

Medicinal Plant Research in Ayurveda: A Scientific Review of Traditional and Modern Applications

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Abstract

Ayurvedic medicine is a millennial health system practised in India since more than 3000 years ago, and makes use of a huge variety of plant materials to medicate themselves. The given review examines the historical role, type of classification, and pharmacology characteristics of Ayurvedic medical plants, along with their contemporary uses. We discuss the classical Ayurvedic system of classifying plants, which is in terms of taste (Rasa), intrinsic qualities (Guna), potency (Virya), post-digestive effect (Vipaka) and special qualities (Prabhava). The review also points at significant bioactive compounds, including curcumin, withanolides, and bacosides, speaking about their antioxidant, anti-inflammatory, and neuroprotective properties. Besides, we consider the spatial distribution of the most popular Ayurvedic plants along with their role shown both in the past and nowadays. This is also the case of integrating Ayurveda and modern scientific methods such as standardization, quality control, and biotechnology development. Regulatory, scientific validation, and sustainability issues continue to be an obstacle in spite of the promising prospects. The purpose of the review is to give a full picture of medicinal plants of Ayurveda leading to interdisciplinary cooperation in future studies and clinical practice.

Keywords: Ayurvedic medicine, medicinal plants, bioactive compounds, pharmacological effects, traditional medicine.

1. Introduction

1.1 Ayurveda and Its Significance in Traditional Medicine

Ayurveda is one of the oldest systems of medicine, whose roots date back more than 3,000 years, but still can be considered one of the most effective and universal approaches to healthcare. Ayurveda is a Sanskrit word, which means science of life and it focuses on the relationship of mind, body and spirit to maintain health and avoid disease. Ayurveda as compared to the modern medicine that mainly believes in symptomatic cure of diseases progresses towards prevention and personal curative practices. It also involves the use of several natural medicines, lifestyle changes and dietary restrictions to establish the balance in the body (Sharma & Clark, 1998). Another most significant aspect of Ayurveda is that it has vast repertory of medicinal plants on which Ayurveda based its pharmacological interventions. Charaka Samhita, Sushruta Samhita, Ashtanga Hridaya and ancient Ayurvedic texts mention the therapeutic values and properties of many of the plants with their classification according to their taste (Rasa), qualities (Gunas), potency (Viryas) of the post digestive effect (Vipaka) and any special action (Prabhava). This systematic division enables those concerned in the field to come up with the most appropriate plant based treatment to ailments. Because herbal medicine as a primary healthcare practice is used by more than 80 percent of the world population, Ayurveda remains significant in the holistic wellness of the people, particularly in India, Nepal, Sri Lanka and Southeast Asia (World Health Organization [WHO], 2023). This ever growing popularity of the effectiveness of Ayurveda in the management of diseases has caused researchers to delve into its other alternative uses even outside its traditional realm, such as its combination with modern biomedical science (Figure 1).

1.2 Role of Medicinal Plants in Ayurvedic Healing Practices

The Ayurvedic treatment systems revolve around medicinal plants as a source of natural and biocompatible and sustainable solutions to a number of diseases. Bioactive compounds found in these plants include alkaloids, flavonoids, tannins, saponins, polyphenols, and adaptogenic properties that provide antioxidant, anti-inflammatory, anti-microbial characteristics in these plants (Balkrishna et al., 2024). As a rule, Ayurvedic formulations require the combination of several plants in order to achieve their synergistic effect and reduce possible adverse effects. Ashwagandha (*Withania somnifera*) is an adaptogenic medicinal plant with properties in the management of stress and cognitive performance; Brahmi (*Bacopa monnieri*) is a neuroprotective plant used in memory enhancement; Neem (*Azadirachta indica*) has potent antimicrobial and anti-inflammatory effects, Tulsi (*Ocimum sanctum*) is an immune-enhancing plant with respiratory

health benefits, and a highly valued immunomodulatory and anti-diabetic plant is G. Such plants are prescribed by Ayurvedic physicians in numerous combinations, as powders (Churna), decoctions (Kwatha), semi-solid preparations (Avaleha) and calcined preparations (Bhasma) to treat an immensely broad range of ailments, including maladies of the metabolism and disorders of the nervous system. The popularity of these herbal remedies as alternative therapies and complementary therapies is on the rise considering that there is increased demand of natural and organic medical options.

1.3 Increasing Global Interest in Herbal and Alternative Medicine

The world is shifting towards herbal and alternative medicine due to numerous reasons such as the growing worries about the side effects of synthetics, the resistance of antibiotics and the rising frequency of lifestyle diseases. There is a growing trend by many consumers to inquire about a natural treatment, a holistic approach of treatment and one which is personalized, and the market of herbal medicine is growing by leaps and bounds. Other nations including the United States, Canada, Australia, and Germany have experienced a sharp rise in curiosity in the Ayurvedic formulations which has led regulatory authorities in these countries to consider how the herbal medicines can be included into national health policy (WHO, 2023). Insights on a few influential factors have helped in the mainstream lifestyle of Ayurveda and medicinal plant research. To begin with, scientific validation has been instrumental in proving credibility of Ayurvedic herbs whereby phytochemical and pharmacological research obviously proceeds in detecting potential active chemicals and their therapeutic potential.

Second, the Traditional Medicine Strategy developed by WHO has promoted the international standardization, safety examination and quality control of herbal products, which has further developed international collaborations on Ayurvedic research. Third, the industry of herbal supplements continues to grow exponentially, and it is expected to reach a global price of \$275 billion in 2030. Finally, the COVID-19 pandemic escalated the need to strengthen the immunity, leading to the increased governmental funding of herbal medicine studies. The arisings are a sign of a great and viable future of Ayurveda in the international health.

1.4 Need for Bridging Traditional Ayurvedic Knowledge with Modern Scientific Research

The history of Ayurveda spans centuries and it has proven its worth, but it is still facing problems in finding a way to integrate it with contemporary scientific studies. The absence of standardization and regulatory frameworks can be considered one of the key barriers since the plant species different growing conditions, and preparation method may produce different results when used in clinical applications. Also, the lack of large-scale randomised controlled trials (RCTs) has hampered the acceptance of the Ayurvedic medicines in the evidence-based medicine throughout the world. Most of the Ayurvedic drug plants are yet to be followed by pharmacokinetic and pharmacodynamic studies to know their absorption, degradation, and bioavailability in human body.

