplements, pharmaceutical needs, colors, insecticides, tissue culture biotechnology, engineering, etc.

The following are some ways that pharmacognosy's reach will grow in t he coming years:

In government sector: The government sector includes employment in state agencies like forensic laboratories and environmental laboratories, as well as federal agencies like the U.S. Department of Agriculture, the Food and Drug Administration, the Drug Enforcement Agency, and medicinal plant research laboratories.

In academics: Teaching at botanical gardens, museums, colleges, and institutions.

References

1. ASP. About the ASP; 2012 http://www.pharmacognosy.us/what-is-pharmacognosy/ [December 2012].
2. Balunas MJ, Kinghorn AD. Drug discovery from medicinal plants. Life Sciences 2005;78:431-41.
3. Bruhn JG, Bohlin L. Molecular pharmacognosy: an explanatory model. Drug Discovery Today 1997;2:243-6.
4. Chaudhary R, Roy R, Uton M. Traditional medicine in Asia. New Delhi: World Health Organization, Regional office for South-East Asia; 2001.
5. Chin Y-W, Balunas M, Chai H, Kinghorn AD. Drug discovery from natural sources. The AAPS Journal 2006;8:239-53.
6. Dewick PM. Medicinal natural products, a biosyntyhetic approach. UK: John Wiley & Sons, Ltd; 2002.
7. Govt. of India. The ayurvedic pharmacopoeia of India. Government of India, Ministry of Health and Family Welfare, Department of AYUSH; 2001.
8. Gurib-Fakim A. Medicinal plants: traditions of yesterday and drugs of tomorrow. Molecular Aspects of Medicine. 2006;27:1-93.
9. Heinrich M, Barnes J, Gibbons S, Williamson EM. Fundamentals of pharmacognosy and phytotherapy. London: Churchill Livingstone; 2003.
10. World Health Organization; 2003. Kazemi M, Eshraghi A, Yegdaneh A, Ghannadi A. Clinical pharmacognosy-a new interesting era of pharmacy

in the third millennium. DARU Journal of Pharmaceutical Sciences. 2012;20:18.

11. Kinghorn AD. Pharmacognosy in the 21st century. Journal of Pharmacy and Pharmacology. 2001;53:135-48.
12. Kokate CK, Purohit A, Gohkale SB. Pharmacognosy. In: Introduction of Pharmacognosy, 48th Edition, Nirali Prakashan, Pune. 2013;1-1.16.
13. Makino T. Introduction of clinical pharmacognosy: integration between pharmacognosy and clinical pharmacy. Yakugaku Zasshi. 2011;131:375-82.
14. Misra SS, Rastogi A. Classical quality standards for medicinal plants in ayurvedic medical science. In: Thomas Y, Karki M, Gurung K, Parajuli D, editors. Himalayan medicinal and aromatic plants: balancing use and conservation. Ministry of Forest and Soil Conservation, Government of Nepal; 2005. p. 379-88.
15. Nissen N, Evans S. Exploring the practice and use of Western herbal medicine: perspectives from the social science literature. Journal of Herbal Medicine 2012;2:6-15.
16. Patwardhan B, Vaidya ADB, Chorghade M, Joshi SP. Reverse pharmacology and systems approaches for drug discovery and development. Current Bioactive Compounds 2008;4:1-12.
17. Tschirch A. Handbuch der Pharmakognosie. Leipzig: Erste Abteilung; 1909, Verlag von Chr. Herm. Tauchnitz, 3.
18. Tyler VE. Recent history of pharmacognosy. In: Higby GJ, Stroud EC, editors. The inside story of medicines: a symposium. United States: Publication of American Institute of the History of Pharmacy; 1997. p. 161-70.
19. Verpoorte R. Pharmacognosy in the New Millennium: lead finding and biotechnology. Journal of Pharmacy and Pharmacology. 2000;52:253-62.
20. Wallis TE. Text book of pharmacognosy. New Delhi, India: CBS Publishers & Distributors; 1985.
21. WHO. WHO Traditional Medicine strategy 2002-2005. Geneva: World Health Organization; 2002.
22. WHO. WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. Geneva:

Chapter - 8
Traditional uses of Pteridophytes: A Forgotten Treasure in Herbal Medicine

Authors

Harvi Patel
Assistant Professor, Department of Botany, Shrimad Rajchandra Vidyapeeth, Dharampur, Valsad, Gujarat, India

Susmita Sahoo
Assistant Professor, Department of Biological and Environmental Sciences, Natubhai V. Patel College of Pure and Applied Sciences (NVPAS), Vallabh Vidyanagar, Anand, Gujarat, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 8

Traditional uses of Pteridophytes: A Forgotten Treasure in Herbal Medicine

Harvi Patel and Susmita Sahoo

Abstract

Pteridophytes, commonly known as ferns and their allies, constitute one of the oldest groups of vascular plants with a rich ethnobotanical heritage spanning diverse cultures worldwide. Despite their widespread distribution and historical significance in traditional medicine systems, pteridophytes have been largely overshadowed by angiosperms in modern herbal pharmacopeia. This chapter examines the ethnomedicinal applications of pteridophytes across different geographical regions, highlighting their use in treating various ailments including respiratory disorders, dermatological conditions, gastrointestinal issues, and wounds. Phytochemical analyses reveal the presence of bioactive compounds such as flavonoids, terpenoids, phenols, and alkaloids that contribute to their therapeutic properties. Recent pharmacological studies have validated several traditional uses, demonstrating antimicrobial, anti-inflammatory, antioxidant, and anticancer activities. However, concerns regarding sustainable harvesting practices and the conservation status of certain species necessitate careful consideration. This chapter emphasizes the need for comprehensive documentation, scientific validation, and integration of this forgotten treasure into contemporary herbal medicine, potentially offering novel drug leads while preserving traditional knowledge systems.

Keywords: Bioactive compounds, ethnobotany, herbal medicine, phytochemistry, pteridophytes, traditional knowledge

Introduction

Earth hosts an astounding diversity of life, with flora ranging from towering redwoods and lush tropical rainforests to microscopic algae and resilient desert succulents, while fauna encompasses everything from the largest blue whales and African elephants to the smallest insects and

microscopic tardigrades. This incredible biodiversity spans terrestrial biomes including forests, grasslands, deserts, and tundra, as well as aquatic ecosystems from freshwater lakes and rivers to coral reefs and the deep ocean trenches, with each environment harboring specialized species that have evolved unique adaptations to survive in their particular niche [1]. Taxonomically floras are categorized as micro floras and macro floras, where the micro floras are crucial for soil enrichment, and macro floras (bryophytes, Pteridophytes, Gymnosperm, and Angiosperm) provide mechanical support to the ground. Of the many categories of the floras, the ferns differ from the other floras in several significant ways that reflect their 360 million years, of ancient evolutionary history. As one of the oldest lineages of vascular plants on earth, and millions of years of development, ferns still have their haploid gametophyte generation, which was developed by their unique ancestors, and so they are evolutionarily different from both their more primitive relatives, mosses and more advanced plants, flowering plants [2]. There are over 12,000 pteridophyte species spread across various ecological niches worldwide and are taxonomically divided into several major groups [3-5].

1) **True ferns (Class-Polypodiopsida):** The largest and most diverse group with approximately 10,560 species in 48 families.
2) **Horsetails (Class-Equisetopsida):** Characterized by jointed stems and whorled branches, with 15 extant species.
3) **Clubmosses (Class-Lycopodiopsida):** Small plants with scale-like leaves arranged spirally, comprising about 1,290 species.
4) **Whisk ferns (Class-Psilotopsida):** Primitive vascular plants lacking true roots and leaves, with only 12 known species.

Certain ferns can adapt to survive and grow in disturbed or arid soil with a moderate capability for hydration and drainage because they are too resilient. Ferns adapt to xeric conditions. Ferns may be found in five primary environments: temperate, tropical alpine, tropical mesic, tropical xeric terrestrial, and tropical xeric epiphytic. Ferns could be frequent survivors again the natural disasters like hurricanes, landslides, fires, floods, and even volcanoes, *Pteris vittata* is frequently seen growing on the ground next to water drainage pipes, on buildings, and even on cement-calcareous waste. *Acrosticium aureum* grows in brackish water [6]. According to the majority of ecologists, they are suitable enough to be dispersed over arid areas. An open area can be used more successfully for fern habitation before undesirable invasive plants take over the ground since ferns also spread aggressively

vegetatively. Tree ferns can also become invasive. Although these genera can differ from the original populations, ferns can withstand drought and can even be grown in man-made destruction caused by large contemporary buildings and cement concrete wasteland masses.

This chapter aims to synthesize current knowledge on pteridophyte ethnobotany, drawing from traditional ecological knowledge, phytochemical profiles, and recent scientific research evidence supporting their medicinal properties. By examining the intersection of traditional uses, and therapeutic modern applications, we can better understand the potential of these ancient plants in addressing contemporary challenges in healthcare, nutrition, and sustainable resource management.

Historical context

Pteridophytes, the second biggest category of vascular plants, account for just 5-7% of all vascular plants, occur globally and their highest diversity is found in tropical and subtropical regions, particularly in humid montane forests [7]. This broad distribution has facilitated their incorporation into various traditional medicinal systems especially in Ayurveda. Despite their ancient origins and widespread distribution across nearly every terrestrial ecosystem, pteridophytes have often been overshadowed in ethnobotanical studies by flowering plants [8, 9]. However, these remarkable plants have played significant roles in traditional medicinal systems worldwide, offering unique bioactive compounds with therapeutic potential that continue to interest modern pharmacological researchers. In the Indian subcontinent, Ayurvedic medicine has incorporated various pteridophytes for thousands of years [10]. Likewise, Theophrastus (ca. 372-287 BC), Charak (ca. 100 AD), and Shushruta (ca. 100 AD). Also, the ferns were recorded by Discorides (ca. 50 AD) in his ‘de Materia Medica’ with their medicinal values [11]. Charak and Sushruta are the largest ancient Ayurvedic medicinal ‘Samhitas’, which recommended the value of most of the Indian medicinal plants, as well as the most Indian ferns are also recorded in these Samhitas [12, 13] some examples:

- ***Adiantum capillus-veneris* (Hansraj):** Prescribed for respiratory conditions, menstrual disorders, and as a hair tonic. The name "Hansraj" (swan king) refers to its ability to float on water without getting wet, analogous to its purported ability to clear fluid from the lungs [14, 15].
- ***Actiniopteris radiata* (Mayursikha):** Used for diarrhea, dysentery, and tuberculosis. Its fan-shaped fronds, resembling a peacock's tail

(Mayur = peacock), were believed to convey strength to patients [16, 17].

- ***Nephrolepis cordifolia* (Jata-Shankar):** Applied for skin diseases and as a cooling agent. The tuberous structures on its roots were particularly valued for treating urinary tract inflammations [18, 19].
- ***Ophioglossum reticulatum* (Sarpajihva):** Employed as a vulnerary for wounds and snake bites. Its name derives from its serpent-tongue appearance, following the Ayurvedic doctrine of signatures that suggested its use against snake venom [20, 21].
- ***Selaginella bryopteris* (Sanjeevani):** The traditional Indian medication known as "Sanjeevani," is a life-saving plant. According to scientific research, it is a great therapeutic herb [22]. Extracts from *S. bryopteris* are proven to be significantly more effective in healing wounds than other species of *Selaginella*, which were originally believed to be found only in the Himalayas [23].

Ethnobotanical significance

Traditional medicine is used to treat a wide range of diseases in both urban and rural regions, as well as in places with a high concentration of Aboriginal people. Caius was the first to investigate the therapeutic qualities of pteridophytes in India [24]. Early literature has long documented the use of several fern species by tribal people to treat a variety of diseases, including asthma, bronchitis, dyspepsia, and phthisis [25, 26]. One of the most primitive communities in India is the aborigines, or tribal people, who live in the Andaman and Nicobar Islands. They are said to have arrived between 35 and 60,000 years ago. The ethnomedical data collected from these individuals has sparked intense interest in starting a scientific investigation into the application of ferns [27, 28]. The spores and rhizomes of sporophytes as well as the whole fronds and the gametophytes have been proven to have therapeutic effects. Many diseases can be recovered by using the fern extract. In the works they composed from 327 to 287 BC, Theophrastus and Dioscorides claimed that several pteridophytes could treat human ailments [29]. Ethnomedicinal knowledge gathered from these individuals has sparked great interest in starting scientific research on pteridophyte usage. The following are some noteworthy pteridophytes with ethical relevance in ethnobotany **(Table No: 1).**

Medicinal properties of Pteridophytes

Ferns possess medicinal properties primarily due to their rich array of bioactive compounds developed over millions of years of evolution. These ancient plants have synthesized diverse secondary metabolites-including, alkaloids, flavonoids, glycosides, phenolics, terpenoids and-largely as chemical defense mechanisms against herbivores, pathogens and environmental stressors. Their adaptation to challenging habitats like forest understories, wetlands, and rocky outcrops has further enhanced their biochemical diversity, while their prolonged evolutionary history has afforded ample time for the refinement of these compounds. These bioactive constituents exhibit various pharmacological activities including anti-bacterial, anticancer, antimicrobial, antioxidant and neuroprotective properties, making ferns valuable resources in traditional medicine systems worldwide and promising candidates for modern drug discovery efforts.

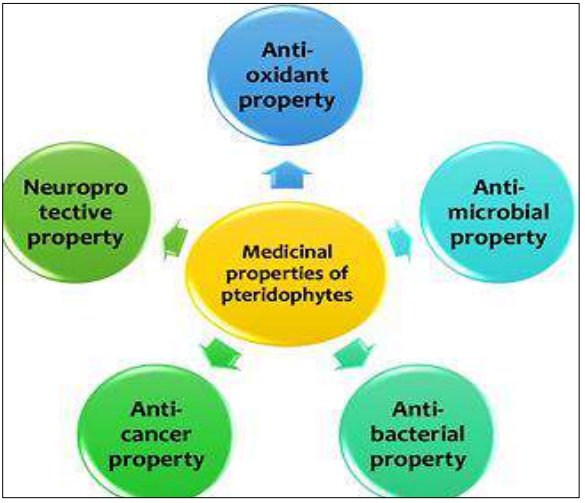


Fig 1: Medicinal properties of pteridophytes

Antioxidant

Ferns have developed robust antioxidant properties as a sophisticated evolutionary survival mechanism to protect themselves from environmental challenges. The antioxidant systems in ferns represent a complex adaptation developed over millions of years, serving as a key mechanism for metabolic stress management and environmental resilience, reflecting their ancient evolutionary strategy of cellular protection and survival [30-41]. These antioxidants, including polyphenols, flavonoids, and phenolic compounds,

neutralize reactive oxygen species (ROS) and provide critical cellular defense against UV radiation, temperature fluctuations, and oxidative stress. By producing these protective biochemical compounds, ferns can maintain cellular integrity, support photosynthetic processes, and survive in diverse and often harsh environments ranging from tropical rainforests to high-altitude regions [42].

Antimicrobial

The antimicrobial properties in ferns originated as a critical evolutionary survival mechanism developed over millions of years of adaptation to diverse and challenging environments. As ancient plants ferns evolved complex biochemical defense systems to protect themselves against pathogenic microorganisms in humid, nutrient-rich habitats [43]. These properties emerged as a response to constant microbial threats, with ferns developing specialized secondary metabolites like phenolics, terpenoids, and alkaloids that could inhibit bacterial and fungal growth. The harsh environmental conditions, including high moisture levels and dense vegetation where microorganisms proliferate, drove the natural selection of plants with stronger chemical defense mechanisms [42]. These antimicrobial compounds serve multiple survival functions, including protecting vulnerable plant tissues, preserving reproductive structures like spores, and preventing microbial colonization. Through generations of evolutionary adaptation, ferns refined these chemical arsenals, creating a sophisticated defense system that not only protects the plant but also represents a remarkable example of biological-chemical warfare at the microscopic level.

Anti-bacterial

The development of antibacterial properties in ferns is a complex process rooted in their evolutionary adaptation to challenging environmental conditions. These properties emerge through a sophisticated biochemical response mechanism where ferns synthesize secondary metabolites as a defense strategy against bacterial threats. As plants are exposed to diverse and often microbe-rich habitats, ferns develop the ability to produce specialized compounds like phenolics, flavonoids, terpenoids, and alkaloids that actively inhibit bacterial growth and colonization [44]. The synthesis of these compounds is triggered by various environmental stressors, including humidity, temperature variations, and potential microbial invasion, which stimulate specific genetic pathways responsible for producing protective chemicals. These metabolites work through multiple mechanisms, such as

disrupting bacterial cell membranes, interfering with bacterial enzymatic processes, and preventing bacterial adhesion to plant tissues. The genetic regulation of these properties is controlled by complex gene expression systems that can be activated in response to specific environmental challenges, allowing ferns to dynamically adjust their chemical defense mechanisms. Over millions of years of evolution, this adaptive response has become increasingly refined, enabling ferns to develop a robust and flexible antibacterial defense system that enhances their survival in diverse and potentially hostile ecological niches.

Anti-carcinogenic

Ferns have developed anticarcinogenic properties as a remarkable evolutionary adaptation driven by complex biochemical mechanisms to protect themselves from cellular damage and environmental stressors. These properties emerge from the synthesis of specialized secondary metabolites that possess potent bioactive compounds capable of inhibiting cellular transformation and preventing abnormal cell growth [45]. The evolutionary development of anticarcinogenic properties in ferns is rooted in their ability to produce diverse phytochemicals like polyphenols, flavonoids, terpenoids, and phenolic compounds that demonstrate significant antioxidant and anti-inflammatory capabilities. These biochemical defense mechanisms have been shaped by millions of years of environmental challenges, including exposure to UV radiation, oxidative stress, and potential mutagenic agents, which have driven the selection of plants with robust cellular protection strategies. The anticarcinogenic compounds in ferns work through multiple mechanisms, including neutralizing free radicals, modulating cellular signaling pathways, inducing apoptosis in potentially damaged cells, and preventing DNA damage [46]. The genetic complexity of ferns allows them to develop these sophisticated chemical defense systems that not only protect the plant itself but also represent a potential source of novel compounds with significant medical research implications. This intricate biochemical adaptation reflects the remarkable capacity of ferns to develop molecular strategies that enhance cellular resilience and potentially offer protective mechanisms against carcinogenic processes.

Neuroprotective

Ferns have developed neuroprotective properties as a remarkable result of their complex biochemical evolution and survival mechanisms, driven by the need to protect their cellular structures from oxidative stress and

environmental challenges. These neuroprotective compounds emerged through millions of years of adaptation, creating sophisticated secondary metabolites that not only defend the plant against external threats but also demonstrate potential neurological protective capabilities [47]. The rich phytochemical composition of ferns, including phenolic compounds, flavonoids, and terpenoids, contributes to their ability to mitigate oxidative damage, reduce neuroinflammation, and support cellular health. Evolutionary pressures in diverse and often stressful environments led ferns to develop these bioactive compounds as a survival strategy, which inadvertently created molecules with the potential to protect neural tissues from damage. The unique molecular structures found in ferns can interact with neural pathways, potentially inhibiting neurodegeneration, reducing oxidative stress, and supporting cellular repair mechanisms. These neuroprotective properties are a testament to the complex biochemical defense systems that ferns have developed over time, representing an intricate intersection of plant survival strategies and potential therapeutic applications for neurological health [48]. The ability to generate these protective compounds reflects the remarkable adaptive capabilities of ferns, transforming their survival mechanisms into potential sources of scientific and medical interest.

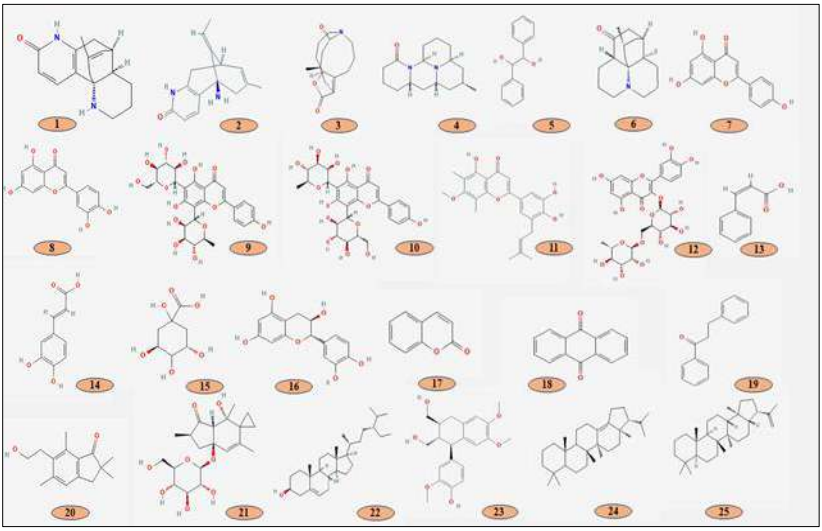


Fig 2: Some phytochemicals of pteridophytes (from ChemDraw). 1. Huperzine B, 2. Huperzine A, 3. Huperzine R, 4. Cernuine, 5. Lycocernuine, 6. Lycopodine, 7. Apigenin, 8. Luteolin, 9. Violanthin, 10. Isoviolanthin, 11. Muxiangrine III, 12. Rutin, 13. Cinnamic acid, 14. Caffeic acid, 15. Quinic acid, 16. Catechin, 17. Coumarin, 18. Anthraquinone, 19. Dihydrochalcone, 20. Pterosin Z, 21. Ptaquiloside, 22. β-sitosterol, 23. Scaphopetalone, 24. Neohop-13(18)-ene, 25.Diploptene

Future perspectives

The intersection of traditional knowledge and modern scientific investigation of ferns presents several promising directions. In terms of drug discovery potential, ferns offer unique secondary metabolites that provide promising scaffolds for drug development, with particularly promising applications for neurological disorders, antimicrobial resistance, and metabolic diseases, while ethnobotanically guided screening continues to yield promising candidates. However, significant challenges in research and development remain, including taxonomic complexities that make accurate identification of pteridophytes challenging, standardization issues in developing quality control parameters for fern-derived products, and sustainable supply concerns about ensuring adequate biomass without threatening wild populations. Moving forward, integrative approaches will be essential, focusing on traditional knowledge documentation to record indigenous knowledge before it is lost, benefit-sharing to ensure equitable distribution of benefits from pteridophyte-derived products, and evidence-based integration to incorporate validated fern preparations into integrative healthcare systems.

Conclusion

Pteridophytes represent an important but often overlooked reservoir of medicinal plants with diverse therapeutic applications across numerous traditional medicine systems. The ethnomedicinal knowledge surrounding these ancient plants has accumulated through centuries of empirical observation and practical application. Modern scientific investigation has begun to validate many traditional claims and elucidate the phytochemical basis for their therapeutic effects. Future research directions should prioritize comprehensive documentation of traditional knowledge, rigorous pharmacological investigation, toxicological assessment and sustainable utilization practices. The unique evolutionary history of pteridophytes has endowed them with distinctive chemical defenses and metabolic pathways that may yield novel bioactive compounds with significant therapeutic potential. By bridging traditional wisdom with modern scientific methods, pteridophytes may contribute valuable additions to modern pharmacopeia while honoring the indigenous knowledge systems that first recognized their healing properties.

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Table 1: Pteridophytes with ethical relevance in ethnobotany

Family	Name of the Pteridophytes	Medicinal Uses	Source of references
Actinopteridaceae	*Actinopteris dichotoma*	Rhizome styptic anthelmintic, fronds chewed for sore throat, rhizome decoction anti-dandruff	[49, 50]
Aspleniaceae	*Asplenium nidus*	Treatment of halitosis, asthma, and sores; has antioxidant properties.	[51]
	Asplenium adiantum-nigrum	Used for treating kidney and spleen disorders; has antiviral properties	[52, 53]
	Asplenium normale	Treatment of jaundice, fever, and as a blood purifier	[54, 55]
Athyriaceae	*Diplazium esculentum*	Treatment of diarrhea, dysentery, and as an anthelmintic agent	[56-58]
	Athyrium filix-femina	Anthelmintic, used for treating intestinal worms and as an astringent	[59, 60]
	Deparia petersenii	Used for fever, dysentery, and as an antibacterial agent	[61]
	Diplazium dilatatum	Used as a vegetable, treatment of dysentery, and intestinal worms	[62, 63]
	Diplazium polypodioides	Treatment of dysentery, diarrhea, and as an antioxidant	[61]
Blechnaceae	*Blechnum orientale*	Anti-inflammatory, antioxidant; used for urinary tract infections	[31, 32, 64]
	Stenochlaena palustris	Treatment of fever, skin diseases, and as an antibacterial agent	[65]
	Blechnum occidentale	Treatment of urinary tract infections, kidney stones, and as a diuretic	[66]
	Doodia media	Treatment of wounds, burns, and as an antimicrobial agent	[67]
	Lomaria spicant	Used for urinary disorders, kidney stones, and as a diuretic	[49]
Cibotiaceae	*Cibotium barometz*	Treatment of rheumatism, lower back pain, and as a kidney tonic	[68, 69]
Cyatheaceae	*Cyathea gigantea*	Treatment of wounds, gastric ulcers, and as an astringent	[70, 71]
	Cyathea brunoniana	Treatment of wounds, ulcers, and as an antimicrobial agent	[72, 73]

	Cyathea spinulosa	Used for gastric ulcers, wounds, and as an astringent	[71]
Davalliaceae	*Davallia trichomanoides*	Treatment of cough, respiratory disorders, and as an expectorant	[74, 75]
	Leucostegia immersa	Treatment of skin diseases, rheumatism, and as an anti-inflammatory	[76]
Dennstaedtiaceae	*Pteridium aquilinum*	Treatment of stomach disorders and diarrhea (note: contains carcinogenic compounds)	[44, 77]
	Microlepia speluncae	Used for dysentery, skin diseases, and as an anti-inflammatory	[78, 79]
	Hypolepis punctata	Treatment of respiratory disorders, cough, and as an expectorant	[79, 80]
Dipteridaceae	*Dipteris wallichii*	Treatment of skin diseases, burns, and as an anti-inflammatory	[70]
	Dipteris chinensis	Treatment of skin diseases, infections, and as an anti-inflammatory	[67, 81]
Dryopteridaceae	*Bolbitis appendiculata*	Anti-inflammatory, used for wounds and skin infections	[82, 83]
	Didymochlaena truncatula	Treatment of stomach disorders, diarrhea, and as an antimicrobial	[84, 85]
	Dryopteris cochleata	Anthelmintic, used for intestinal worms and as an antimicrobial	[86]
	Dryopteris filix-mas	Anthelmintic, used for tapeworms and other intestinal parasites	[87]
	Elaphoglossum conforme	Treatment of wounds, skin infections, and as an anti-inflammatory	[88]
	Polystichum aculeatum	Treatment of respiratory disorders, cough, and as an expectorant	[52, 89]
	Polystichum squarrosum	Treatment of wounds, burns, and as an anti-inflammatory	[44, 90]
Equisetaceae	*Equisetum arvense*	Diuretic, anti-inflammatory; used for urinary tract infections and kidney disorders	[91, 92]
	Equisetum ramosissimum	Treatment of kidney stones, urinary tract infections, and as a hemostatic	[30, 39]
Gleicheniaceae	*Dicranopteris linearis*	Wound healing, treatment of fever, asthma, and rheumatism	[93-95]
	Dicranopteris linearis var. montana	Treatment of wounds, burns, and as an anti-inflammatory	[96]

	Gleichenia dicarpa	Treatment of fever, pain, and as an anti-inflammatory	[63]
Hymenophyllaceae	*Hymenophyllum javanicum*	Used for urinary disorders and as a diuretic agent.	[97, 98]
	Hymenophyllum exsertum	Used for urinary disorders, kidney stones, and as a diuretic	[99]
Isoetaceae	*Isoetes coromandelina*	Treatment of bone fractures, joint pain, and as an antipyretic	[100, 101]
Lindsaeaceae	*Lindsaea ensifolia*	Treatment of skin diseases, wounds, and as an antimicrobial agent	[102]
Lycopodiaceae	*Lycopodium clavatum*	Treatment of kidney disorders, rheumatism, and as a diuretic	[34, 103]
	Huperzia serrata	Treatment of contusions, strains, and as a memory enhancer	[104]
	Lygodium flexuosum	Treatment of jaundice, skin diseases, rheumatism, and sprains	[41, 105]
	Lygodium japonicum	Used for burns, boils, and as an antidote for snake bites	[106, 107]
Lygodiaceae	*Lygodium venustum*	Treatment of rheumatism, arthritis, and as an anti-inflammatory	[107]
Marattiaceae	*Angiopteris evecta*	Treatment of scabies, abscesses, and as an antibacterial agent	[89, 108]
Marsileaceae	*Marsilea minuta*	Treatment of insomnia, cough, bronchitis, and diabetes	[37, 109]
	Marsilea quadrifolia	Antidiabetic, anti-inflammatory; used for eye disorders and snake bites	[109, 110]
	Marsilea strigosa	Treatment of diabetes, inflammation, and as an antioxidant	[111]
Nephrolepidaceae	*Nephrolepis cordifolia*	Treatment of cough, skin diseases, and as an anthelmintic	[112-114]
	Nephrolepis exaltata	Used for respiratory disorders, skin infections, and as an anti-inflammatory	[114]
Oleandraceae	*Oleandra pistillaris*	Treatment of snake bites, wounds, and as an anti-inflammatory	[35, 36]
Ophioglossaceae	*Helminthostachys zeylanica*	Treatment of impotence, liver disorders, and as an aphrodisiac	[115, 116]
	Ophioglossum reticulatum	Treatment of inflammations, boils, and as an antiseptic	[117-119]
	Botrychium lanuginosum	Treatment of cuts, wounds, and as an antiseptic	[90, 120]

	Ophioglossum pendulum	Treatment of snake bites, wounds, and as an antimicrobial agent	[118]
Osmundaceae	*Osmunda regalis*	Treatment of rickets, rheumatism, and intestinal worms	[77, 111]
Polypodiaceae	*Drynaria quercifolia*	Treatment of tuberculosis, typhoid, chronic jaundice, and fever	[40, 121]
	Microsorum punctatum	Treatment of skin diseases, rheumatism, and as an antipyretic	[122, 123]
	Platycerium coronarium	Treatment of fever, cough, and as an anthelmintic	[124, 125]
	Pyrrosia lanceolata	Treatment of cough, bronchitis, wounds, and cuts	[120, 126]
	Pseudodrynaria coronans	Treatment of rheumatism, bone fractures, and as an analgesic	[127]
	Drynaria propinqua	Treatment of bone fractures, joint pain, and as an anti-inflammatory	[104, 128]
	Lepisorus excavatus	Treatment of cough, asthma, and respiratory disorders	[46]
	Loxogramme involuta	Treatment of wounds, cuts, and as an antimicrobial agent	[122]
	Microsorum membranaceum	Treatment of fever, inflammation, and as an antipyretic	[122, 129]
	Microsorum scolopendria	Treatment of wounds, skin infections, and as an antimicrobial	[130]
	Microsorium punctatum	Treatment of respiratory disorders, cough, and as an expectorantv	[100]
	Phymatosorus scolopendria	Treatment of fever, inflammation, and as an analgesic	[85]
	Pyrrosia adnascens	Treatment of cough, bronchitis, and as an expectorant	[35, 94]
Pteridaceae	*Adiantum capillus-veneris*	Treatment of respiratory disorders, demulcent, diuretic, kidney stones, skin diseases, wound healing, antidiabetic, hair care, menstrual disorders	[26, 38, 131, 132]
	Adiantum lunulatum	Treatment of Fever, cough, diabetes, asthma, bronchitis, antifungal, skin diseases, bronchitis, and as a hemostatic agent.	[133, 134]
	Ceratopteris thalictroides	Treatment of skin infections, burns, and as a wound healing agent	[42, 135]
	Cheilanthes albomarginata	Treatment of diabetes, kidney stones, and as an antipyretic	[136, 137]

	Pityrogramma calomelanos	Treatment of asthma, cough, and as an antiseptic for wounds	[119]
	Pteris biaurita	Treatment of dysentery, wounds, and as an antibacterial agent	[138]
	Pteris vittata	Used for skin diseases, dysentery, and gastric disorders	[139]
	Actiniopteris radiata	Treatment of tuberculosis, asthma, dysentery, and as a styptic	[89, 120]
	Cheilanthes farinosa	Used for diabetes, epilepsy, and as an antipyretic	[140]
	Ceratopteris pteridoides	Treatment of burns, skin disorders and as an anti-inflammatory	[65, 140]
	Cheilanthes tenuifolia	Treatment of diabetes, urinary disorders, and as an antipyretic	[108]
	Coniogramme fraxinea	Treatment of dysentery, diarrhea, and as an anthelmintic	[89, 108]
	Onychium siliculosum	Treatment of respiratory disorders, cough, and as an antimicrobial	[90]
	Pellaea falcata	Treatment of respiratory disorders, cough, and as an expectorant	[126]
	Pityrogramma chrysophylla	Treatment of respiratory disorders, asthma, and as an expectorant	[120]
	Pteris cretica	Treatment of dysentery, diarrhea, and as an antimicrobial agent	[139]
	Hemionitis arifolia	Treatment of infertility, menstrual disorders, and as a diuretic	[141]
Salviniaceae	*Azolla pinnata*	Wound healing, treatment of anemia, and skin infections	[45, 142]
	Salvinia molesta	Treatment of skin diseases, burns, and as an antibacterial agent	[90]
Selaginellaceae	*Selaginella involvens*	Used for amenorrhea, postpartum recovery, and as a general tonic	[89, 108]
	Selaginella repanda	Treatment of urinary tract infections and as a diuretic	[142]
	Selaginella bryopteris	Treatment of gonorrhea, menstrual irregularities, and uterine disorders	[23]
Tectariaceae	*Tectaria coadunata*	Treatment of stomach pain, dysentery, and as an anthelmintic	[140, 141]
	Tectaria polymorpha	Treatment of stomach disorders, diarrhea, and as an antimicrobial	[52, 89]
Thelypteridaceae	*Christella dentata*	Used for skin diseases, digestive disorders, and as an astringent	[96]