To overcome such a gap, scientists encourage the collaboration of Ayurveda and modern biotechnological developments. Quality control and purity testing can be improved by using the high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), and Fourier transform infrared (FTIR). Moreover, molecular research in terms of gene expression, and biochemical pathways may assist in clarifying the mechanism of actions of the bioactive compounds of medicinal plants. Moreover, nanotechnology based drug delivery systems have been found out as one of the promising means of enhancing the delivery, as well as bioavailability of herbal medicine and making them even more effective in terms of therapeutic efficacy. These challenges need to be addressed in an interdisciplinary research and collaboration of Ayurvedic scholars, pharmacologists, and clinicians, which will create a path towards the mainstream gateway of implementing Ayurveda into compatible modern-day healthcare.

1.5 Objectives of the Review

This review aims to:

- Examine the historical significance of medicinal plants in Ayurvedic practices.
- Analyze the therapeutic roles of key Ayurvedic medicinal plants in disease management.
- Evaluate modern scientific research validating the pharmacological and clinical efficacy of these plants.
- Identify challenges and opportunities in integrating Ayurvedic medicinal plants into contemporary healthcare.

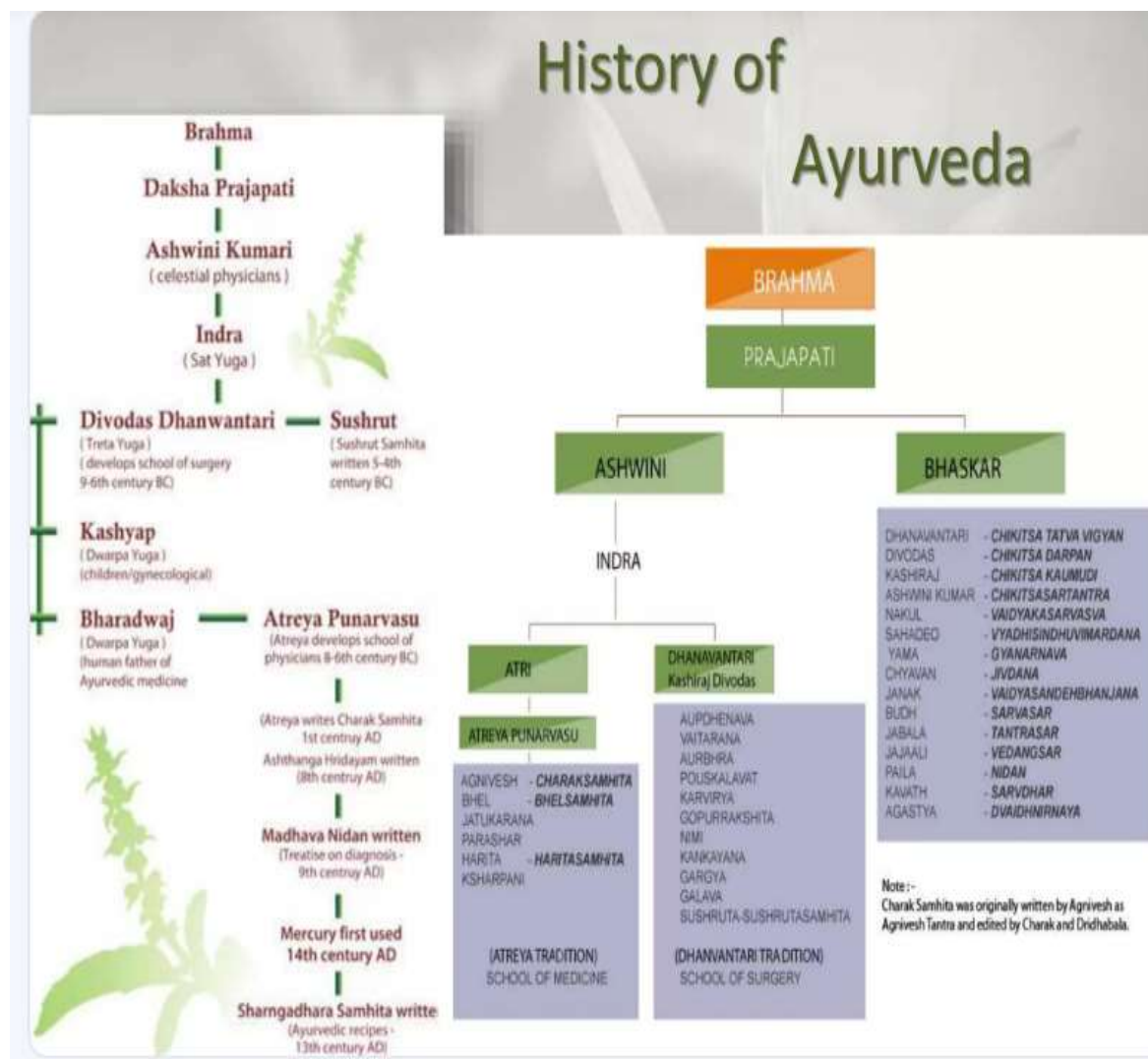


Figure 1: History of Ayurveda

Source: <https://www.slideshare.net/slideshow/ayurveda-simplified/57053838>

2. Historical and Theoretical Foundations of Ayurvedic Medicinal Plants

Ayurveda is an old medical system in which there exists a systematic and properly documented method of the medicative usage of the medicinal flora. Ayurvedic pharmacology theoretical basis revolves deeply into the aspect of Dravyaguna Vijnana or the categorization of the medicinal substances in terms of their inherent characters and effects. Some of the classical texts like Charaka Samhita, Sushruta Samhita, and Ashtanga Hridaya are used as the references on Ayurveda studies of medicinal plants. Moreover, the ethnobotanical knowledge including indigenous and cultural view of the plant-based healing are important to the development of Ayurvedic medicine. The integrations of Ayurveda into the modern research of medicines of the scientific world need to learn these theoretical and historical points.

2.1 Ayurvedic Pharmacology Principles (*Dravyaguna Vijnana*)

Ayurveda has a system of study of medicinal plants, the study of the properties of materials and substances (*Dravyaguna Vijnana*), also known as the science of substances and their properties. This field holds the system to comprehend the pharmacology of herbs by using the five important qualities called Rasapanchaka. These qualities can guide the practitioners in establishing how medicinal plants react in the human body and this is a key aspect in the formation of effective treatment procedures. The first one, Rasa (Taste), is the primary sensation that is experienced when one tastes a substance and dictates the therapeutic effect of the substance. According to Ayurveda there exist six basic tastes namely Madhura (sweet), Amla (sour), Lavana (salty), Katu (pungent), Tikta (bitter) as well as Kashaya (astringent). The effects of each taste on the digestion, metabolism as well as doshic balance are different. Guna (Qualities) is the qualities of a

medicinal plant: heaviness, lightness, dryness or unctuousness. These properties affect the way that the herb behaves with body systems. Virya (Potency) is the power of substances that can be classified as Ushna (or hot), or Shita (or cold) to determine their metabolic and physiological functioning. Vipaka (Post-digestive Effect) is the state of change which takes place subsequent to digestion and affects long-term therapeutic effect. Finally, Prabhava (Unique Action) is described as a unique action which cannot be elucidated through the other four attributes and is actually an indication of how complex and specific Ayurvedic pharmacology is. In contrast with the current pharmacology approach of almost exclusive focus on isolation of active compounds, Ayurveda pays attention to synergism of medicinal plants. Ayurveda is a completely personalized approach to treating different diseases by studying the holistic effect of herbs using the Dravyaguna Vijnana.