	Cyclosorus parasiticus	Treatment of fever, skin infections, and as an anthelmintic	[140, 141]
	Thelypteris interrupta	Used for skin diseases, wounds, and as an astringent	[139, 124]
	Cyclosorus interruptus	Treatment of skin diseases, wounds, and as an anti-inflammatory	[127]

Table 2: Pharmacologically significant pteridophyte species and their few representative bioactive chemical compounds

Class	Bioactive compounds	IUPAC name	Family
Alkaloids	Huperzine A ($C_{15}H_{18}N_2O$)	(1R,9S,13E)- 1-Amino-13-ethylidene- 11-methyl-6-azatricyclo [7.3.1.02,7] trideca- 2(7),3,10- trien- 5-one	Lycopodiaceae
	Huperzine B ($C_{16}H_{20}N_2O$)	(1R,10R)-16-methyl-6,14-diazatetracyclo[7.5.3.01,10.02,7]heptadeca-2(7), 3,16-trien-5-one	
	Huperzine R ($C_{15}H_{21}NO_3$)	(1S,6R)-6-methyl-2-oxa-9-azatricyclo[7.4.3.04,13]hexadec-4(13)-ene-3,8-dione	
	Cernuine ($C_{16}H_{26}N_2O$)	(1S,7S,9R,11S,13S)-11-methyl-2,17-diazatetracyclo[7.7.1.02,7.013,17] heptadecan-3-one	
	Lycocernuine ($C_{14}H_{14}O_2$)	1,2-diphenylethane-1,2-diol	
	Lycopodine ($C_{16}H_{25}NO$)	(1R,2R,10S,13S,15R)-15-methyl-6-azatetracyclo[8.6.0.01,6.02,13] hexadecan-11-one	
Flavonoids	Apigenin ($C_{15}H_{10}O_5$)	5,7-dihydroxy-2-(4-hydroxyphenyl)chromen-4-one	Marattiaceae
	Luteolin ($C_{15}H_{10}O_6$)	2-(3,4-dihydroxyphenyl)-5,7-dihydroxychromen-4-one	
	Violanthin ($C_{27}H_{30}O_{14}$)	5,7-dihydroxy-2-(4-hydroxyphenyl)-6-[(2S,3R,4R,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]-8-[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]chromen-4-one	
	Isoviolanthin ($C_{27}H_{30}O_{14}$)	5,7-dihydroxy-2-(4-hydroxyphenyl)-8-[(2S,3R,4R,5S,6R)-3,4,5-trihydroxy-6-	

		(hydroxymethyl)oxan-2-yl]-6-[(2S,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]chromen-4-one	
	Muxiangrine-III ($C_{23}H_{24}O_6$)	2-[3,4-dihydroxy-5-(3-methylbut-2-enyl)phenyl]-5-hydroxy-7-methoxy-6,8-dimethylchromen-4-one	
Phenolics	Rutin ($C_{27}H_{30}O_{16}$)	2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R,4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl] oxymethyl]oxan-2-yl]oxychromen-4-one	Pteridaceae, Adiantaceae, Aspleniaceae
	Cinnamic acids ($C_9H_8O_2$)	(Z)-3-phenylprop-2-enoic acid	
	Caffeic acid ($C_9H_8O_4$)	(E)-3-(3,4-dihydroxyphenyl)prop-2-enoic acid	
	Quinic acid ($C_7H_{12}O_6$)	(3S,5S)-1,3,4,5-tetrahydroxycyclohexane-1-carboxylic acid	
	Catechin ($C_{15}H_{14}O_6$)	(2R,3S)-2-(3,4-dihydroxyphenyl)-3,4-dihydro-2H-chromene-3,5,7-triol	
	Coumarin ($C_9H_6O_2$)	chromen-2-one	
	Anthraquinone ($C_{14}H_8O_2$)	anthracene-9,10-dione	
	Dihydrochalcone ($C_{15}H_{14}O$)	1,3-diphenylpropan-1-one	
Sesquiterpenoids	Pterosin Z ($C_{15}H_{20}O_2$)	6-(2-hydroxyethyl)-2,2,5,7-tetramethyl-3H-inden-1-one	Pteridaceae
	Ptaquiloside ($C_{20}H_{30}O_8$)	(2R,3aR,7S,7aR)-7-hydroxy-2,5,7-trimethyl-3a-[(2S,3R,4S,5S,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2-yl]oxyspiro[3,7a-dihydro-2H-indene-6,1'-cyclopropane]-1-one	
Triterpenoids	β-sitosterol ($C_{29}H_{50}O$)	(3S,8S,9S,10R,13R,14S,17R)-17-[(2R,5R)-5-ethyl-6-methylheptan-2-yl]-10,13-dimethyl-2,3,4,7,8,9,11,12,14,15,16,17-dodecahydro-1H-cyclopenta[a]phenanthren-3-ol	Polypodiaceae
	Scaphopetalone ($C_{21}H_{26}O_6$)	4-[(1R,2S,3S)-2,3-bis(hydroxymethyl)-6,7-dimethoxy-1,2,3,4-tetrahydronaphthalen-1-yl]-2-methoxyphenol	

	Neohop-13(18)-ene ($C_{30}H_{50}$)	(3R,3aR,5aS,5bR,11aS)-3a,5a,5b,8,8,11a-hexamethyl-3-propan-2-yl-1,2,3,4,5,6,7,7a,9,10,11,11b,12,13-tetradecahydrocyclopenta[a]chrysene	
	Diploptene ($C_{30}H_{50}$)	3S,3aS,5aR,5bR,7aS,11aS,11bR,13aR,13bS)-5a,5b,8,8,11a,13b-hexamethyl-3-prop-1-en-2-yl-1,2,3,3a,4,5,6,7,7a,9,10,11,11b,12,13,13a-hexadecahydrocyclopenta[a]chrysene	

References

1. Miller WB. Bioverse How the Cellular World Contains the Secrets to Life's Biggest Questions, Globe Pequot, United States, 2022, vol. 324.
2. Gar W. Fossils and ferns in the resolution of land plant phylogeny, A botanical Review. 1999;65(2):188-218.
3. Ozturk M, Altay V, Latıff A, Salman T, Choudhry I. A comparative analysis of the medicinal pteridophytes in Turkey, Pakistan, and Malaysia. Plant and Human Health, Ethnobotany and Physiology. 2018;1:349-390.
4. Ebihara A, Dubuisson JY, Iwatsuki K, Hennequin S, Ito M. A taxonomic revision of Hymenophyllaceae. Blumea, Journal of Plant Taxonomy and Plant Geography. 2006;51(2):221-280.
5. Brownsey PJ, Perrie LR. Flora of New Zealand-Ferns and Lycophytes. 2017;2:1-58.
6. Sato T, Itoh H, Kudo G, Kheong YS, Furukawa A. Species Composition and Structure of Epiphytic Fern Community on Oil Palm Trunks in Malay Archipelago, Tropics. 1996;6(1/2):139-148.
7. Kachhiyapatel RN. Systematics and Molecular Studies on Diversity of Pteridophyte and Gymnosperm of Gujarat, Maharaja Sayajirao University of Baroda; 2021.
8. Stuessy T, Bayer R. Systematics, evolution, and biogeography of Compositae; 2009.
9. Snyder A. Greening Urban Spaces: Harnessing Houseplants to Reclaim Ecosystem Services; 2024.
10. Reinaldo RCPDS, Santiago ACP, Medeiros PM, Albuquerque UP. Do ferns and lycophytes function as medicinal plants? A study of their low representation in traditional pharmacopoeias. J Ethnopharmacol. 2015;175:39-47.
11. Adaíses Simone Maciel-Silva LVL. Brazilian Bryophytes and Pteridophytes as Rich Sources of Medicinal Compounds, CRC Press, 2019, vol. 38.
12. Sebastian C. Ayurveda and the medical knowledge in ancient India: Shadows and realities. Indian J Med Ethics. 2022;7(1):8-15.

13. Tiwari SB, Singh SD, Verma AK, Awasthi D, Rastogi AK. History of Ayurvedic System of Medicines: From Prehistoric to Present, Journal of Drug Delivery & Therapeutics, 2021, vol. 11.

14. Mohammed FS, Sevindik M, Bal C, Akgül H, Selamoglu Z. Biological activities of *Adiantum capillus-veneris* collected from Duhok province (Iraq), Communications Faculty of Sciences University of Ankara Series C Biology. 2019;28(2):128-142.

15. Akbar S. Adiantum Venustum G. Don. *Adiantun capillus-veneris* L. (Pteridaceae). In: Handbook of 200 Medicinal Plants. Springer, Cham; 2020. p. 103-107.

16. Sankar KG, Venkateswarlu BS. Phytochemical Analysis, Antioxidant and Hepatoprotective Activity of *Actiniopteris radiata*. Int. J Pharm Sci.; 2020. p. 69-74.

17. Sagar PK, Alam M, Sajwan S, Khan AS, Meena RP. HPTLC finger printing studies and evaluation of Pharmacopoeial Standards for the medicinal plant *Adiantum capillus-veneris* L. 2022;7(3):1-15.

18. Oyeyemi SD, Adebiyi SD, Ojo VI. Phytochemical and Nutritional Evaluation of *Nephrolepis cordifolia* (L.) C. Presl., a Tropical Edible Fern. East African Scholars Journal of Biotechnology and Genetics. 2019;1(4):91-98.

19. Mary FJ, Kumar Dr MS, Vijaykumar E, Yadeshwaran G, Yamuna V, Yuvalakshmi E. *Nephrolepis cordifolia*: A Review on the fern. Journal of University of Shanghai for Science and Technology. 2021;23(10):301-305.

20. Jash S, De A. The genus Ophioglossum (Ophioglossaceae) in West Bengal, India. Fern Gazette. 2020;21(3):123-132.

21. Yadav BL, Meghvansi MK, Meena K, Gena CB. Discovery of a new species of Adder's tongue fern from India with comparative analysis of morphological and molecular attributes. Sci. Rep. 2021;11(1):1-12.

22. Soni AK, Rawat VK, Kumar A. *Selaginella bryopteris* (L.) Baker: a new record to the fern allies and an overview of the genus Selaginella P. Beauv. (Selaginellaceae) for Arunachal Pradesh (India). 2021;15(2):233-245.

23. Antony R, Thomas R. A mini review on medicinal properties of the resurrecting plant *Selaginella bryopteris* (Sanjeevani). Int. J of Pharm & Life Sci. (IJPLS). 2011;2(7):933-940.

24. Sureshkumar J, Ayyanar M, Silambarasan R. Ethnomedicinal uses, phytoconstituents and pharmacological importance of pteridophytes used by Malayalis in Kolli hills, India: A quantitative survey. J Herb Med.; 2021. p. 100418.

25. Muhammad M, Ismail ZS, Schneider H, Hawkins JA. Medicinal use of ferns: An ethnobotanical review. Sains Malays. 2020;49(5):1003-1014.

26. Blanchy S. Seul ou tous ensemble? Dynamique des classes d'âge dans les cités de l'île de Ngazidja, Comores. L'Homme. Revue française d'anthropologie. 2003;167:153-186.

27. Balakrishnan M, Ravisankar N, Srivastava RC, Jayakumar S, Ramachandran M. Database for Biodiversity of Andaman and Nicobar Islands. International Journal of Bioinformatics, International Science Press. 2023;2(1):1.

28. Balakrishnan M, Balakrishnan M, Srivastava RC, Pokhriyal M. Biodiversity of Andaman and Nicobar Islands; 2008. p. 1-42.

29. Singh C, Chauhan N, Rani A, Kishore K, Singh K, Singh R. Ethnobotanical and pharmacological studies of pteridophytes (Ferns) from Mussoorie region, Dehradun district, Uttarakhand, International Journal of Botany Studies. 2021;6(6):694-702.

30. Štajner D, Popović BM, Čanadanović-Brunet J, Anačkov G. Exploring *Equisetum arvense* L., *Equisetum ramosissimum* L. and *Equisetum telmateia* L. as sources of natural antioxidants. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2009;23(4):546-550.

31. Lai HY, Lim YY, Kim KH. *Blechnum orientale* Linn-a fern with potential as antioxidant, anticancer and antibacterial agent. BMC Complementary and Alternative Medicine. 2010;10:1-8.

32. Deepa J, Parashurma TR, Krishanappa M, Nataraja S. Antioxidant activities of *Blechnum orentle* L., International Journal of Biological & Pharmaceutical Research. 2013;4(2):105-118.

33. Kandukuri G, Bendi S. Phytochemical Analysis, Antioxidant and Hepatoprotective Activity of Actiniopteris Radiata. Int. J Pharm Sci.; 2020. p. 69-74.

34. Orhan I, Özçelik B, Aslan S, Kartal M, Karaoglu T, Şener B, *et al*. Antioxidant and antimicrobial actions of the clubmoss *Lycopodium clavatum* L. Phytochemistry Reviews. 2007;6(1):189-196.

35. Nofrizal, Putra DP, Arbain D. Antioxidant and antibacterial constituents from two Sumatran ferns, *Trichomanes javanicum* and *Oleandra pistillaris*. Nat Prod Commun. 2017;12(8):1263.

36. Arokiyaraj S, Bharanidharan R, Agastian P, Shin H. Chemical composition, antioxidant activity and antibacterial mechanism of action from *Marsilea minuta* leaf hexane: methanol extract. Chemistry Central Journal. 2018;12:1-11.

37. Al-Tohamy R, Ali SS, Saad-Allah K, Fareed M, Ali A, El-Badry A, *et al*. Phytochemical analysis and assessment of antioxidant and antimicrobial activities of some medicinal plant species from Egyptian flora. J Appl. Biomed. 2018;16(4):289-300.

38. Sureshkumar J, Amalraj S, Murugan R, Tamilselvan A, Krupa J, Sriramavaratharajan V, *et al*. Chemical profiling and antioxidant activity of *Equisetum ramosissimum* Desf. stem extract, a potential traditional medicinal plant for urinary tract infections, Springer. 2021;7(1):192. https://link.springer.com/article/10.1186/s43094-021-00339-8

39. Chaity F, Khatun M, alternative MRB complementary and, 2016 undefined. In vitro membrane stabilizing, thrombolytic and antioxidant potentials of *Drynaria quercifolia* L., a remedial plant of the Garo tribal people of Bangladesh, Springer, 2016, 16(1). https://link.springer.com/article/10.1186/s12906-016-1170-5

40. Gou J, Zou Y, Ahn J. Enhancement of antioxidant and antimicrobial activities of *Dianthus superbus*, *Polygonum aviculare*, *Sophora flavescens* and *Lygodium japonicum* by pressure-assisted water extraction, Food Sci. Biotechnol. 2011;20(1):283-287.

41. Daeschlein G. Antimicrobial and antiseptic strategies in wound management. Int. Wound J. 2013;10(1):9-14.

42. Manhas SH, Attri CH, Seth MK, Seth AM. Determination of phytochemical constituents and evaluation of antimicrobial activity of medicinal fern *Christella dentata*, Indian Fern Journal. 2018;35:169-78.

43. Robert A, Isaac I, Joel W, Phytochemistry J, Activity A. Phytochemistry and antibacterial activity of platycerium coronarium (Tanduk Rasa Fern)

leaf extracts. Hal. Science. 2023;9(4):137-47. https://hal.science/hal-04317307/

44. Barba-Ostria C, Carrera-Pacheco SE, Gonzalez-Pastor R, Heredia-Moya J, Mayorga-Ramos A, Rodríguez-Pólit C, *et al*. Evaluation of Biological Activity of Natural Compounds: Current Trends and Methods. Molecules, 2022, 27(14).

45. Modena De Medeiros C, Alegre P. Licófitas e samambaias: uma revisão etnobotânica no Brasil.; 2022. https://lume.ufrgs.br/handle/10183/265112

46. Cao Tsun-Thai, Chai Xin Wang, Maria Flaviana, Morais-Braga, Jing-Hua Yang, Fai-Chu Wong, *et al*. Phytochemicals from fern species: potential for medicine applications, Springer. 2017;16(3):379-440. https://link.springer.com/article/10.1007/s11101-016-9488-7

47. Lai H, Lim Y, Antioxidative, tyrosinase inhibiting and antibacterial activities of leaf extracts from medicinal ferns. 2009;73(6):1362. https://academic.oup.com/bbb/article-abstract/73/6/1362/5947617

48. Waswa EN, Muema FW, Odago WO, Mutinda ES, Nanjala C, Mkala EM, *et al*. Traditional Uses, Phytochemistry, and Pharmacological Properties of the Genus Blechnum-A Narrative Review. Pharmaceuticals. 2022;15(7):905.

49. Bajracharya GB, Bajracharya B. A comprehensive review on Nepalese wild vegetable food ferns. Heliyon. 2022;8(11):11687. https://doi.org/10.1016/j.heliyon.2022.e11687

50. https://www.researchgate.net/publication/387723253. 28 March, 2025.

51. Rao H, Ahmad S, Zeeshan M, Laiq M, Basit A, Iqbal S, *et al*. Exploring phytochemical and biological profile of *Adiantum aleuticum* (Western maidenhair fern); an indigenous fern with medicinal potential, Results Chem.; 2024. p. 101751.

52. Shrinet K, Singh RK, Chaurasia AK, Tripathi A, Kumar A. Bioactive compounds and their future therapeutic applications. In Natural bioactive compounds, Academic Press; 2021. p. 337-362.

53. Chang Y, Li J, Lu S, Taxon HS. Species diversity and reticulate evolution in the *Asplenium normale* complex (Aspleniaceae) in China and adjacent areas. Wiley Online Library. 2013;62(4):673-687. https://onlinelibrary.wiley.com/doi/abs/10.12705/624.6

54. Chang Y, Ebihara A, Lu S, Liu H, Schneider H. Integrated taxonomy of the Asplenium normale complex (Aspleniaceae) in China and adjacent areas, J Plant Res. 2018;131(4):573-587.

55. Naik B, Maurya VK, Kumar V, Kumar V, Upadhyay S, Gupta S. Phytochemical Analysis of *Diplazium esculentum* Reveals the Presence of Medically Important Components. Curr. Nutr. Food Sci. 2020;17(2):210-215.

56. Semwal P, Painuli S, Painuli KM, Antika G, Tumer TB, Thapliyal A, *et al*. *Diplazium esculentum* (Retz.) Sw.: Ethnomedicinal, Phytochemical, and Pharmacological Overview of the Himalayan Ferns. Wiley Online Library; 2021. https://onlinelibrary.wiley.com/doi/abs/10.1155/2021/1917890

57. Archana GN, Pradeesh S, Chinmayee MD, Mini I, Swapna TS. *Diplazium esculentum*: A Wild Nutrient-Rich Leafy Vegetable from Western Ghats. Prospects in Bioscience; 2012. p. 293-301.

58. Schneller J, Liebst B. Patterns of variation of a common fern (*Athyrium filix-femina*; Woodsiaceae): population structure along and between altitudinal gradients. American Journal of Botany. 2007;94(6):965-971.

59. Schneller JJ. Biosystematic investigations on the lady fern (*Athyrium filix-femina*). Plant Systematics and Evolution. 1979;132(4):255-77.

60. Shah SN, Ahmad M, Ansari MJ, Khan MN, Iqbal M, Ali B, *et al*. Spore morphometric analysis in Sino-Himalayan and W-Himalayan Athyriaceae taxa: taxonomic insights and molecular phylogenetic comparison. Genetic Resources and Crop Evolution. 2025;72(1):1183-1204. https://link.springer.com/article/10.1007/s10722-024-02040-0

61. Irfan M, Jan G, Murad W, Jan FG, Rauf A, Alsayari A, *et al*. Ethnomedicinal and traditional uses of the Ferns of Khyber Pakhtunkhwa, Pakistan. Brazilian Journal of Biology. 2021;84:e250256. https://www.scielo.br/j/bjb/a/dXgfgsrDV7n9TGTW6pLLvBm

62. Ranil RH, Bussmann RW. Potential uses of lycophytes and ferns in Sri Lanka: an ethnopteridological perspective. Ethnobotany Research and Applications. 2021;21(36):1-11.

63. Lai HY, Lim YY, Kim KH. Potential dermal wound healing agent in *Blechnum orientale* Linn. BMC Complementary and Alternative Medicine; 2011. p. 1-9. https://link.springer.com/article/10.1186/1472-6882-11-62

64. Choden K, Verma P. Pteridophytes of Guma and Talo Gewog, Punakha (Bhutan): Pteridophytes of Punakha. Phyto Talks. 2024;1(3):171-184.

65. Singh C, Chauhan N, Rani A, Kishore K, Singh K, Singh R. Ethnobotanical and pharmacological studies of pteridophytes (Ferns) from Mussoorie region, Dehradun district, Uttarakhand. International Journal of Botany Studies. 2021;6(6):694-702.

66. De Medeiros CM, Ritter MR, Gonzatti F. Ferns and lycophytes: an ethnobotany review for Brazil. Ethnobotany Research and Applications. 2023;25:1-27.

67. Ranker TA, Balick MJ, Plunkett GM, Harrison KD, Wahe JP, Wahe M. Ethnobotany and vernacular names of the lycophytes and ferns of Tafea province, Vanuatu. American Fern Journal. 2022;112(3):143-177.

68. Korall P, Conant DS, Metzgar JS, Schneider H, Pryer KM. A molecular phylogeny of scaly tree ferns (Cyatheaceae). American Journal of Botany. 2007;94(5):873-886.

69. Nath K, Das Talukdar A, Bhattacharya MK, Bhowmik D, Chetri S, Choudhury D, *et al*. Cyathea gigantea (Cyatheaceae) as an antimicrobial agent against multidrug resistant organisms. Springer. 2019;19(1):1-8. https://link.springer.com/article/10.1186/s12906-019-2696-0

70. Rakotondrafara A, Rakotondrajaona R, Rakotoarisoa M, Ratsimbason M, Rasamison VE, Rakotonandrasana SR. Ethnobotany of medicinal plants used by the Zafimaniry clan in Madagascar. Contribution a l'etu medicinales et aroma ethnobotaniques, chimiques et activit, 2018, vol. 64.

71. Azka S, Azirda MF. Diversity and bioprospecting of pteridophyte in the indigenous Talang mamak tribe, riau, Indonesia. Sabrao Journal of Breeding & Genetics. 2024;56(5):1854.

72. Yang FC, Sarathchandra C, Liu JX, Huang HP, Gou JY, Li Y, *et al*. How fern and fern allies respond to heterogeneous habitat-a case in Yuanjiang dry-hot valley, Taylor & Francis. 2021;14(1):248-260. https://www.tandfonline.com/doi/abs/10.1080/19420889.2021.2007591

73. Mildawati M, Sobir S, Sulistijorini S, Chikmawati T. Diversity, distribution and ecology of Davallia in Sumatra (Indonesia) and the nearby small islands, Biodiversitas Journal of Biological Diversity, 2022, 23(1). https://smujo.id/biodiv/article/view/9868

74. Amoroso CB, Amoroso VB. Spore culture studies on some economic ferns of Mindanao, Philippines. In International Symposium on Biotechnology of Tropical and Subtropical Species Part 21; 1997. p. 231-236. https://www.actahort.org/books/461/461_24

75. Quave CL, Pardo-de-Santayana M, Pieroni A. Medical ethnobotany in Europe: From field ethnography to a more culturally sensitive evidence-based CAM? Evidence-Based Complementary and Alternative Medicine. 2012;(1):156846.

76. Sledge WA. *Microlepia speluncae* (L.) Moore, *M. trapeziformis* (Roxb.) Kuhn and M. firma Mett. in Kuhn. Kew Bulletin. 1956;11(3):523-31. https://www.jstor.org/stable/4109139

77. Schwartsburd PB. Proposal to conserve the name Microlepia against Scyphofilix (dennstaedtiaceae). Taxon. 2017;66(2):516.

78. Yuan Y, Fu L, Ma CY. *Microlepia boluoensis* sp. nov. (Dennsteadtiaceae) from Guangdong, China. Nord J Bot. 2012;30(2):168-173.

79. Chetia P, Dey D, Puzari M, Dutta Choudhury M. Bioactive Compounds and Biological Activities of *Dipteris wallichii*. In Bioactive Compounds in Bryophytes and Pteridophytes, Springer International Publishing; 2023. p. 461-470. https://link.springer.com/content/pdf/10.1007/978-3-031-23243-5_15.

80. Benko-Iseppon AM, Pinangé DS, Chang SC, Morawetz W. Ethnobotanical uses of the native flora from Brazilian North-Eastern region. Advances in the Study of Medicinal Plants. CRC Press, New Hampshire; 2012. p. 84-105.

81. Bussmann RW, Paniagua-Zambrana NY, Njoroge GN. Ethnobotany of Mountain Regions: Africa. Springer International Publishing; 2021. p. 3-42. https://link.springer.com/content/pdf/10.1007/978-3-030-38386-2_1

82. Xu M, Heidmarsson S, De Boer HJ, Kool A, Olafsdottir ES. Ethnopharmacology of the club moss subfamily Huperzioideae (Lycopodiaceae, Lycopodiophyta): A phylogenetic and chemosystematic perspective. Journal of Ethnopharmacology. 2019;245:112130.

83. Rendón-Aguilar B, Alberto Bernal-Ramírez L, Bravo-Avilez D, Mendoza-Ruiz A. Ethnobotany of lycophyta and polypodiophyta in priority terrestrial regions of Oaxaca, Mexico. Bio One. 2025;107(4):200-218.

84. Kathirvel A, Rai AK, Maurya GS, Sujatha V. Dryopteris cochleata rhizome: a nutritional source of essential elements, phytochemicals, antioxidants and antimicrobials. Int. J Pharm. Pharm. Sci. 2014;6:179-88.

85. Wang J, Seyler BC, Ticktin T, Zeng Y, Ayu K. An ethnobotanical survey of wild edible plants used by the Yi people of Liangshan Prefecture, Sichuan Province, China. J Ethnobiol Ethnomed. 2020;16(1):1-27.

86. Cazar ME, Armijos C, Avilés OM. Phytochemistry and Bioactivity from Huperzias, used by Healers from Saraguro Community, in the Southern Ecuadorian Andes. Ethnobotany: Ethnopharmacology to Bioactive Compounds. 2023;1:159-166.

87. Yumkham SD, Singh PK. Less known ferns and fern-allies of Manipur with ethnobotanic uses. Indian Journal of Traditional Knowledge. 2011;10(2):287-291. https://nopr.niscpr.res.in/handle/123456789/11505

88. Prance GT. Keller, Hector Alejandro; The ethnobotany of ferns and fern allies; British Pteridological Society, Fern Gazette. 2015;20(1):1-14. https://ri.conicet.gov.ar/handle/11336/2599

89. Şahinler SŞ. *Equisetum arvense* L. Novel Drug Targets with Traditional Herbal Medicines: Scientific and Clinical Evidence; 2022. p. 249-262.

90. Boeing T, Tafarelo Moreno KG, Gasparotto Junior A, Mota da Silva L, De Souza P. Phytochemistry and pharmacology of the genus Equisetum (Equisetaceae): A narrative review of the species with therapeutic potential for kidney diseases. Evidence-Based Complementary and Alternative Medicine. 2021;(1):6658434. https://onlinelibrary.wiley.com/doi/abs/10.1155/2021/6658434

91. Zakaria ZA, Abdul Ghani ZDF, Raden Nur RNS, Gopalan HK, Sulaiman MR, Mat Jais AM, *et al*. Antinociceptive, anti-inflammatory, and antipyretic properties of an aqueous extract of *Dicranopteris linearis* leaves in experimental animal models, J Nat Med. 2008;62(2):179-187.

92. Cohen AL, Singhakumara BMP, Ashton PMS. Releasing Rain Forest Succession: A Case Study in the *Dicranopteris linearis* Fernlands of Sri Lanka. Restor. Ecol. 1995;3(4):261-270.

93. Russell A, Raich J. The ecology of the climbing fern *Dicranopteris linearis* on windward Mauna Loa, Hawaii. 1998;86(5):765-79. https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2745.1998.8650765.x

94. Tanzin R, Rahman S, Hossain MS, Agarwala B, Khatun Z, Jahan S, *et al*. Medicinal potential of pteridophytes-An antihyperglycemic and antinociceptive activity evaluation of methanolic extract of whole plants of Christella dentata. Adv. Nat Appl. Sci. 2013;7(1):67-73. https://www.academia.edu/download/32798941/67-73

95. Rio C Del, Hennequin S, Rouhan G, Ebihara A, Lowry PP, Dubuisson JY, *et al*. Origins of the fern genus hymenophyllum (Hymenophyllaceae) in new caledonia: Multiple independent colonizations from surrounding territories and limited in situ diversification, Taxon. 2017;66(5):1041-1064.

96. Singh AP, Johari D. *Hymenophyllum javanicum* Spreng: An Addition to the Pteridophytic Flora of Central India. Proceedings of the National Academy of Sciences India, Biological Sciences. 2018;88(2):531-537.

97. Vasques DT, Ebihara A, Hirai RY, Prado J, Motomi I. Phylogeny of Hymenophyllum subg. Mecodium (Hymenophyllaceae), with special focus on the diversity of the *Hymenophyllum polyanthos* species complex, Plant Systematics and Evolution. 2019;305(9):811-825.

98. Liu XI, Gituru WR, Wang QF. Distribution of basic diploid and polyploid species of Isoetes in East Asia. Journal of biogeography. 2004;31(8):1239-1250. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2699.2004.01115.x

99. Crouch NR, Klopper RR. Fern hunting in southern Africa: extraordinary finds behind the new comprehensive guide, Plant Life. 2012;41:68-77.

100. Karthik V, Raju K, Ayyanar M, Gowrishankar K, Sekar T. Ethnomedicinal uses of pteridophytes in kolli hills, Eastern Ghats of Tamil Nadu, India. J Nat Prod Plant Resour. 2011;1(2):50-55.

101. Wang B, Guan C, Fu Q. The traditional uses, secondary metabolites, and pharmacology of Lycopodium species, Phytochemistry Reviews. 2022;21(1):1-79.

102. Dos Santos Reinaldo RC, Santiago AC, Medeiros PM, Albuquerque UP. Do ferns and lycophytes function as medicinal plants? A study of their low representation in traditional pharmacopoeias. Journal of ethnopharmacology. 2015;175:39-47. https://www.sciencedirect.com/science/article/pii/S0378874115301288

103. Sharma A, Kumar A, Singh AK, Kumar KJ, Narasimhan B, Kumar P. Ethnomedicinal Uses, Phytochemistry, Pharmacology, and Toxicology of *Ruellia tuberosa* L.: A Review. Chem Biodivers. 2024;21(8):e202400292.

104. Cho HJ, Bae WJ, Kim SJ, Hong SH, Lee JY, Hwang TK, *et al*. The inhibitory effect of an ethanol extract of the spores of *Lygodium japonicum* on ethylene glycol-induced kidney calculi in rats. Urolithiasis. 2014;42(4):309-315.

105. Chandra P, Yadav E, Mani M, Ghosh AK, Sachan N. Protective effect of *Lygodium flexuosum* (family: Lygodiaceae) against excision, incision and dead space wounds models in experimental rats. Toxicol. Ind. Health. 2015;31(3):274-280.

106. Sureshkumar J, Silambarasan R, Bharati KA, Krupa J, Amalraj S, Ayyanar M. A review on ethnomedicinally important pteridophytes of India. Journal of ethnopharmacology. 2018;219:269-287.

107. https://www.sciencedirect.com/science/article/pii/S0378874117302891

108. Banerjee S, Sarkar K, Sil PC. Ethnobotany, Phytochemistry, and Pharmacological Activity of *Marsilea minuta*, Aquatic Medicinal Plants. 2023. p. 37-47.

109. Nazar S, Ravikumar S, Prakash Williams G. Ethnopharmacological survey of medicinal plants along the southwest coast of India. J Herbs Spices Med Plants. 2008;14(4):219-239.

110. Iqbal MS, Ahmad KS, Ali MA, Akbar M, Mehmood A, Nawaz F, *et al*. An ethnobotanical study of wetland flora of Head Maralla Punjab Pakistan. Plos one. 2021;16(10):e0258167. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0258167

111. Mulani S, Tamboli FA, Kolekar Y, Bhosale P, Patil K, Shendage S, *et al*. Morphological, Histological and Phytochemical Features of *Nephrolepis cordifolia* (L.) C. Presl. National Academy Science Letters. 2024;47(3):239-245. https://link.springer.com/article/10.1007/s40009-023-01348-2

112. Christenhusz MJM, Zhang XC, Schneider H. A linear sequence of extant families and genera of lycophytes and ferns, Phytotaxa. 2011;19:7-54.

113. Hovenkamp PH, Miyamoto F. A conspectus of the Native and Naturalized Species of Nephrolepis (Nephrolepidaceae) in the World, Blumea J Plant Tax Plant Geog. 2005;50(2):279-322.

114. Huang YC, Hwang TL, Chang CS, Yang YL, Shen CN, Liao WY, *et al*. Anti-inflammatory flavonoids from the rhizomes of *Helminthostachys zeylanica*. J Nat Prod. 2009;72(7):1273-1278.