2.2 Ayurvedic Formulations and Their Therapeutic Applications

The Ayurvedic medicine is based on a wide range of medicines used to increase the action of medicinal plants and guarantee their high bioavailability. This is carefully prepared according to the principles of synergistic action, as used in a number of herbs combined in such a way that, balanced and potent formulations are obtained. There are mainly four forms of Ayurvedic formulations: Charak, Kwatha, Avaleha and Bhasma and all these types of formulations have their own purposes of therapeutic characters. Churna (Herbal Powders) finely powdered herbs mixture are readily absorbed into the body swiftly which is usually employed in case of digestive and metabolic disorders. Triphala Churna is one such common example, where three fruits are combined in order to maintain the well-being of the gastrointestinal system and detoxification. Kwatha (Decoctions) are herbal extracts which are extracted by boiling in water the dried herbs of plants. This is because the active compounds are concentrated later after the process, thus making it effective in conditions that need deep tissue penetration. A typical example is Guduchi Kwatha to be used in immune boost and detoxification. Avaleha (Herbal Confections) in which the medicine in the form of medicinal herbs is mixed with honey, ghee or sugar to enhance palatability and bioavailability. Probably, the most famous of all Avalehas is Chyawanprash, an adaptogenic antioxidance boosting formulation. Bhasma (Calcinated Preparations) are compounds of minerals or metals which have severe purification steps to attain their safety and efficacy. Such preparations are commonly recommended in refractory cases including anemia and chronic respiratory diseases. The accuracy in the preparation procedures which is employed in Ayurveda warrants the stability, strength, and long-term efficacy of these preparations, hence, becoming a part of traditional curative techniques (Figure 2).

2.3 Contributions of Classical Ayurvedic Texts to Medicinal Plant Research

The traditional knowledge of the medicinal herbs in Ayurveda is contained in three major classical texts also referred to as the Brihat Trayi (Great Trilogy). These ancient writings contain elaborate descriptions of herb classification, drug prescriptions and their medical use. The Charaka Samhita which is regarded as the compendium to the internal medicine, explains more than 341 medications plant as well as their corresponding impacts on different physiological body organs. It allows access to the information about herbal combinations, nutrition advice, and detox programs that promotes the whole health. The Sushruta Samhita which is mostly known best with regard to surgery (Shalya Tantra), also contains lengthy information with regard to medical plants that are used in wound cure, healing surgical aftereffects (post operative medicines, treatment), and also as post treatment drugs. It provides a list of antiseptic solutions, herbal dressing, and analgesics which are still useful and applied in current wound treatment. A more systematic classification of medicinal plants is found in the Ashtanga Hridaya, a synthesis of the teachings by Charaka, Sushruta, etc. It combines plant prescriptions based on disease and it becomes a functional book of reference to Ayurvedic health practitioners. The writings are not only historical literature on Ayurvedic herbal medicine, but also forms the main source of contemporary research in ethnopharmacology and herbal medicines.

2.4 Ethnobotanical Insights in Ayurveda and Cultural Significance of Medicinal Plants

Ethnobotany or the study of human relation with plants has been very relevant in the coming up of Ayurveda. Some of the medicinal plants used in Ayurveda were discovered over centuries of native knowledge through the scattered tribal communities and received information on plant-based remedies by the local healers. This traditional knowledge is a key to connect the cultural wisdom with the scientific study and provide the knowledge on sustainable harvesting mechanisms, seasonality and the ecological conservation of medicinal plants. Reports of their use in Indian indigenous communities for skin infections (Neem [*Azadirachta indica*]), wound healing (Turmeric [*Curcuma longa*]), or respiratory ailment (Holy Basil [*Ocimum sanctum*]) extend back to many centuries. Ayurveda makes use of such insights in the healing process by making sure that the plant-based remedies correspond to the natural course and being environmentally friendly. Moreover, differences between the methods of Ayurvedic plant usage in various regions speak about the flexibility of the herbal treatment to common climate conditions and culture of the region. An example is that, according to tradition, Amla (*Phyllanthus emblica*) is utilized as a digestive tonic in North India, but in the south India, the parts are included in the formulations of rejuvenating herbs. Ayurveda underlies the patients reliance on the ethnobotanical knowledge and pharmacological study, it is important to recognize that keeping such biodiversity alive will require making them relevant

to modern medicine. This is where conventional healing meets scientific confirmation and entrepreneurs are opening the path to a more sustainable and holistic solution to global healthcare (Table 1).

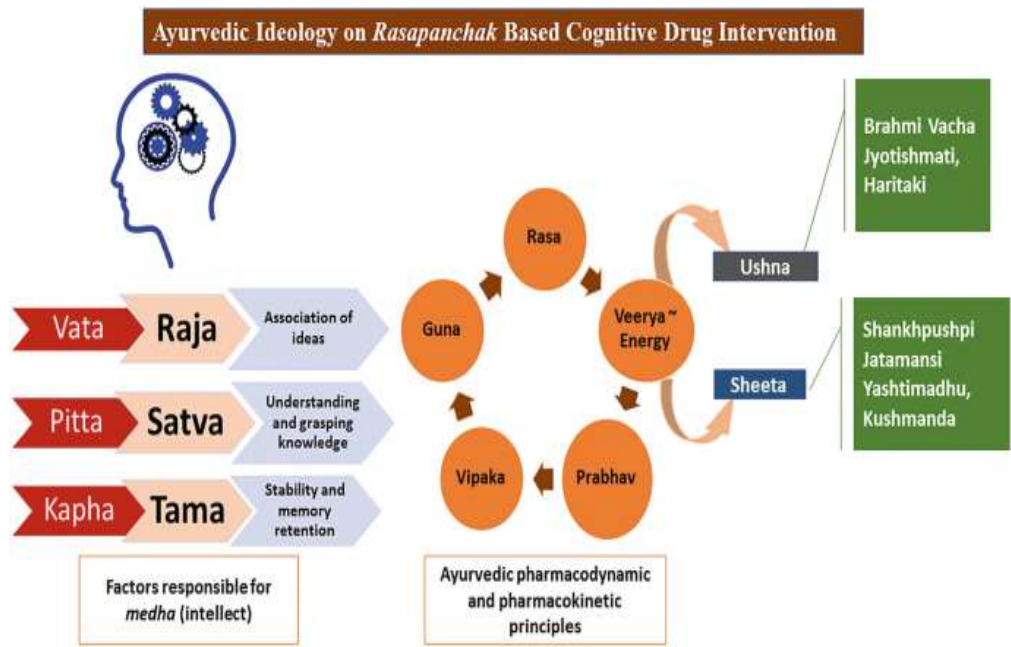


Figure 2: Ayurvedic Classification of Medicinal Plants
Source: Ranade *et al.*, 2021