115. Huang YL, Shen CC, Shen YC, Chiou WF, Chen CC. Anti-inflammatory and Antiosteoporosis Flavonoids from the Rhizomes of *Helminthostachys zeylanica*. J Nat Prod. 2017;80(2):246-253.

116. Clericuzio M, Burlando B, Gandini G, Tinello S, Ranzato E, Martinotti S, *et al*. Keratinocyte wound healing activity of galactoglycerolipids from the fern *Ophioglossum vulgatum* L. Springer. 2014;68(1):31-37. https://link.springer.com/article/10.1007/s11418-013-0759-y

117. Zhu X, Tian C, Yao D, Li S, Lv J, Chen Y, *et al*. Anti-inflammatory properties of ophioglonin derived from the fern *Ophioglossum vulgatum* L. via inactivating NF-κB and MAPK signaling pathways, FEBS Open Bio. 2025;15(1):122-139. https://febs.onlinelibrary.wiley.com/doi/abs/10.1002/2211-5463.13914

118. Abraham S, Thomas T. Ferns: A Potential Source of Medicine and Future Prospects. Ferns: Biotechnology, Propagation, Medicinal Uses and Environmental Regulation; 2022. p. 345-378.

119. Nwosu MO. Ethnobotanical studies on some pteridophytes of Southern Nigeria. Economic Botany. 2002;56(3):255-259.

120. Prasanna G, Anuradha R. A comprehensive review on Phytopharmacological activities of *Drynaria quercifolia* L. Int J Pharmacogn Phytochem Res. 2016;8(8):1304-1313. https://www.academia.edu/download/50231176/review_DQ_GP

121. Ho R, Teai T, Loquet D, Bianchini JP, Girault JP, Lafont R, *et al*. Phytoecdysteroids in the genus Microsorum (Polypodiaceae) of French Polynesia, Nat Prod Commun. 2007;2(8):803-816.

122. Sharma U. Ethnobotany of religious and supernatural beliefs of the Mising tribes of Assam with special reference to the 'Dobur Uie', Springer. 2011;7:1-13. https://link.springer.com/article/10.1186/1746-4269-7-16

123. Nufus CA, Rasnovi S, Dharma W, Navia ZI, Razi NM, Rahmadani R, *et al*. Ethnobotanical Study and Medicinal Plant Bioprospecting in Tamiang Tribal Community, Aceh, Journal of Tropical Ethnobiology. 2024;7(1):1-20. http://jte.pmei.or.id/index.php/jte/article/view/177

124. Chassagne F, Hul S, Deharo E, Bourdy G. Natural remedies used by Bunong people in Mondulkiri province (Northeast Cambodia) with special reference to the treatment of 11 most common ailments. Journal of Ethnopharmacology. 2016;191:41-70. https://www.sciencedirect.com/science/article/pii/S0378874116303555

125. Singh AV. Edible and medicinal ferns of Lakhimpur, Assam. International Journal of Engineering, Science and Mathematics. 2017;6(3):1-6. https://www.cabidigitallibrary.org/doi/full/10.5555/20193430057

126. León JM, Yabar H, Medina EL, Estraver WZ, De La Cruz J. Identification, Mapping and Ethnobotany of Plant Species in the Peruvian High Andean Wetlands: Stimulating Biodiversity Conservation Efforts towards Sustainability. Journal of Sustainable Development, 2021, 14(2). https://www.academia.edu/download/96923610/47314.

127. Raju R, Jithin Raj MP, Gangaprasad A. *Tectaria polymorpha* (Wall. ex-Hook.) Copel. (Tectariaceae), a new distributional record for Kerala. Plant Science Today. 2023;10(1):45-74.

128. Singh M, Singh N, Khare PB, Rawat AKS. Antimicrobial activity of some important Adiantum species used traditionally in indigenous systems of medicine, J Ethnopharmacol. 2008;115(2):327-339.

129. Kumar V, Charde V, Prasad SB, Gandhi Y, Mishra SK, Rawat H, *et al*. Therapeutic potential of evergreen maiden hair fern *Adiantum venustum* D. Don: a comprehensive review, Food Chemistry Advances. 2023;3:100439.

130. Kholia BS, Balkrishna A. Pteridophytes used by peoples of Indian Himalayan region and Northern India: An overview. Ferns: Biotechnology, Propagation, Medicinal Uses and Environmental Regulation; 2022. p. 379-412.

131. O'Neill AR, Badola HK, Dhyani PP, Rana SK. Integrating ethnobiological knowledge into biodiversity conservation in the Eastern Himalayas. J Ethnobiol Ethnomed. 2017;13(1):21.

132. Albahri G, Badran A, Hijazi A, Daou A, Baydoun E, Nasser M, *et al*. The Therapeutic Wound Healing Bioactivities of Various Medicinal Plants. Life. 2023;13(2):317. https://www.mdpi.com/2075-1729/13/2/317/html

133. Lamichhane R, Kim SG, Poudel A, Sharma D, Lee KH, Jung HJ. Evaluation of *in vitro* and *in vivo* Biological Activities of *Cheilanthes albomarginata* Clarke. BMC Complement Altern Med. 2014;14(1):1-11.

134. Lamichhane R, Kim SG, Poudel A, Sharma D, Hee Lee K, Poudel P, *et al*. Identification of Flavonoids from *Cheilanthes albomarginata* Clarke and Their Simultaneous Determination and Quantification by UPLC/DAD Method. Taylor & Francis. 2015;38(19):1713-1721. https://www.tandfonline.com/doi/abs/10.1080/10826076.2015.1091011

135. Machado A, Zamora-Mendoza L, Alexis F, Álvarez-Suarez JM, Machado A, Zamora-Mendoza L, *et al*. Use of Plant Extracts, Bee-Derived Products, and Probiotic-Related Applications to Fight Multidrug-Resistant Pathogens in the Post-Antibiotic Era, Future Pharmacology. 2023;3(3):535-567. https://www.mdpi.com/2673-9879/3/3/34/htm

136. Suraj RH, Jadeyegowda M, Kushalappa CG, Maheshwarappa V, Chandrashekar SY. An ethnobotanical study of medicinal pteridophytes in kodagu region of Western Ghats, India. Int. J Curr. Microbiol. App. Sci. 2020;9(10):367-380.

137. Ojha R, Devkota HP. Edible and medicinal pteridophytes of Nepal: a review. Ethnobotany Research and Applications. 2021;22:1-6.

138. Bandyopadhyay A, Dey A. Medicinal pteridophytes: ethnopharmacological, phytochemical, and clinical attributes. Beni Suef Univ. J Basic Appl. Sci. 2022;11(1):113. https://doi.org/10.1186/s43088-022-00283-3

139. Bouattou K, Ali-Nehar A, Djamai W, Bekhouche K. Assessment of the biological activities of *Azolla pinnata* growing in the North-West of Algeri. Bionatura Journal. 2024;1(3):1-19.

140. Xu G, Zhang C, Lee Y, Chen Z, Zeng X. Impact of phytoecdysone fractions of the ferns *Cyclosorous interruptus*, *Christella dentata* and *Nephrolepis cordifolia* on the biology of *Spodoptera litura* (Fab.). jbiopestic.com. 2023;8(1):181-185. https://jbiopestic.com/journals/vol_9_2_125-134

141. Li ZY, He ZR, Zhang XC. A taxonomic revision of *Cyclosorus subgenus* Cyclosoriopsis (Thelypteridaceae) from China. J Syst. Evol. 2013;51(5):609-638.

142. Naugolnykh SV, Wang L, Han M, Jin JH. A new find of the fossil Cyclosorus from the Eocene of South China and its paleoclimatic implication, J Plant Res. 2016;129(1):3-12.

143. Quadri-Spinelli T, Heilmann J, Rali T, Sticher O. Bioactive coumarin derivatives from the fern *Cyclosorus interruptus*. Planta Med. 2000;66(8):728-733.

Chapter - 9
Secondary Metabolites Plays an Important Role in Traditional Medicinal Plants

Author

Shoeb Ahmad

Department of Botany, Gandhi Faiz-e-Aam College, Shahjahanpur, Affiliated to M.J.P. Rohilkhand University, Bareilly, Uttar Pradesh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 9

Secondary Metabolites Plays an Important Role in Traditional Medicinal Plants

Shoeb Ahmad

Abstract

Understanding a plant's potential medical usefulness is facilitated by having a solid understanding of its chemical makeup. The extensive and varied pharmacological effects of medicinal plants are largely due to their phytochemical components. These phytochemicals can be categorized into two main types based on their involvement in essential metabolic processes: primary and secondary metabolites. Primary metabolites are found universally in all living organisms as they are crucial for cellular life. In contrast, secondary metabolites arise from supplementary processes such as the shikimic acid pathway. Research on the medicinal properties of herbal remedies primarily targets these secondary metabolites. These compounds have played a significant role in treating numerous diseases in both traditional and modern medicine, providing foundational substances for the development of drugs used today to treat conditions like migraines and cancer. The chemical structures of plant secondary metabolites are used to classify them into several groups. The various categories of secondary plant metabolites, how they are distributed across plant families, & their important medicinal uses will all be covered in this chapter.

Keywords: Alkaloids, secondary plant metabolites, phenolics, terpenes, saponins

1. Introduction

Herbal medicine is based on chemistry of plants. Understanding a plant's potential medical usefulness is facilitated by having a solid understanding of its chemical makeup. Modern chemistry has provided an explanation for the role that important plant metabolites play in basic biological activities like respiration, cell division as well as development, storage, and reproduction. They are fundamental to numerous biological processes, including

glycolysis, the Krebs cycle, photosynthesis, and related pathways. Primary metabolites are small molecules that include sugars, tricarboxylic acids, proteins, amino acids, nucleic acids, and polysaccharides. They can also be intermediates in the Krebs cycle. All live cells eventually have comparable basic metabolites.

Plant cells utilize metabolic pathways that branch off from core metabolic processes to generate a diverse array of chemicals known as secondary plant metabolites. The term "secondary metabolite" was initially introduced by Albrecht Kossel, a Nobel Prize laureate in medicine or physiology in 1910 (Jones *et al.*, 1953). According to Czapek, cited by Bourgaud *et al.* in 2001, these compounds are considered end products. According to him, these substances, such as deamination, are the outcome of "secondary modifications" in the nitrogen metabolism. The growing recovery of these substances, made feasible by advancements in analytical techniques such as chromatography, gave rise to the subject of phytochemistry in the mid-1900s. The biological consequences of secondary metabolites provide a scientific basis for the traditional medicinal usage of herbs in many ancient civilizations. Because they are classified as antibiotics, antifungals, and antivirals, they have the capacity to protect plants from infections. They are also important UV-absorbing substances that protect leaves from damaging light. It has been observed that certain plants, such alfalfa or clover, which are used as feed grasses, have estrogenic qualities and influence animal fertility.

According to their chemical structures, secondary metabolites found in plants are divided into several types. After discussing the characteristics of secondary plant metabolites, this chapter will examine the primary categories of substances that are thought to have therapeutic benefit. Each section begins with a description of the botanical distribution, structure, & general pharmacological findings of an assortment of secondary plant metabolites. Illustrations of representative molecules are then provided. The following classes comprise plant secondary metabolites:

1. Phenolics
2. Alkaloids
3. Saponins
4. Terpenes

5. Lipids
6. Carbohydrates

2. Phenolics

2.1 Simple phenolics

In general, phenols with a single carboxylic acid functional group are referred to as "phenolic acids." Phenolic acids found in nature have two different carbon frameworks: Phenolic acids are abundant in plants; free phenols are rare, while gallic acid, primary component of gallotannins, is quite prevalent. Gallic acid is well-known for its astringent properties but has also shown a wide range of other functions *in vitro*. These include antiviral, antibacterial, antifungal, anticancer, anti-inflammatory, antianaphylactic, antimutagenic, choleretic, and bronchodilatory effects. Additionally, it inhibits insulin breakdown and promotes smooth muscle relaxation (Saxena *et al.*, 2013). Other examples of phenolic acids in this category include ferulic, salicylic, and caffeic acids, along with eugenol (a phenolic phenylpropane) and vanillin (a phenolic aldehyde). These compounds vary depending on whether the functional group is carboxylic, aldehydic, or hydroxyl. Hydroquinone, one of the most widely distributed simple phenols, is also found in some plants as the glycoside arbutin. Lignin is derived from the commonly occurring glycoside coniferin and other phenolic cinnamic alcohol derivatives, with glycoside synthesis frequently occurring.

Of these frequently occurring components, the most notable examples of their pharmacological properties are probably the anti-inflammatory salicylates & urinary system antibacterial arbutin. All phenols have the same antibacterial action. Actually, the first disinfectant used in surgery was phenol itself. Many plants' pharmacological properties are ascribed to simple phenolics; *Arctostaphylos uva-ursi's* phenolic content was found to be responsible for both its antibacterial and diuretic properties. Because capsaicinoids are simple phenolic chemicals, capsicum species have been shown to exhibit circulatory stimulant, rubefacient, and analgesic properties (Spiller *et al.* 2008). Additionally, it is believed that simple phenolics are the cause of the cholagogue, anticatarrhal, diuretic, anthelmintic, analgesic, and *Filipendula ulmaria*, *Solidago virgaurea*, *Dryopteris filix-mas*, and *Cynara scolymus's* qualities (Hoffmann 2003) Figure 1 shows a few instances of basic phenolics.

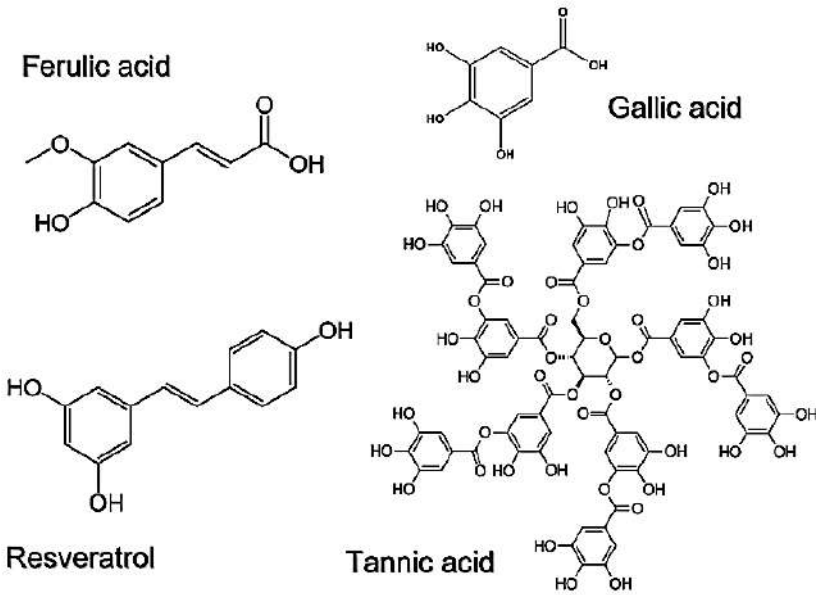


Fig 1: Illustrations of simple phenolics

2.2 Tannins

Tannins are challenging to identify chemically because the term encompasses a wide variety of oligomers and polymers (Harborne *et al.*, 1999). Tannins are a broad class of high molecular weight polyphenolic compounds capable of binding to polysaccharides (such as cellulose, hemicellulose, and pectin), proteins, alkaloids, minerals, nucleic acids, and various other materials, forming both irreversible and reversible complexes (Schofield *et al.,* 2001). Polypenols with the capacity to precipitate protein are called tannins. For decades, leather has been made from raw animal hides using these substances. By creating a crosslink in the protein during this process, tannin molecules strengthen its defense against bacterial and fungal invasion. However, several chemicals that are now thought to be tannins due to their structure and origin in biosynthesis have little to no potential to form leather.

Within the tannin family, there are two main types: hydrolyzable & condensed. Many phenolic acid molecules, including gallic & hexa hydroxydiphenic acids, are linked to a core glucose molecule via ester bonds to generate hydrolyzable tannins. Gallic acid & ellagic acid units, which make up gallotannins and ellagitannins, respectively, are two main forms of

hydrolyzable tannins. Geraniin {isolated from *Geranium robertianum* (Herb Robert) as well as *Geranium maculatum* (American cranesbill)} (Catarino *et al.* 2017); as well as tellimagrandins 1 & 2 {isolated from *Punica granatum* (pomegranate), *Quercus alba* (Oak bark) & *Filipendula ulmaria* (Meadowsweet)} (Evans 2009); are examples of ellagitannins found in medicinally significant plants for which structures have been clarified. Proanthocyanidins, also known as condensed tannins, are a class of chemicals whose structures originate from precursors of oligomeric flavonoids. They differ in terms of the kind of connections that exist between flavonoid units, the patterns of hydroxylation, the stereochemistry of the carbons 2, 3, & 4 in pyran ring as well as the additional substituents. Certain medications, including tea from *Camellia sinensis* & leaves as well as bark of *Hamamelis virginiana*, contain both condensed & hydrolyzable tannins, (Puneet *et al.* 2013). Tannic acids have been utilized as antidiarrheal drugs and as counterdrugs for heavy metal toxicity and alkaloids. It has been shown that the primary component of tea, epigallocatechin-3-gallate, has antiangiogenic effects in mice.

2.3 Coumarins

Benzo-α-pyrone, the lactone of O-hydroxycinnamic acid, serves as the basis for derivatives known as coumarins. To date, there are over a thousand naturally occurring coumarins identified. Coumarin has been identified in over 150 species across more than 30 different plant families. According to Hoffman (2003), the three plants that are the richest in coumarin are G*alium odoratum*, often known as sweet woodruff, *Dipteryx odorata*, and *Melilotus spp*., which is sweet clover or melilot. Common coumarins that are present in plants both as glycosides & in Free State include scopoletin, umbelliferone, and aesculetin. Some plants that are high in coumarins are *Ruta graveolens* (Umbelliferae), *Daphne mezereum* (Thymeliaceae), *Datura stramonium* (Solanaceae), *Atropa belladonna*, & some *Aesculus hippocastanum* (Horse-chestnut) (Hippocastanaceae) and Rosaceae (Evans 2009). The most significant pharmacological effects associated with coumarins have been reported to include anticoagulant, anti-inflammatory, anti-Alzheimer's & anticancer. In Figure 2, coumarin examples are displayed.

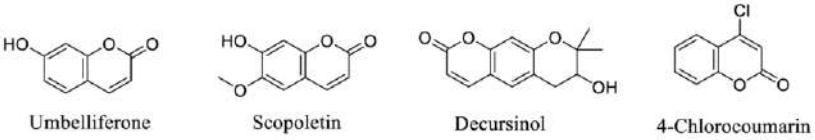


Fig 2: Illustrations of coumarins

2.4 Flavonoids

Polyphenolic substances called flavonoids are widely found in natural world. There are around 4,000 known flavonoids, numerous of which may be found in vegetables, fruits, coffee, tea, & fruit-based beverages (Pridham 1960). Flavonoids are the term for the bulk of phenols that occur naturally.

Flavonoids' structural framework has an aromatic ring at positions two, three, or four attached to a chroman ring. On the basis of degree of oxidation of central ring (ring C), flavonoids may be categorized in several classes. Among them, anthocyanins, flavonols & flavones are most prevalent.

Yellow is a prevalent color among flavones and their related compounds (derived from the Latin "flavus," meaning yellow). These substances are widely distributed throughout nature, particularly in higher plants and growing tissues, where they are primarily found in the cell sap. Flavones are prominently present in several plant families, including Rutaceae, Leguminosae, Polygonaceae, Compositae, and Umbelliferae. Recent research has demonstrated the therapeutic effects of flavonoid-containing drugs, including those for Ginkgo biloba (gingko), Roman chamomile (Chamaemelum nobile), and liquorice root (Glycyrrhiza glabra). Many herbs that contain flavonoids are now listed in the British Pharmacopeia; these include Equisetum ramosissimum (horsetail), Calendula officinalis Flower, Betula pendula (birch leaf), Sambucus *nigra* (elder flower), *Passiflora edulis* (passion flower), *Leonurus cardiaca* (motherwort) & *Tilia cordata* (lime flower). According to Serafini *et al*. (2010), this group well-known for its antiallergic & anti-inflammatory, vasoprotective & antithrombotic properties, prevention of tumor promotion & protective qualities for stomach mucosa. Flavonoid illustrations are displayed in Figure 3.

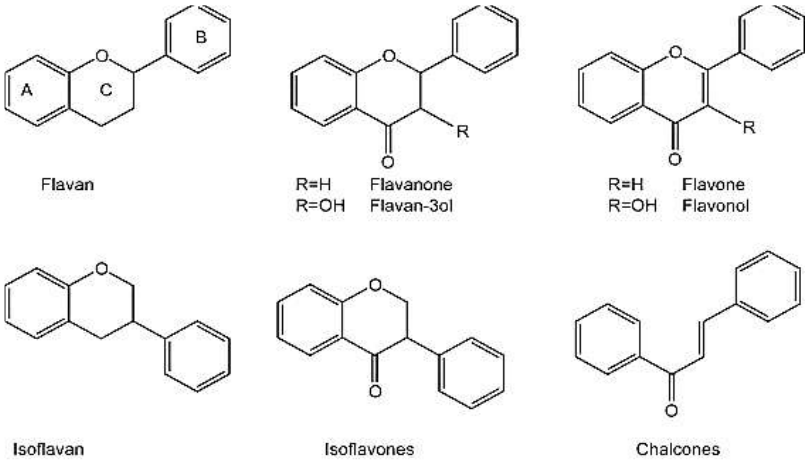


Fig 3: Illustrations of flavonoids

3. Alkaloids

Alkaloids are naturally occurring products with basic characteristics that contain heterocyclic nitrogen atoms. Alkaloids are named after the word "alkaline," which was formerly used to refer to any base that contained nitrogen (Mueller & McAllan 1992). Alkaloids are categorized into numerous groups according on their basic chemical structure. Aphedras, ergots, indoles, imidazoles, bisindoles, manzamines, indolizidines, oxindoles, quinozolines, quinolines, purines, phenylisoquinolines, pyrrolidines, phenylethylamines, piperidines, pyrroloindoles, pyrrolizidines, pyridines, and simple tetrahydroisoquinolines are among the fundamental types of alkaloids (Tadeusz 2015).

Despite the fact that people have been using plant alkaloids for more than 3000 years as teas, potions, and medicines, the chemicals that give these plants their active properties had not identified & separated until the 19th Century. Alkaloids usually don't exist in lower plants. Alkaloids containing sulfur, such as gliotoxins & lysergic acid derivatives are known to be found in fungi. Taxus, Lycopodium & Ephedra alkaloids are a few of pteridophytes & gymnosperms alkaloids with known medicinal uses. The distribution of alkaloids is not uniform in angiosperms. The orders listed below are said to be abundant in alkaloids: Magnoliales (Magnoliaceae, Lauraceae,), Centrospermae (Chenopodiaceae), Papaverales (Fumariaceae, Papaveraceae), Rutales (Rutaceae), Rosales (Leguminosae), Gentiales (Rubiaceae, Apocynaceae, Loganiaceae), Tubiflorae (Convolvulaceae,

Boraginaceae, Solanaceae), Campanulales (Campanulaceae & Compositae) (Evans 2009).

Alkaloids have a variety of pharmacological actions, including hypertensive, antineoplastic, hypotensive, respiratory stimulation & relaxation, cardiac stimulation, muscular relaxation, vasoconstriction & toxicity. Alkaloids' carcinogenic or mutagenic activity, toxicity in vertebrates, cytotoxic activity, antibacterial, antifungal, antiviral, and allelopathic activities, as well as their molecular targets, have all been documented in the literature. Many alkaloids are so deadly that consuming them will kill an animal. A number are utilized as pesticides (Seigler 1995; Hoffmann 2003), including nicotine and anabasine. Figure 4: A few examples of alkaloids:

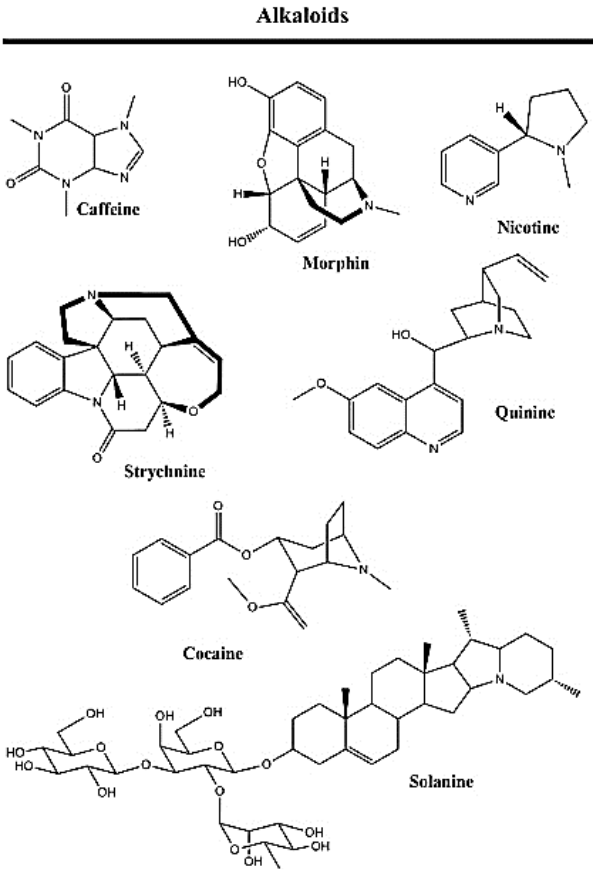


Fig 4: Illustrations of alkaloids

3.1 Nicotine

Nicotine is addictive ingredient in tobacco & widely present in tobacco plant (*Nicotiana tabacum*) as well as other *Nicotiana species*. Nicotine also provides calming effects. Furthermore, at high dosages, it is very toxic and can cause respiratory paralysis (Figure 4). As a ganglion cholinergic receptor agonist, nicotine possesses an extensive array of complicated pharmacological effects. These effects can be mediated by attaching to brain receptors, adrenal medulla, neuromuscular junction & autonomic ganglia.

3.2 Caffeine

Numerous botanically unrelated species, such as guarana (*Paullinia cupana*), mate (*Ilex paraguariensis*), tea (*Camellia sinensis*), kola *(Cola acuminata*) & coffee (*Coffea* spp.), contain caffeine (Figure 4). In raw coffee beans, chlorogenic acid binds caffeine. Caffeine and other substances that give coffee its aroma are released during the roasting process. Caffeine stimulate central nervous system, lungs & heart in addition to being a diuretic.

3.3 Vinblastine

Catharanthus roseus G. is the source of the isolated compound vinblastine, which is used as a disinfectant & for treatment of diabetes & high blood pressure. Nevertheless, vinblastine plays a critical role in combating cancer. When used in therapeutic settings, it is combined with other vinca alkaloids, vincristine, vindesine & vinorelbine in US & Europe (Moudi *et al*. 2013).

4. Saponins

The term "saponin" refers to a class of secondary metabolites called saponins that are extensively dispersed throughout the kingdom of plants and that, in aqueous solutions like soap, produce a stable foam. Chemically speaking, saponins are substances with polycyclic aglycone moiety linked with carbohydrate unit (a mono-or oligosaccharide chain) by either steroid (steroidal saponins) or triterpenoid (triterpenoidal saponins) (examples shown in Figures 5). These sugar units can consist of various combinations of uronic acids, pentoses or hexoses. These materials can lower surface tension & have a soap-like consistency due to their hydrophobic-hydrophilic asymmetry. They cause blood erythrocytes to hemolyze *in vitro* and generate foam in aqueous solutions. The term "genin" or "sapogenin" refers to aglycone component of saponin molecule.

Saponins are abundant in plants; over 500 different species from more than 90 families have been found to have them. Their seclusion from leaves, stems, roots, flowers, bulbs & fruits, though many species, including *Digitalis purpurea* (foxglove), *Dioscorea villosa* (wild yam), *Eleutherococcus senticosus* (Siberian ginseng), *Gentiana lutea* (gentian), *Panax ginseng* (Korean ginseng) & *Glycyrrhiza* spp. (licorice), tend to have concentration of these substances in their roots (Assa *et al.* 1973). Many pharmacological properties of saponins are being demonstrated. Certain saponins possess sedative, anticancer, piscicidal, expectorant, spermicidal, analgesic & molluscicidal properties. As an expectorant and antitussive, glycyrrhizin from glycyrrhizae radix (from Glycyrrhiza glabra, Fabaceae) is beneficial. Additionally, cirrhosis & chronic hepatitis are treated with it. Some saponins, such those from the Apiaceae plant Bupleurum falcatum, have anti-inflammatory properties. In Korean medicine, *Phytolacca Americana* roots are said to have anti-inflammatory qualities.

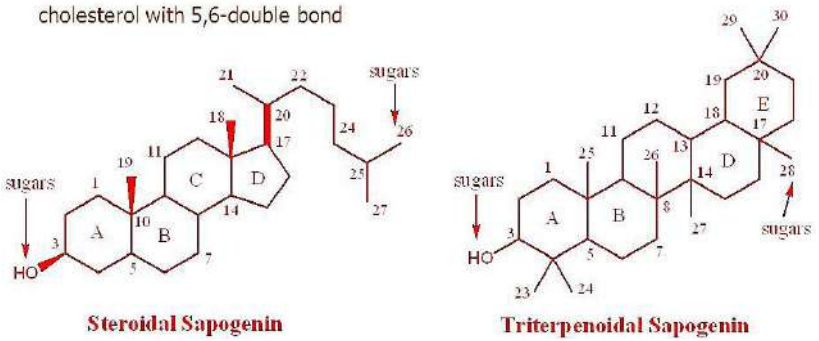


Fig 5: Illustrations of saponins

5. Terpenes

The biggest & most varied class of secondary chemicals found from plants are known as terpenes. The word "turpentine", which itself derives from old French word ter (e) bintb, which means "resin", is where the name "terpene" originates. Chemically they are all formed from Five-carbon isoprene units that have been put together differently (Hoffmann 2003). The quantity of isoprene atoms within a molecule determines classification of terpenes; prefix in name indicates how many terpene units there are.

5.1 Hemiterpenes

Hemiterpenes are a class of terpenes consisting of a single isoprene unit, which is a five-carbon molecule (C_5H_8). Unlike larger terpenes, which are

built from multiple isoprene units, hemiterpenes are the simplest form and have a basic structure. Isoprene itself is only hemiterpene; however, isoprene derivatives with oxygen, such as isovaleric acid from *Vaccinium myrtillus* & angelic acid obtained from *Angelica archangelica*, are also hemiterpenoids (Seigler 1995).

5.2 Monoterpenes

The corresponding monoterpenoids are created when monoterpenes undergo biochemical changes such oxidation or rearrangement. Monoterpenoids are molecules with the chemical formula C10H16 and two isoprene units (Figure 6). They are crucial elements of essential oils or volatile oils, obtained from plants. Several plant families, like Lamiaceae, Rutaceae, Pinaceae, & Apiaceae, are known to contain monoterpenes and are the source of many essential oils used in the market. Certain chemicals, like geraniol, are practically universal and present in trace levels in volatile secretions of several plants. Monoterpenes can further divided into aldehydes (like citronellal), ketones (like Carvone), alcohols (like linalool), unsaturated hydrocarbons (like limonene), and alcohol esters (like linalyl acetate). Numerous common medical applications exist for monoterpenes along with other volatile terpenes. Materials with anti-itching, analgesic, and counter irritating properties include menthol and camphor. As anthelmintics, several monoterpenes have been employed. Many monoterpene glycosides appear to have a vasodilatory effect on coronary arteries & femoral vascular bed.

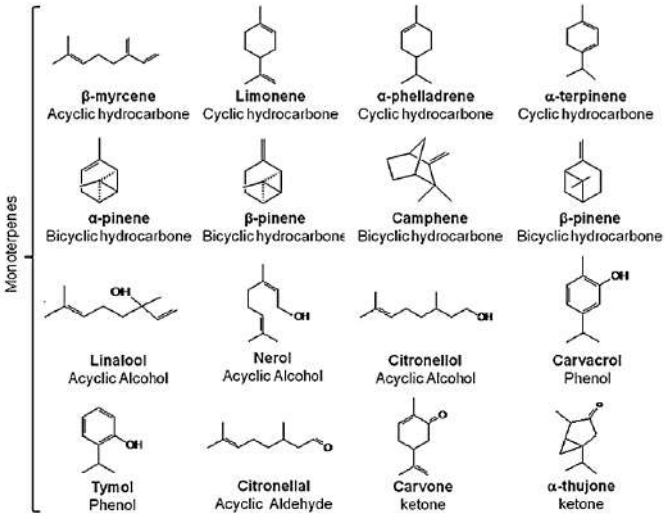


Fig 6: Illustrations of monoterpenes

5.3 Sesquiterpenes

They consist of three different isoprene units with the chemical formula C15H24 (see Figure 7). Sesquiterpenes have more than 200 different structural, with several thousand identified molecules, based on their biogenetic origin. Structure allows for an easy classification of these chemicals into 3 main groups: acyclic (farnesol), monocyclic (bisabolol & bicyclic (caryophyllene). Several sesquiterpene lactones exhibit antifungal, antibacterial & antiprotozoan properties. At quantities equivalent to those of the antiamoebic medication metronidazole, sesquiterpenes from *Vernonia colorata* inhibit *Entamoeba histolytica*. Cardiotonic qualities of *Arnica Montana* flowers are attributed to helanelin & number of similar substances. Clinical uses for *Atractylodis rhizoma*, a member of the Asteraceae family, include analgesic, anti-inflammatory, and diuretic effects. The existence of active chemicals, such as atractylenolide I & eudesma-4(14)-7(11)-dien-8-one, is associated to the activity. Because sesquiterpenes are present in many related medicinal plants, they are likewise utilized for similar purposes.