Table 1: Comparative Overview of Major Ayurvedic Texts and Their Contributions to Medicinal Plant Research

Classical Text	Focus Area	Number of Medicinal Plants Documented	Unique Contributions
Charaka Samhita	Internal Medicine (Kaya Chikitsa)	341	Detailed pharmacology of plants, dietary therapies
Sushruta Samhita	Surgery & Post-Operative Care	200+	Wound healing herbs, antiseptic formulations
Ashtanga Hridaya	Comprehensive Ayurveda	200+	Systematic classification of medicinal plants

3. Traditional Ayurvedic Applications of Medicinal Plants

One of the most powerful traditional medicines based on plants was Ayurveda that helped to establish the balance and bring health back. The Ayurvedic philosophy is a holistic approach which does not only look at the symptoms but the ailments as well and remedial plants are important in this regard. The most common Ayurvedic herbs are Ashwagandha (*Withania somnifera*), Brahmi (*Bacopa monnieri*), Neem (*Azadirachta indica*), Tulsi (*Ocimum sanctum*) and Guduchi (*Tinospora cordifolia*). The plants are widely employed due to their rare medicinal qualities, which contain properties to relieve stress, also to improve cognition power, as well as antimicrobial and immunostimulant properties (Table 2). The classical Ayurvedic literature has the Ayurvedic text as Charaka Samhita, Sushruta Samhita and Ashtanga Hridaya documenting their use in medicine and modern literature has the same revealing the validity of the medicinal benefits of them (Sharma & Clark, 1998).

3.1 Ashwagandha (*Withania somnifera*) – Adaptogen and Stress Relief

Ashwagandha (scientific names known as Ovies: Indian ginseng, winter cherry) are an Ayurvedic form of medicine listed as a Rasayana (rejuvenating herb). It is commonly known to have adaptogenic qualities that aid the body with stresses, fatigue as well as anxiety. Historically Ashwagandha is utilized as a potentiator in vitality, an increase in energy levels, and as a reproductive enhancer. Ayurvedic doctors always prescribed Ashwagandha in their treatment of lowering the content of cortisol in the human body as it is a hormone inducer of stress and triggers the state of mental alertness and mind-rest. In the Ashwagandha root, the main place of application of the material is Ashwagandha Churna (powder) and Ashwagandha Lehyam (herbal jam). Ashwagandha importantly alleviates the condition of anxiety and depression and

also enhances physical endurance and muscle strength (Chandrasekhar et al., 2012). The herb is also useful to people with nervous exhaustion and insomnia hence it is an amazing adaptogen in the Ayurvedic medicine.

3.2 Brahmi (*Bacopa monnieri*) – Cognitive Function and Memory Enhancement

Brahmi, which has been accorded sacrosanct status in Ayurveda as medhya (intellect-enhancing), is the most abundantly used herb that upgrades mental ability, memory and clarity. It is conventionally recommended among those who have brain fog, an inability to concentrate, and age-related brain slowdown. Brahmi Herb Brahmi is usually used along with other Ayurvedic medicines such as Shankhpushpi (*Convolvulus pluricaulis*) in order to enhance the cognitive-enhancing effects further. Brahmi is incorporated in various preparations and Brahmi Ghrita (medicated ghee), Brahmi Vati (tablets) are usually prescribed to students, old aged people and those who have recovered a neurological issue. Its neuroprotective advantages have been supported by scientific studies which say that Brahmi improves neuronal communication and minimizes the oxidative stress in the brain (Calabrese et al., 2008). Due to its capacity to ameliorate the symptoms of ADHD and promote learning capabilities as well as synaptic plasticity, the herb has been thoroughly researched.

3.3 Neem (*Azadirachta indica*) – Antimicrobial and Skin Health

Neem is known as a Village Drug store And it is one of the strongest antimicrobial plants in Ayurveda. Neem in the traditional medicine has been applied detoxifying, antifungal and antibacterial agents especially in healing skin diseases, dental infection and clean up of circulating blood (Subapriya & Nagini, 2005). Neem leaves are incorporated into many products such as Neem Patra churna (leaf powder) and Neem Oil that have found many applications towards curing of acne, eczema, psoriasis and so many other diseases of the skin. The bitter extracts of neem like nimbin and nimbidin display effective antibacterial properties hence a natural substitute to artificial antibiotics (Girish & Shankara, 2008). Moreover, it has considerable contribution in oral health care because it is incorporated in herbal toothpaste, mouth rinses and chewing sticks to preserve the health of the gums and also prevent cavities.

3.4 Tulsi (*Ocimum sanctum*) – Immune Modulation and Respiratory Benefits

Tulsi or Holy Basil is probably the most sacred herb in Ayurveda and sometimes it is called the Queen of Herbs because of an immense variety of medical uses. Tulsi has been traditionally consumed in order to increase immunity, alleviate respiratory conditions and decrease inflammation (Cohen, 2014). It is recognized as a substance with adaptogenic, anti-stress, and anti-inflammatory effect, which is an essential component of the Ayurvedic preparations. Tulsi Tea and Tulsi Ark (herbal extract), are both taken commonly to boost immune system and lung health. Tulsi works more specifically in the management of cough, asthma and chronic bronchitis because it aids in the removal of mucus and promotes respiration (Prakash & Gupta, 2005). It was also found out through research that Tulsi is antiviral and it can make the body resist infections like viral fevers and flu.

3.5 Guduchi (*Tinospora cordifolia*) – Anti-inflammatory and Metabolic Health

Guduchi or Amrita, also termed as nectar of immortality is a significant immunomodulatory and anti-inflammatory medicinal herb in Ayurveda. It has been traditionally employed due to the properties of boosting immunity, normalizing metabolism, and improving conditions of the liver. Indian Guduchi is mostly used as Guduchi Kwath (decoction) or Guduchi Satva (starch extract) form. Its reduction of inflammation and oxidative stress has been attributed to its bioactive compounds which are alkaloids, flavonoids and diterpenoid lactones (Jagetia & Rao, 2006). In case of diabetes and obesity, i.e., metabolic disorders, Guduchi has been found to manage these diseases significantly owing to its ability to enhance the sensitivity of insulin and normalize the blood sugar (Figure 3).

Table 2: Traditional Ayurvedic Uses of Key Medicinal Plants and Their Formulations

Medicinal Plant	Traditional Uses	Common Ayurvedic Formulations
Ashwagandha (<i>Withania somnifera</i>)	Stress relief, energy enhancement, reproductive health	Ashwagandha Churna, Ashwagandha Lehyam
Brahmi (<i>Bacopa monnieri</i>)	Cognitive function, mental clarity, memory retention	Brahmi Ghrita, Brahmi Vati
Neem (<i>Azadirachta indica</i>)	Skin health, blood purification, antimicrobial	Neem Oil, Neem Patra Churna
Tulsi (<i>Ocimum sanctum</i>)	Immune boosting, respiratory health, stress relief	Tulsi Ark, Tulsi Tea
Guduchi (<i>Tinospora cordifolia</i>)	Immunity enhancement, metabolic health, liver support	Guduchi Kwath, Guduchi Satva

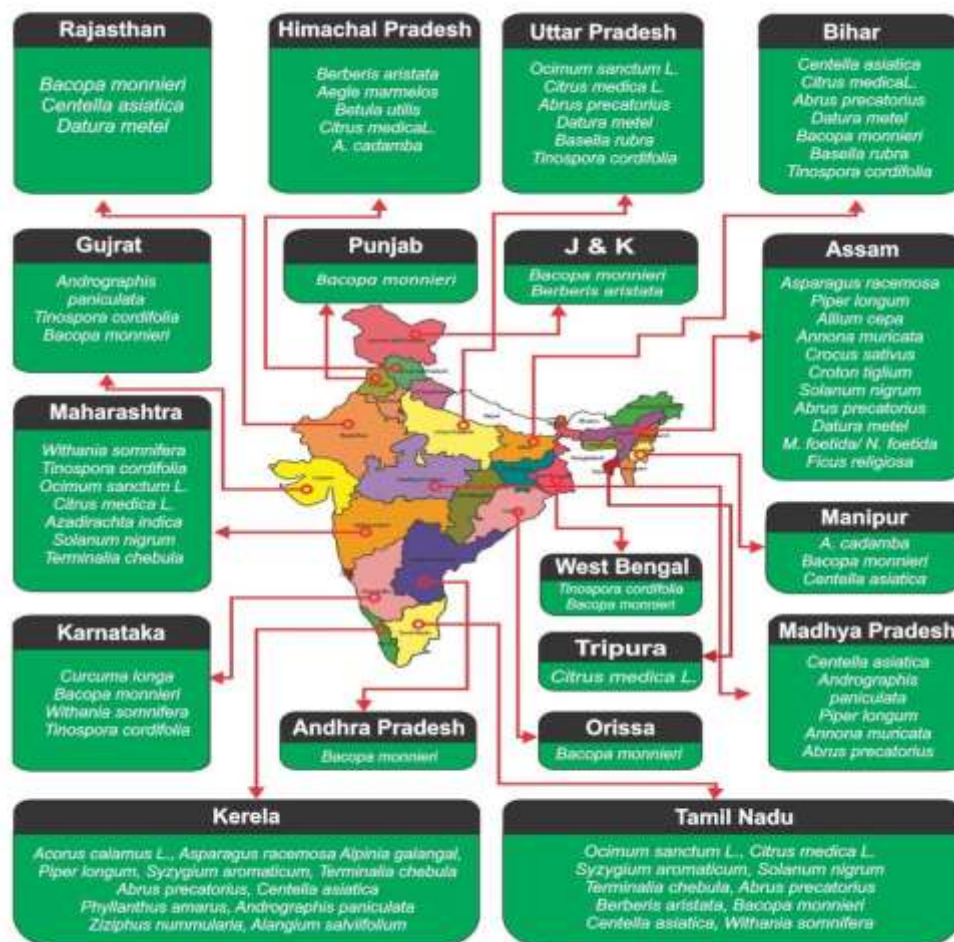


Figure 3: Geographical Distribution of Major Ayurvedic Medicinal Plants in India and Globally

Source: Fatima *et al.*, 2021

4. Modern Scientific Perspectives on Ayurvedic Medicinal Plants

Ayurvedic medicinal plants have many centuries of use behind them and thus to incorporate them into the contemporary medicine field needs to be scientifically validated. Improvements in the fields of phytochemical research, pharmacokinetics, and clinical trials have illuminated on their therapeutic capabilities. Traditional Ayurvedic texts give us empirical knowledge, where scientific ways of understanding give us mechanistic knowledge, enhancement of bioavailability and evidence-based uses. In this section, the information provided is about the phytochemical profile, the pharmacological action, pharmacokinetics, bioavailability and challenges associated with bioavailability and clinical studies regarding Ayurvedic medicinal plants (Patwardhan *et al.*, 2004) (Table 3).

4.1 Phytochemical and Pharmacological Properties

Ayurvedic medicinal plants contain abundance of bioactive compounds, such as alkaloids, flavonoids, tannins, polyphenols, terpenoids, and saponins, all of which have antioxidant anti-inflammatory, antimicrobial, and neuroprotective effects (Pandey & Rizvi, 2009). These phytochemicals form an important part in the therapeutic power of Ayurvedic herbs. Neuroprotective, adaptogenic or anti-stress properties are shown by alkaloids including withanolides in Ashwagandha (*Withania somnifera*) (Chandrasekhar *et al.*, 2012). Brahmi (*Bacopa monnieri*) uses flavonoids to increase mental capability, defend the neurons against oxidative stress, and upgrade neurotransmitters (Calabrese *et al.*, 2008). Tannins are rich in Neem (*Azadirachta indica*) and these are antimicrobial and astringent, that help in wound healing and prevent bacteria (Girish & Shankara, 2008). The enclosing gums of Tulsi (*Ocimum sanctum*) include polyphenols eugenol and rosmarinic acid which are found to have anti-inflammatory and immunomodulatory properties (Cohen, 2014). Guduchi (*Tinospora cordifolia*) has been found to be useful in enhancing immune response, creating anti-inflammation activity, and ensuring good metabolism. These bioactive substances may perform their functions by various pharmacological action, such as antioxidant defense (scavenging of free radicals), anti-inflammatory activity (inhibition

of inflammatory mediators) and regulation of neurotransmitter levels (improved cognitive functions and response to stress). This scientific evidence confirms the therapeutic power of Ayurvedic plants that prove their presence in integrative medicines.