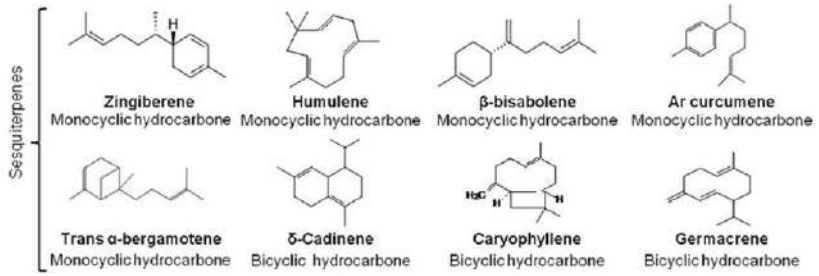


Fig 7: Illustrations of sesquiterpenes

5.4 Diterpenes

Their chemical formula is C20H32, and they consist of 4 isoprene units (Figure 8). There are two types of diterpenes: acyclic and macrocyclic molecules. Moreover, the amount of ring systems a macrocyclic diterpene has determines its classification. Diterpenes can have fused 5-as well as 7-membered ring structures, or they can have Six-membered ring structures. Numerous diterpenes also have extra ring structures. As esters or epoxides, these happen as side replacements (Hoffmann 2003).

Many medicinal plants contain active ingredients called diterpenoids. Vitamin K1, a diterpene with antihemorrhagic properties, was initially identified in plants in 1929. Called a "carotenoid" along with other related chemicals, vitamin A is a diterpenoid. Furanoditerpenes are bitter elements

of *Jateorhiza palmata* commonly known as calumba root. Neoclerodane-type diterpenes are produced by *T. scorodonia* (wood sage) & *Teucrium chamaedrys* (wall germander), both members of Labiatae family. They have antirheumatic and diaphoretic properties in herbal therapy. Diterpenes, like all other classes of terpenes, have shown a variety of pharmacological characteristics, such as antiprotozoal, antibacterial, antifungal, analgesic, and antineoplastic effects (Hoffmann 2003). Regarding the gypsy moth, some diterpenes from *Kalmia latifolia* (Ericaceae) have antifeedant qualities. Gibberellins are diterpenoid acids that were first discovered in fungus of genus *Gibberella* & they also present in higher plants. They have a significant impact on the growth of seedlings. (Evans, 2009)

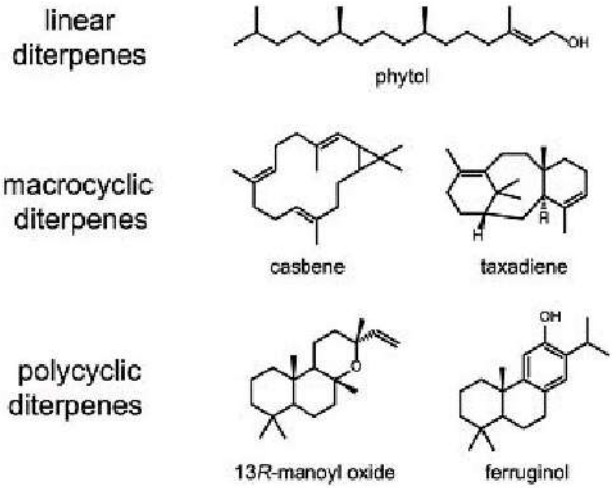


Fig 8: Illustrations of diterpenes

5.5 Triterpenes

They consist of 6 isoprene units which have the chemical formula C30H48 (Figure 9). Primary component of shark liver oil, linear triterpene squalene, is produced by reductive coupling of two farnesyl pyrophosphate molecules. All plants contain lipid compounds that are mostly composed of triterpenes; there are roughly 4000 triterpenoids known to exist. In both flora & fauna, these substances serve as the building blocks for steroids. Steroids and triterpenes can be found alone, as glycosides, or in other combinations. There are roughly 40 main categories into which the structures of steroids and triterpenes can be separated (Seigler 1995). Two triterpenes, α-boswellic acids (of the oleanane type) & β-boswellic acids (of the ursane type), are

found in the oleo-gum-resin of Boswellia carterii and are well-known for their anti-inflammatory and anti-rheumatic qualities. A class of substances exhibiting a variety of intriguing biological properties are the quassinoids that are separated from *Quassia amara*. These are the byproducts of triterpene breakdown and rearrangement. Insecticides, bitter tonics, and enemas for thread worm expulsion are all applications for quassia. Together with polyterpenes & norisoprenoids (long chains of several isoprene units), terpenes also comprise sesquarterpenes (Seven isoprene units, C35H56), tetraterpenes (Eight isoprene units, C40H64) & other compounds.

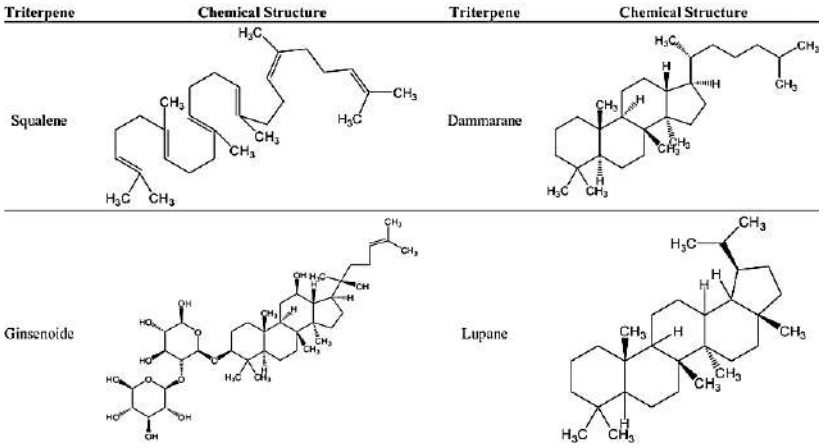


Fig 9: Illustrations of triterpenes

6. Lipids

The term "lipids" refers to a group of naturally occurring substances that includes sterols, waxes, essential oils, fixed oils, phospholipids, & fat-soluble vitamins (e.g. A, E, D, & K). Lipids are not only vitamins and hormones, but they also have structural functions in all biological membranes, serving as fuel for cellular processes and energy reserves (Subramaniam *et al*. 2011; Fahy *et al.* 2009). Lipids are thought to be fundamental plant metabolites, however recent studies have revealed that they also have medicinal effects.

6.1 Fixed oils

Heavy molecular aliphatic long-chain fatty acids esterified with glycerol, such as oleic acids, palmitic & stearic, make up fixed oils. According to Fahy *et al.* (2009), fats are mostly composed of solid glycerides like glycerin stearate, whereas fixed oils have a comparatively

higher % of liquid glycerides (polyunsaturated) like glycerin oleate. *Linum usitatissimum*, a member of the Linaceae family, is the source of flax and linseed oil. Certain fixed oils contain polyunsaturated fatty acids, which have strong anti-inflammatory & antioxidant characteristics because to their reduced excretion of lipid peroxidation products. They mostly used preventatively to lower the risk of atherosclerosis & cardiovascular disease.

6.2 Waxes

Lipid matter primarily composed of lengthy aliphatic chains with one or several functional groups can be found in waxes. They might have hydroxyl groups, just like long-chain alcohols (primary and secondary), which are commonly found as esters. Others have carboxylic, ketonic, aldehydic, aromatic systems, unsaturated bonds, or amide functional groups. Conversely, long-chain hydrocarbons without functional groups—alkanes or paraffins—make up synthetic waxes. Given that they are fatty acid esters, they resemble fixed oils and fats with the exception that the alcohol is not glycerin. Straight chain esters of fatty acids & alcohols make up jojoba wax, a liquid wax derived from *Simmondsia chinensis* seeds. Jojoba wax can be used for a variety of skin disorders because of its anti-inflammatory, anti-aging, and wound-healing properties. Jojoba wax has also been utilized to improve drug absorption in topical treatments. Furthermore, it is a component of cosmetics and skin care products like moisturizers and sunscreens.

6.3 Essential oils

Essential oils are complex combinations of volatile aromatic chemicals with relatively low molecular weight. They can include up to 60 components, but what makes them unique is that they have 2 or 3 primary components in relatively high concentrations (20–70%), while the other components are only present in trace amounts. For instance, two main constituents of *Origanum compactum* essential oil are thymol (27%) & carvacrol (30%). Up to 68% of essential oil of *Coriandrum sativum* is made up primarily of linalol. Additional instances include the essential oil of Artemisia herba-alba, which has α- & β-thuyone (57%) & camphor (24%) as its primary constituents; *Cinnamomum camphora*, which has 1,8-cineole (50%) as its primary constituent; & *Mentha piperita*, which has menthol (59%) & menthone (19%) as its primary constituents. According to Pichersky *et al.* (2006), these primary constituents typically dictate biological characteristics of the essential oils. They are used in medicine for a wide range of conditions, including spasmolytic, analgesic, sedative, antibacterial, antiseptic, and locally anesthetic treatments.

7. Carbohydrates

All organisms on our planet that are living contain carbohydrates. Carbohydrates, the primary byproduct of photosynthesis, serve as the building block for all phytochemicals and, consequently, all biochemicals found in animals. More cars than any other kind of natural chemical can be found in nature. Cellulose, a polymer of glucose and primary structural component of plants, is most prevalent organic compound on Earth. Despite being primary metabolites, carbohydrates are integrated through glycosidation links into a huge number of secondary metabolites. Gums & mucilage are polymers of uronic acid and simple sugars (Asif *et al.* 2011).

Carbon, hydrogen, and oxygen make up carbohydrates; the latter 2 components are frequently found in same ratios as those found in water. The four chemical classes into which they are divided are oligosaccharides, polysaccharides, disaccharides, and monosaccharides. Monosaccharides can have three, five, or six carbon atoms; however, the majority of them are found in plants in the form of pentoses ($C_5H_{10}O_5$) and hexoses ($C_6H_{12}O_6$). Depending on how many saccharide units are involved, the condensation of monosaccharides produces the other kinds.

Carbohydrates play a vital biological and structural role in plants, but some species, like mucilage, can have therapeutic properties. Mucilage, a sticky, viscous material present in almost all plants and some microorganisms, aids in the thickening of plant membranes for defense. It also aids in seed germination & storage of food & water. It is composed chemically of an exopolysaccharide and a polar glycoprotein. Mucilage is a demulcent used in medicine. The main sources of mucilage are *Linum usitatissimum* (flax seeds) and cacti and other succulent plants. Due to its sedative properties, extract from mucilaginous root of *Althaea officinalis* plant, which is typically used to produce marshmallows, has been used as a cough suppressant. Because *Ulmus rubra* (the slippery elm) has a mucilaginous composition, its inner bark is also employed as a demulcent. When mucilage comes into direct touch with skin or mucous membrane surfaces, it primarily functions as a local demulcent or emollient. Here, they create a "slime" layer that calms and shields the gastrointestinal tract's exposed or inflamed areas. They are widely utilized in the treatment of inflammatory gastrointestinal conditions, particularly ulcerative ones. Bowel behavior is significantly impacted by their respective indigestibility and hydrophilic qualities (Anbalahan, 2017).

8. Conclusion

High phytochemical variety structures can only be found in nature, and many of them have intriguing biological functions as well as therapeutic qualities. The aforementioned information indicates that the biological effects of herbal remedies are caused by a number of kinds of secondary plant metabolites. Eventually, plant secondary metabolites function on different molecular targets based on the circumstances. These targets may include transcription factors, enzymes, mediators, and even nucleic acids. In order to identify the chemical components of the plants involved, thorough phytochemical investigations should form the basis for the use of herbal medicines. Therefore, it is feasible to infer the pharmacological and toxicological consequences that follow from the use of several component herbal formulations, as well as potential synergistic or antagonistic effects. Because of this, the field of secondary plant metabolite isolation & structural elucidation is still vast and expanding, and techniques for analysis and separation are constantly improving. More in-depth research on the pharmacological actions of metabolites and their possible applications in human health are made possible by the development of effective extraction techniques and the array of techniques available for the examination of the extracts of these medicinal plants.

References

1. Al-Gabbiesh A, Kleinwächter M, Selmar D. Influencing the contents of secondary metabolites in spice and medicinal plants by deliberately applying drought stress during their cultivation. Jordan J Biol Sci. 2015;8(1):1-10.
2. Anbalahan N. Pharmacological activity of mucilage isolated from medicinal plants. Int J Appl Pure Sci Agric. 2017;3(1):98-113.
3. Asif HM, Akram M, Saeed TM, Khan I, Akhtar N, Ur Rehman R, *et al*. Review paper carbohydrates. Int Res J Biochem Bioinform. 2011;1(1):1-5.
4. Assa Y, Shany S, Gestetner B, Tencer Y, Birk Y, Bondi A *et al*. Interaction of alfalfa saponins with components of the erythrocyte membrane in hemolysis. Biochim Biophys Acta. 1973;307(1):83-91.
5. Bourgaud F, Gravot A, Milesi S, Gontier E. Production of plant secondary metabolites: a historical perspective. Plant Sci. 2001;161:839-51.

6. Catarino MD, Silva AMS, Cruz MT, Cardoso SM. Antioxidant and anti-inflammatory activities of *Geranium robertianum* L. decoctions. Food Funct. 2017;8(9):3355-65.

7. Evans WC. Pharmacognosy. 16th ed. Edinburgh, London, New York, Philadelphia, St Louis, Sydney, Toronto: Saunders; 2009.

8. Fahy E, Subramaniam S, Murphy RC, Nishijima M, Raetz CR, Shimizu T, *et al*. Update of the LIPID MAPS comprehensive classification system for lipids. J Lipid Res. 2009;50(Suppl):S9-14.

9. Harborne JB. An overview of antinutritional factors in higher plants. In: Caygill JC, Mueller-Harvey I, editors. Secondary plant products: antinutritional and beneficial actions in animal feeding. Nottingham (UK): Nottingham Univ Press; 1999. p. 7-16.

10. Hoffmann D. Medical herbalism: the science and practice of herbal medicine. Rochester (VT): Healing Arts Press; 2003.

11. Ingenuity. Science. 2006;311(5762):808-11.

12. Jones ME, Kossel A. A biographical sketch. Yale J Biol Med. 1953;26(1):80-97.

13. Moudi M, Go R, Yong Seok Yien C, Nazre M. Vinca alkaloids. Int J Prev Med. 2013;4(11):1231-5.

14. Mueller-Harvey I, McAllan AB. Tannins: their biochemistry and nutritional properties. In: Morrison IM, editor. Advances in plant cell biochemistry and biotechnology. London (UK): JAI Press Ltd; 1992. Vol. 1, p. 151-217.

15. Pichersky E, Noel JP, Dudareva N. Biosynthesis of plant volatiles: nature's diversity and plants. J Pharm Phytochem. 2013;1(6):168-82.

16. Pridham JB. Phenolics in plants in health and disease. New York: Pergamon Press; 1960. p. 34-5.

17. Puneet G, Aditi S, Vinayak K, Anant GN, Samir D, Nikhil M. *Camellia sinensis* (tea): implications and role in preventing dental decay. Pharmacogn Rev. 2013;7(14):152-6.

18. Saxena M, Saxena J, Nema R, Singh D, Gupta A. Phytochemistry of medicinal plants. J Pharm Phytochem. 2013;1(6):168-82.

19. Schofield P, Mbugua DM, Pell AN. Analysis of condensed tannins: a review. Anim Feed Sci Technol. 2001;91:21-40.

20. Seigler DS. Plant secondary metabolism. New York: Springer Science & Business Media; 1995.

21. Serafini M, Peluso I, Raguzzini A. Flavonoids as anti-inflammatory agents. Proc Nutr Soc. 2010;69(3):273-8.

22. Spiller F, Alves MK, Vieira SM, Carvalho TA, Leite CE, Lunardelli A, *et al*. Anti-inflammatory effects of red pepper (*Capsicum baccatum*) on carrageenan- and antigen-induced inflammation. J Pharm Pharmacol. 2008;60(4):473-8.

23. Subramaniam S, Fahy E, Gupta S, Sud M, Byrnes RW, Cotter D, *et al*. Bioinformatics and systems biology of the lipidome. Chem Rev. 2011;111(10):6452-90.

24. Tadeusz A. Alkaloids: chemistry, biology, ecology, and applications. 2nd ed. Amsterdam (NL): Elsevier; 2015. ISBN: 978-0444594334.