4.2 Pharmacokinetics and Bioavailability Challenges

Ayurvedic medicinal plants despite their strong pharmacological effects are exposed to bioavailability and pharmacokinetic problems that restrict the efficacy of such medicinal plants. The poor solubility and low permeability, high metabolism and minimal systemic absorption characterize many phytochemicals making them to have only limited use in clinics. As an example, the low aqueous solubility and strong metabolism limits the oral bioavailability of curcumin in Turmeric (*Curcuma longa*) (Prasad et al., 2014). This is also the case with Brahmi bacosides which are fast metabolized hence little therapeutic effect in promoting cognitive stimulation. The low gastrointestinal stability of most Ayurvedic plants makes it important to come up with new delivery mechanisms that would enhance the absorbability of herbs. The skills in nanotechnology and the herbal drug delivery systems have improved those last years. To improve of Ayurvedic bioactives is via nano-emulsions, phytosomes and polymeric nanoparticles (Kesarwani & Gupta, 2013). The targeted delivery of flavonoids has been increased by implementing liposomal encapsulation, the curcuminoid and withanolides have been enhanced in their plasma concentration and therapeutic effect due to the nanoparticle formulation (Singh et al., 2010). Such innovation allows a greater therapeutic effect, and with it, Ayurvedic medicinal herbs can be successfully included in the pharmacology of the modern word.

4.3 Clinical Trials and Evidence-Based Research

Ayurvedic medicinal plants are proven to be safe and effective as scientific validation of the Ayurvedic medicinal plants has been tested by preclinical and clinical investigations. The health benefits attributable to these plants have been shown by various researches that especially afford these plants with health augmentation in the management of stress, cognitive functions, immune balance, and metabolic processes (Khan & Balick, 2001). A major randomized controlled trial of the Ashwagandha (*Withania somnifera*) produced a large decrease in the level of cortisol and increased stress resilience and cognitive performance (Chandrasekhar et al., 2012). In yet another double blind trial, placebo controlled study, on Brahmi (*Bacopa monnieri*) it was discovered that Brahmi enhanced memory potential and slowed the effects of memory loss and improved ADHD symptoms (Calabrese et al., 2008). Among the various antimicrobial and antiviral agents, Neem (*Azadirachta indica*) has undergone a wide study which has revealed that it possesses potent antibacterial action against *Staphylococcus aureus* and *Escherichia coli* (Girish & Shankara, 2008). Through its respiratory and immune-enhancing effects, it has been revealed that tulsi (*Ocimum sanctum*), An ancient Ayurvedic remedy, improves lung function in patients with asthma and decreases the levels of oxidative stress markers (Cohen, 2014). *Tinospora cordifolia* or guduchi has been significantly explored in connection with metabolic health where administered, it exhibited glucose-modification, immune modulating and liver protective attributes in clinical trials. Although such significant results are promising, there are still restrictions in the existing studies, such as small sample size, no standardized dose limit, and insufficient data of longer follow-up studies. Larger multi-center clinical trials and formulation of standardized formulations are needed to develop evidence based guidelines on clinical use of Ayuradyic medicinal plants (Patwardhan et al., 2004).

Table 3: Comparison of Ayurvedic Medicinal Plant Efficacy – Traditional Claims vs. Modern Research Findings

Medicinal Plant	Traditional Use	Modern Research Findings
<i>Withania somnifera</i> (Ashwagandha)	Stress relief, vitality enhancement	Clinical trials confirm adaptogenic effects and reduced cortisol levels (Chandrasekhar et al., 2012).
<i>Bacopa monnieri</i> (Brahmi)	Memory enhancement, cognitive health	Demonstrated improvement in cognitive function and ADHD symptoms (Calabrese et al., 2008).
<i>Azadirachta indica</i> (Neem)	Antimicrobial, detoxification	Shown to exhibit strong antibacterial and antifungal properties (Girish & Shankara, 2008).
<i>Ocimum sanctum</i> (Tulsi)	Immune modulation, respiratory health	Found to enhance lung function and reduce inflammation in asthma patients (Cohen, 2014).
<i>Tinospora cordifolia</i> (Guduchi)	Immunity booster, metabolic health	Clinical trials support its role in glucose metabolism and liver detoxification.

5. Ayurvedic Medicinal Plants in Disease Management

It has been shown that ayurvedic medicinal plants possess therapeutic benefits in treatment of a broad spectrum of disease conditions such as neurological disorders, metabolic syndromes, cardiovascular diseases, cancer and immune related diseases. Bioactive compounds that possess their pharmacological effects provide neuroprotection, anti-diabetes,

cardioprotection, anticancer activity and immunomodulation (Patwardhan et al., 2004). This discussion examines evidence use of Ayurvedic medicinal plants in contemporary disease management, including their modes of actions and confirmation (Table 4).

5.1 Neurological Disorders – Ashwagandha and Brahmi in Alzheimer’s and Parkinson’s Disease

Diseases such as Alzheimer’s and Parkinson diseases are neurodegenerative because they are characterized with progressive loss of neurons, oxidative stress and neuroinflammation, with the outcome being cognitive impairment as well as motor loss (Choudhary & Singh, 2021). Ashwagandha (*Withania somnifera*) is a well-known adaptogen which has been used to understand its neuroprotective effects, memory enhancement, and effects on neurotransmitters. Brahmi (*Bacopa monnieri*) is also a well-known memory enhancer that has been studied due to its neuroprotective effects and able to modulate neurotransmitters. Ashwagandha is found to prevent amyloid deposits, a characteristic of Alzheimer disease and prevent oxidative destruction in dopaminergic neurons, serving as protection against Parkinson disease. Withanolides, its active compounds, regulate cholinergic activity and neurotrophic factors that are key ingredients of synaptic plasticity and cognitive performance. Brahmi has been observed to sharpen memory, prevent oxidative damage as well as regulate levels of acetylcholine and hence enhance cognitive functions in individuals with Alzheimer disease (Calabrese et al., 2008). Regular use of supplements of Brahmi has been shown to improve working memory, attention, and regeneration of the neurons through clinical trials.

5.2 Metabolic Disorders – Turmeric and Guduchi in Diabetes Management

Diabetes mellitus, a chronic metabolic disorder characterized by insulin resistance and hyperglycemia, is a major global health concern. Ayurvedic plants such as Turmeric (*Curcuma longa*) and Guduchi (*Tinospora cordifolia*) have exhibited anti-diabetic effects through modulation of glucose metabolism and insulin sensitivity. Curcumin, the primary bioactive compound in Turmeric, has been reported to enhance pancreatic beta-cell function, reduce insulin resistance, and lower blood glucose levels. Studies suggest that curcumin supplementation significantly decreases HbA1c levels in prediabetic individuals, preventing the progression to full-blown diabetes (Prasad et al., 2014). Guduchi, known for its immunomodulatory and adaptogenic properties, regulates glucose homeostasis by inhibiting α -glucosidase, reducing postprandial hyperglycemia, and modulating oxidative stress pathways. Clinical studies have demonstrated that Guduchi lowers fasting blood sugar levels and improves insulin sensitivity, making it a potential complementary therapy for type 2 diabetes.

5.3 Cardiovascular Health – Arjuna (*Terminalia arjuna*) and Heart Protection

Cardiovascular diseases (CVDs) are the most well-documented cause of death in the world, and Arjuna (*Terminalia arjuna*) has received lessons that it has lots of cardioprotective potentials resourced in Ayurvedic medicine. Traditionally, the medicinal plant has been used in the treatment of cardiac support, hypertension, and cholesterol. It has been found that triterpenoids, flavonoids and glycosides are contained in the Arjuna bark and have shown antioxidant, anti-inflammatory and lipid lowering effects. Research has indicated that extract of Arjuna plays large roles in enhancing endothelial functioning, decreasing the formation of plaques in arteries, and the improvement of cardiac output in the patients with coronary artery disease (Karthikeyan et al., 2003). Further, Arjuna has been demonstrated to lower LDL cholesterol and lowering triglyceride levels and the health of the heart in general (Gupta et al., 2001). The vasodilatory and anti-hypertensive abilities of Arjuna are achieved via alteration of nitric oxide and thereby enhancing blood flow and minimizing arterial wall hardness. Such results confirm the status of Arjuna as an endogenous cardioprotectant, which promotes its application as an adjuvant therapy to treat cardiovascular diseases.

5.4 Cancer Research – Anticancer Potential of Ayurvedic Herbal Medicine

Ayurvedic medicinal plants are indeed worthy of special consideration when it comes to the prevention and the treatment of cancer. Anti-proliferative, Apoptotic and cytotoxic attributes of bioactive compounds in many Ayurvedic herbs are known to attack cancer cell growth and metastasis. The most well-researched anticancer Ayurvedic plants are turmeric (*Curcuma longa*). Through its downstream inhibition of NF-kB activation, curcumin retards tumor growth through less angiogenesis, and causes apoptosis on cancerous cells (Aggarwal & Sung, 2009). According to the preclinical evidence, it has been indicated that curcumin can complement the process of chemotherapy without compromising its potency and magnitude of toxicity (Goel et al., 2008). Anticancer activity of neem against breast, prostate and colon cancer cells has been reported, which could be due to the modulation of the oxidative stress pathway and the initiation of cell cycle arrest (Brahmachari, 2004). On top of that, Ashwagandha (*Withania somnifera*) has been discovered to slow the growth of tumors through control over p53 genes that suppress tumors, as well as to increase immunity surveillance. Although these are positive results, there is a need to conduct extensive clinical studies in order to establish efficacy and safety of Ayurvedic herbal medicine in cancer management.

5.5 Immunity and Infectious Diseases – Tulsi and Neem in Immune Support

Improvement of immunomodulatory effect: The immune-modulative changes of Ayurvedic plants are extensively reported, and Tulsi (*Ocimum sanctum*) and Neem (*Azadirachta indica*) are known widely because of immune boosting and prevention of infections (Cohen, 2014). Tulsi also boosts innate and adaptive immunity by resulting in cytokine manufacture, T-helper cell activation, and macrophage enhancement. It has been observed that a person who regularly consumes Tulsi extracts is less prone to such respiratory disorders as pneumonia and bronchitis, viral fevers and bacterial infections (Prakash & Gupta, 2005). Neem is also hailed as having high antiviral, antifungal and antibacterial activities, and in that way helps in fighting the infectious diseases, such as malaria, tuberculosis and skin infections (Girish & Shankara, 2008). Other active components of neem like azadirachtin and nimbolide were found to inhibit viral replication and immune modulation which makes it a prospective alternative agent of natural origin in controlling infectious diseases (Biswas et al., 2002).

Table 4: Key Ayurvedic Plants and Their Role in Disease Management Based on Modern Studies

Medicinal Plant	Traditional Use	Modern Research Findings
<i>Withania somnifera</i> (Ashwagandha)	Neuroprotection, stress relief	Shown to improve cognitive function and reduce neuroinflammation.
<i>Bacopa monnieri</i> (Brahmi)	Memory enhancement	Demonstrated benefits in Alzheimer's and ADHD patients (Calabrese et al., 2008).
<i>Curcuma longa</i> (Turmeric)	Anti-inflammatory, anti-cancer	Clinical trials confirm its role in reducing cancer progression (Aggarwal & Sung, 2009).
<i>Terminalia arjuna</i> (Arjuna)	Cardioprotective	Found to improve heart function and reduce LDL cholesterol (Gupta et al., 2001).
<i>Ocimum sanctum</i> (Tulsi)	Immune modulator, anti-viral	Enhances cytokine production and reduces respiratory infections (Cohen, 2014).

6. Integration of Ayurveda with Modern Science

Ayurvedic medicinal system needs to be amalgamated with scientific innovation to improve credibility, efficacy and global acceptance of herbal medicine. Ayurvedic formulations have been exposed to the new horizons of standardization, biotechnology and nanotechnology that has ensured quality management, increased bioavailability and evidence-based validation (Patwardhan et al., 2004). In this section on the role of modern methods of analysis, the advances in biotechnology, delivery methods of newer drugs and interdisciplinary effort come forward in trying to increase the scope of Ayurvedic medicine (Table 5).

6.1 Standardization and Quality Control in Ayurvedic Formulations

The quality control and standardization will play a key role in the acceptability of the Ayurvedic formulations across the world. The efficacy and safety of herbal medicines are influenced by the differences in the place where they are grown, expertise in manufacturing the medicines, and the amounts of bioactive substances. Complex analytical methods of phytochemical profiling and standardization are used to achieve reproducibility and consistency. High-Performance Liquid Chromatography (HPLC) and Gas Chromatography-Mass Spectrometry (GC-MS) and Fourier-Transform Infrared (FTIR) Spectroscopy methods are very important in fingerprinting bioactive constituents, detecting contaminants, and batch-to-batch consistency (Kunle et al., 2012). Quantification of polyphenols and flavonoids in Turmeric (*Curcuma longa*) and Ashwagandha (*Withania somnifera*) are widely examined by HPLC to guarantee that they are effective therapies. GC-MS helps in the characterization of volatile oils in Tulsi (*Ocimum sanctum*) and neem (*Azadirachta indica*), which confirmed the purity or bioactivity of the same. To guarantee the level of Ayurveda, I used to introduce the pharmacopoeial standards developed by the World Health Organization (WHO) and AYUSH Ministry of India, which guarantee the level of Ayurvedic formulation, its purity, safety, and efficacy. The potentiality of Ayurvedic formulation has been boosted further due to Good Manufacturing Practices (GMP) DNA barcoding and chemical fingerprinting.