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 10
Use of Some Traditional Medicinal Plants in Ayurveda for Diseases

Authors

Raj Kumar Singh Bharti
Faculty of Pharmacy, School of Pharmaceutical Sciences, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Sushil Kumar
Faculty of Pharmacy, School of Pharmaceutical Sciences, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Krishna Kumar
Department of Pharmaceutical Chemistry, Uttaranchal Institute of Pharmaceutical Sciences, Uttaranchal University, Dehradun, Uttarakhand, India

Swatantr Bahadur Singh
Faculty of Pharmacy, School of Pharmaceutical Sciences, IFTM University Lodhipur Rajput, Moradabad, Uttar Pradesh, India

Ravi Kumar
DMR College of Pharmacy, Kanth road Moradabad, Uttar Pradesh, India

Yogesh Kumar
Rajkiran College of Pharmacy, Near Rampur Doraha, Zero Point Dehli Road Moradabad, Uttar Pradesh, India

Paperback ISBN: 978-93-6135-630-8 *E- Book ISBN: 978-93-6135-161-7*

Chapter - 10

Use of Some Traditional Medicinal Plants in Ayurveda for Diseases

Raj Kumar Singh Bharti, Sushil Kumar, Krishna Kumar, Swatantr Bahadur Singh, Ravi Kumar and Yogesh Kumar

Abstract

Plants with medicinal properties are important sources of readily available remedies used in rural healthcare systems. The purpose of this study was to identify and document plants utilised for medical therapy by three groups in the Cherangani Hills. So far, no single study has documented the entire area's medicinal plant population. Traditional medicine makes use of cultural knowledge and traditions to promote health while also diagnosing and treating disease. The majority of people in underdeveloped nations use traditional medicines; yet, many of these practices have not been properly and systematically examined or documented.

I review the current understanding and research regarding traditional therapies used in the Indian subcontinent, such as mind-body and energy-based therapy, botanical medicine, and herbal cures. Topics addressed include Ayurveda, yoga, naturopathy, Unani, Siddha, Sowa-Rigpa, homoeopathy, and medicinal herbs including Ashwagandha, guggul, tulsi, amla, and turmeric etc.

Keywords: Medicinal plant, traditional uses, turmeric, siddha and Ayurvedic

Introduction

Medicinal plants have been a vital source of both therapeutic and protective medicinal therapeutic preparations for humans, and they have also been used to extract significant bioactive chemicals. It is estimated that about 80% of the global population relies on traditional medicine and goods for their healthcare requirements, particularly in third-world countries. Many sick persons in poor countries combine conventional medicine and traditional medicine. Traditional medicines are typically less expensive than

modern pharmaceuticals, and they are likely the only natural therapies available and accessible in distant rural communities in underdeveloped countries.

India and bordering nations, including Pakistan, Nepal, Sri Lanka, and Bangladesh, have long-standing healing practices that complement or substitute traditional medicine 2. These traditions include.

Ayurveda

Ayurveda is a natural medicine system that originated in the Indian subcontinent. Ayurveda is widely used in India and Nepal, where as much as eighty percent of the overall population claims to utilize it.

"Ayurveda" comes from Sanskrit to "life-knowledge," and it refers to a medical system that has been employed for millennia. Ayurvedic remedies are based on unique botanical components, minerals, and metal elements. While some believe Ayurveda to be a sort of supplemental and alternative medicine, in many rural areas, it functions as the sole "medicine."

Yoga and Naturopathy

Yoga represents the art of everyday life. It's about getting to know oneself. Yoga is a healing system that combines physical exercise, mental focus, and meditation. The beauty of yoga is that it is accessible to everyone, as the session can be tailored to each individual's physical fitness or health status. Naturopathy is a holistic approach to treatment that addresses preventive through diet and lifestyle, as well as social, environmental, genetic, and mental factors influencing health. The emphasis is on helping the body repair itself. Botanical medicine is part of this heritage.

Fig 1: During the Yoga

Unani

Unani medicine, just like western medicine, is claimed to be founded by the Greek scholar Hippocrates was with contributions from Galen and Aristotle. It was further refined in Arabian countries before being introduced to India by the Arabs around 1350 CE, where it was practiced in Mughal India and Muslim cultures throughout South Asia. Unani medicine connected with Indian Buddhist medicine during Alexander's invasion of India.

The theory is founded on the idea that the body is made up of four elements (Earth, Air, Water, and Fire) with varying temperaments (Cold, Hot, Wet, Dry), and that health is a balance of four humors: phlegm, blood, yellow bile, and black bile. Unani diagnoses disease by examining the pulse, stool, and urine, and therapies focus on restoring normal bodily tissues and organs through dietary adjustments, herbal remedies, vigorous physical activity, and massage therapy.

Siddha

The Siddha tradition of medicine is one of India's traditional medical systems that originated from Ancient culture. Siddha medicine is derived from Tamil culture in South India. The core idea is that a healthy soul can only be obtained through a healthy body; thus, food and yoga/meditation as mind-body activities are essential to this therapeutic method. Siddha medicine and Ayurveda share many similarities, including the goal of balancing the three doshas.

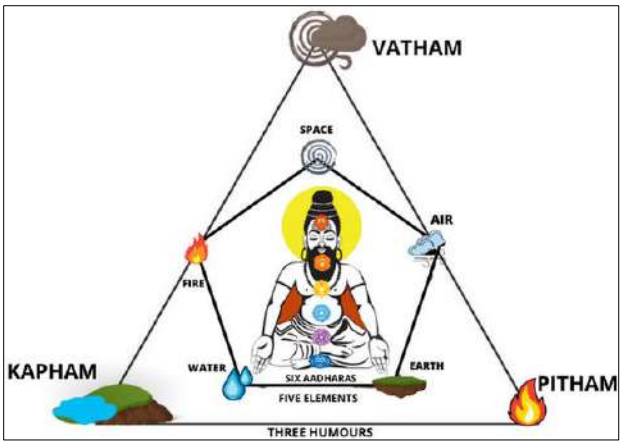


Fig 2: Siddha system

Homeopathy

Homoeopathy is a personalized approach to treatment that promotes self-regulation and healing. Homoeopathy (or homoeopathy) is a 200-year-old form of complementary therapy that purports to trigger a healing response and improve the body's ability to repair itself. Because each person is unique, homoeopathic medications are used to treat individuals. The usefulness of homoeopathy has yet to be demonstrated by medical research. There is no homoeopathic vaccination, and homoeopathic medications do not substitute conventional medical care for severe illnesses or epidemics.

What is medicinal plant?

Medicinal plants, often known as medicinal herbs, have been identified and employed in traditional medicine practices since ancient times. Plants produce hundreds of chemical compounds for a variety of purposes, including defense and protection against insects, fungus, parasites, and herbivorous mammals. Herbs have been utilised as medicine for thousands of years around the world. In the United States, the FDA regulates the safe use of herbal supplements. However, they are not subject to the same tight controls as prescription medications. It's critical to understand the herbs you're using.

The nutritional value of herbs is very important. Some companies use fillers. This helps to keep their herbal supplements affordable. However, they may not perform as well. Alternatively, they may induce adverse effects. Even if something is natural, it might not be safe. The following are common herbal remedies that research has proved to be safe and effective when used correctly. Always inform your healthcare providers if you take any herbs or supplements. They need to know if they will create difficulties when coupled with other medications you use.

Some important medicinal plant who used in traditional

Natural remedies such as aloe, tulsi, ginger, and turmeric can treat common problems quickly. Recipes are created utilizing medicinal plants to treat common problems such as diarrhoea, constipation, hypertension, low sperm count, dysentery, weak penile erection, coated tongue, menstrual disorders, and fevers. As a result, they are regarded home remedies in many areas of the country.

S. No	Name of Plants with family	Parts of plant	Uses of Medicinal Plant
1.	**Aloe** (*Aloe barbadensis*)	Leaves	Extract a bitter yellow juice with aloin and polysaccharide gel. In cosmetics and medicinal formulations, it is used as a moisturizer, emollient, or wound healer, as well as in the flavoring of anti-obesity liquors.
2.	**Amla** (*Emblica officinalis)*	Fruits, Leaves, Bark etc.	Amla represents one of the most significant herbs in traditional medicine. It is often used as a hair oil to improve hair shaft strength, promote hair growth, and prevent premature thinning. Some societies use it to cure scabies by roasting or crushing the seeds and applying an oil combination to the affected region.
3.	**Ashwagandha** (*Withania sominifera*)	Roots and seeds	Used for aphrodisiac, remunerative tonic, diuretic, hypnotic, sedative, and restorative purposes. It also helps with rheumatism, cough debility from old age, dropsy, and general weakness. Leaf paste treats tubercular gland inflammation, bronchitis, skin disorders, and ulcers. Ashwagandha is a key component in Siddha and Unani remedies.
4.	**Chamomile** (*Matricaria recutita*)	Flower	Chamomile is commonly used for anxiety and relaxation. In Europe, it is used to treat wounds and reduce inflammation and swelling. Chamomile for the skin can help alleviate radiation-induced skin rash. Chamomile capsules may be used to relieve chemotherapy-induced vomiting.
5.	**Coneflower** (*Echinacea purpurea*) *L*	(Leaf, stalk, root)	Echinacea is commonly used to cure or prevent colds, flu, and infections, as well as to promote wound healing and help with upper respiratory infections. Many researches have been conducted to determine how effective it is at preventing or shortening colds.
6..	**Dioscorea** (*Dioscorea floribunda*)	Yam tubers	Diosgenin serves as a beginning element for the production of steroids. In the production of oral contraceptives, used for edible tubers.
7.	**Feverfew** (*Tanacetum parthenium*) L.	(Leaf)	Feverfew is used to treat fevers. Some studies have suggested that feverfew can help avoid migraines. It is also prescribed to treat arthritis. Chewing the leaves might cause mouth sores and intestinal distress.
8.	**Garlic** (*Allium sativum*)	(Cloves, root)	Garlic is used during cookery. It also has proven health benefits. Garlic has been demonstrated to help fight bacteria, protect the heart, and reduce inflammation. It may assist to reduce cholesterol and blood pressure.

9.	**Ginger** (*Zingiber officinale*)	(Root)	Ginger is best known for reducing nausea and motion sickness. According to research, it may aid with nausea caused by pregnancy or chemotherapy. Ginger is being studied for surgical applications as well as anticancer properties. It has strong anti-inflammatory properties. It is also a powerful antioxidant. Bloating, gas, heartburn, and nausea are some of the possible side effects.
10.	**Ginkgo** (*Ginkgo biloba*)	(Leaf)	Ginkgo leaf extract is used to treat asthma, bronchitis, tiredness, and tinnitus. It helps to strengthen memory and prevent dementia. Some research has indicated that it may work marginally. However, the exact mechanism by which gingko acts remains unknown.
11.	**Ginseng** (*Panax ginseng*)	(Root)	Ginseng is claimed to improve vitality, sex desire, and overall health. The benefits have yet to be determined by research. High blood pressure and a rapid heartbeat are possible side effects. Ginseng should not be used by those with diabetes.
12.	**Goldenseal** (*Hydrastis Canadensis*)	(Root, rhizome)	Goldenseal can treat diarrhoea. It can relieve eye and skin discomfort. It can serve as an antiseptic. It is not proven to treat colds. Use it with caution. Too much might irritate the skin, mouth, and stomach. Always follow your healthcare provider's directions. Goldenseal can be toxic in excessive amounts.
13.	**Glory Lil** *(Gloriosa superba*)	Leaves, tubers	The plant's tubers are antiperiodic, anthelminthic, and prevent snake bites, labour pains, and scorpion stings. Effective in the treatment of chronic ulcers, piles, and gonorrhoea. To treat asthma, leaves are removed and put as a paste to children's necks and foreheads.
14.	**Isabgol** (*Plantago ovate*)	Whole plant	The seed husk has the ability to absorb water and is thus used as an anti-diarrhea medicine as well as to treat chronic amoebic dysentery.
15.	**Milk thistle** (*Silybum marianum*)	(Fruit)	Milk thistle is used to treat liver disease and high cholesterol. It is also used to inhibit the proliferation of cancer cells. The study results are unclear regarding its true benefits for liver illness.
16.	**Nuxvomica** (*Strychmus nuxvomica*)	Seeds	In minute doses, it is used to treat nerve diseases and paralysis, as well as for insect elimination.
17.	**Periwinkle** (*Catharanthus roseus*)	Roots, leaves and Seeds	The plant's alkaloids, including as rebasing and serpentine, have been used to treat hypertension and spasms. The leaves contain vincristine and vinblastine, which are utilized in cancer treatment. Vinblastine sulphate, brand name VELBE, is used to treat Hodgkin's disease.

18.	**Poppy** (*Papaver somniferum*)	Flower	Plants with psychoactive compounds can be utilized to treat mental and nervous disorders. Poppy, commonly known as Opium poppy, is an annual herb that belongs to the Papaveraceae family. The plant grows to 60-120 cm tall and contains about 40 alkaloids.
19.	**Rauvolfia** (*Rauvolfia serpentine*)	(Roots)	The roots are an essential component of Ayurvedic and Un.ani treatments in India. Used to treat central nervous. System problems such as mania, insanity, and schizophrenia.
20.	**Saw palmetto** (*Serenoa repens*)	(Fruit)	Saw palmetto is used to treat urinary issues caused by an enlarged prostate. However, subsequent research h.as found that it is ineffective for this purpose. It may produce a little upset stomach or headaches.
21.	**Senna** (*Cassia angustifolia*)	(Leaves)	It is primarily used as a blood purifier, laxative (to relieve constipation), and to cure skin problems. It is commonly combined with herbal tea in European countries.
22.	**Tulsi** (*Ocimum sanctum*)	(Leaves/ seeds)	Tulsi is a popular traditional plant for treating moderate fevers, stress, headaches, and other simple diseases. The anti-oxidant properties lower blood pressure, prevent hypertension, and improve heart health.
23.	**Valerian** (*Valeriana officinalis*)	(Root)	Valerian has been proven to improve sleep and reduce anxiety. Research indicates that it may help as a sleep aid, although the results are mixed. Consult your doctor before taking it.

Know this before taking the herbal medicine

Before using any herb as medicine, consult your doctor. Tell them about all the medications and vitamins you take. They will need to ensure the herbal remedy is safe. Some herbs are not safe to combine with other medications. Ask them how much is safe for you to take. Follow their directions. Tell them if you have any side effects. Medicinal plants, as the name implies, are those that are utilised for medical purposes. Medicinal plants are those that contain high levels of secondary metabolites and could be used as medication sources. Secondary metabolites include alkaloids, glycosides, Coumarins, flavonoids, steroids, and so on.

Conclusion

Many diseases are being treated in Ayurveda, Its side effects are either less or negligible as compared to allopathy medicine. That's why we should mostly use Ayurvedic medicine which is being used traditionally. In today's

time, treatment of all diseases is possible through Ayurveda, we just need to have good knowledge of trees, herbs and plants, Which plant is more useful for which disease, that can cure the disease? So we should know most of the medicinal plants which are being used traditionally.

Reference

1. Dasaroju S, Mohan Gottumukkala K. Current trends in the research of *Emblica officinalis* (Amla). A pharmacological perspective; 2014. p. 150-159.
2. Kinyanjui, MJ, Latva-Käyrä P, Bhuwneshwar PS, Kariuki P, Gichu A, Wamichwe K. An Inventory of the above ground biomass in the Mau forest ecosystem, Kenya. Open J Ecol. 2014;4:619-627.
3. Kumar VS, Navaratnam V. Neem (*Azadirachta indica*): prehistory to contemporary medicinal uses to humankind. Asian Pacific journal of tropical biomedicine. 2013;3:505-514.
4. Lambert J, Srivastava J, Vietmeyer N. Medicinal Plants. Rescuing a Global Heritage; World Bank: Washington, DC, USA; 1997.
5. Mahwasane ST, Middelton L, Boaduo N. An ethnobotanical survey of indigenous knowledge on medicinal plants used by the traditional healers of the Lwamondo area, *Limpopo province*. S. Afr. J Bot. 2013;88:69-75.
6. Musila W, Kisangau D, Muema, J. Conservation Status and Use of Medicinal Plants by Traditional Medical Practitioners in Machakos District; Kenya National Museums of Kenya: Nairobi, Kenya; 2000.
7. Popovic Z, Matic R, Bojovic S, Stefanovic M, Vidakovic V. Ethnobotany and herbal medicine in modern complementary and alternative medicine: An overview of publications in the field of I&C medicine 2001-2013. J. Ethnopharmacol. 2016;181l:182-192.
8. Rasool HB. Medicinal Plants. Importance and Uses. Pharmaceut. Anal. Acta. 2012;3:e139.
9. Ravishankar B, Shukla VJ. Indian Systems of Medicine. A Brief Profile. African Journal of Traditional, Complementary, and Alternative Medicines. 2007;4:319-337.
10. Rudra S, Kalra A, Kumar A, *et al*. Utilization of alternative systems of medicine as health care services in India: Evidence on AYUSH care from NSS 2014. PloS one. 2017;12:e0176916.

11. Thirumalai T, Kelumalai E, Senthilkumar B, David E. Ethnobotanical study of medicinal plants used by the local people in Vellore District, Tamil Nadu. Indian Ethnobot. Leafl. 2009;13:1302-1311.