6.2 Biotechnology and Ayurvedic Research

Biotechnology has transformed the Ayurvedic medicinal plants and in the studies of genomic, metabolomic and proteomic researches. These methods make it possible to learn more about the herbal pharmacology of plants, the synthesis of bioactive compounds and plant-based therapy (Tiwari et al., 2014). Genomic and metabolomic profiling can be used to validate species of medicinal plants, enhance good cultivation processes as well as discover new phytoconstituents. As an example, DNA barcoding has been used to distinguish real Ashwagandha (*Withania somnifera*) and its adulterants hence therapeutic reliability (Sharma and Vijnana, 2011). There is some information available on synergistic interaction among phytochemicals in Ayurvedic formulations using metabolomics, a method involving quantitative analysis of bioactive

metabolites. Nuclear magnetic resonance (NMR) and liquid chromatography-mass spectrometry (LC-MS) studies have reported that the co-administration of Curcumin and Piperine increases the bioavailability of Curcumin justifying their co-administration in Ayurveda (Kesarwani & Gupta, 2013).

6.3 Nanotechnology in Ayurveda

Nanotechnology has overcome these issues of poor solubility, bioavailability and targeted delivery of formulations in Ayurveda herbal drugs. Ayurvedic medicines have enhanced their pharmacokinetics and therapeutic efficacy with the help of nanoformulas especially herbal nanoparticles, phytosomes, and nanoemulsions (Prasad et al., 2014). Curcuma longa modified and nano-formulated Nano-Curcumin has shown better results regarding the improved bioavailability and potency in anti-inflammatory activity hence has a potential therapeutic value against cancer, arthritis, and neurodegenerative diseases (Singh et al., 2010). In the same way, nanoparticles loaded with Ashwagandha have better facilitated neuroprotective and adaptogenic effects and negated the problem faced by many withanolides of rapid metabolism (Katiyar et al., 2024). Improved effectiveness of Ayurvedic drugs Ayurvedic medicinal compounds preserved over a longer period The recent developments in liposomal encapsulation and polymeric nanoparticle systems have further streamlined drug release patterns and specificity, so that Ayurvedic medicinal compounds are active prolonged periods of time. These advancements facilitate the inclusion of Ayurveda in the regular drug uses.

6.4 Bridging Traditional Knowledge with Evidence-Based Medicine

Multi-disciplinary alliances of Ayurvedic physicians, pharmacologists, and biomedical scientists plenary is important in establishing the traditional formulations via scientific methodology in its authenticity. Herbal clinical studies and evidence-based research have contributed to the currently growing status of Ayurveda as an alternative system of medical care in the world. Randomized controlled trials (RCTs) have been conducted on herbal formulations as stress coping agent (Ashwagandha), cognitive enhancers (Brahmi), and immune modulatory (Tulsi) where a substantial clinical effect is displayed (Chandrasekhar et al., 2012). Inclusion of Ayurveda in international healthcare strategies in form of research programmes, regulatory overrides, and multidisciplinary symposiums has helped Ayurveda gain more grounds. In spite of these developments, there are still issues about reconciliation of Ayurvedic theories with contemporary scientific theories. Ayurvedic is based on holistic and personalized system of treatment as compared to modern pharmacology which is based on standardized drug doses. Globalization of Ayurvedic medicine will be important in realizing a balance between conventional wisdom and evidence-based validation without compromising on the principle of Ayurveda medicine.

Table 5: Advancements in Ayurvedic Medicinal Plant Research Using Modern Technology

Technological Approach	Application in Ayurveda	Example Medicinal Plants
HPLC & GC-MS	Phytochemical profiling & purity testing	Turmeric, Ashwagandha, Tulsi
FTIR Spectroscopy	Structural characterization of bioactive compounds	Neem, Guduchi, Arjuna
Genomics & DNA Barcoding	Authentication & standardization of medicinal plants	Brahmi, Ashwagandha, Shatavari
Nanotechnology (Phytosomes, Nanoparticles)	Enhancing bioavailability & targeted drug delivery	Nano-curcumin, Ashwagandha nanoparticles
Metabolomics & LC-MS	Synergistic analysis of Ayurvedic polyherbal formulations	Curcumin-Piperine, Triphala

7. Challenges and Future Directions

Globalization of Ayurvedic medicinal plants in the contemporary healthcare systems poses a number of challenges and opportunities. Even though Ayurvedas have immense potential as therapeutic, areas of concern like regulatory inconsistencies, scientific validation, sustainability concern and changing research methodologies need to be dealt with. There is further protocol of guaranteeing technology, conservation and interdisciplinary collaboration to reinforce the authority of Ayurveda in the evidence based medicine (Table 6).

7.1 Regulatory and Legal Frameworks

Lack of consistent global regulations in Ayurveda medicine may be considered one of the key concerns. Although some nations draw Ayurveda as a brand of medical practice, in others the Ayurvedic drugs may be categorized as dietary supplements, and different standards may be placed on them. Ayurvedic herbal formulations have to be standardized; this will have to be achieved through alignment of safety, efficacy and quality control provisions with global regulatory agencies. Setting of the guidelines of good manufacturing practices, phytochemical profiling and standardized dosage forms is crucial in making the product reliable. Ayurvedic pharmacopoeia needs to be developed using ancient knowledge and modern scientific authenticity to make the world accept herbal medicines. Also, in the era of the growing

commercialization, protection of the intellectual property and fair distribution of benefit concerning the common knowledge of ayurveda is an essential aspect to be considered.

7.2 Scientific Validation and Clinical Translation

Modern legal recognition of herbal medicines primarily relies on their scientific confirmation by clinical tests although Ayurveda has enjoyed empirical evidence over the entire duration of its existence. Ayurvedic formulations have not had broad-based appeal in conventional healthcare due to insufficiency in any large-scale randomized controlled trials. Developing an effective clinical study process with the congruency of the contemporary pharmacological science would be necessary to fill in the gap between Ayurveda and evidence-based medicine. One other clinical translation issue is standardization of complicated polyherbal formations. As opposed to individual-compound pharmaceutical drugs, Ayurvedic herbal products frequently contain several different herbs that show synergistic effects, and single compounds and isolate active components are therefore hard to quantify pharmacologically. To gain a better understanding of how Ayurvedic herbs work and how effective they can be, the combination of complex analytical methods, bioinformatics, and pharmacokinetics could be used.

7.3 Sustainability and Conservation of Medicinal Plants

The success of Ayurvedic herbal medicine in the international market as a global trend has generated concerns over the viability of the medicinal plants resources. Some of the main Ayurvedic species of plants have been depleted due to overharvesting, destroying their habitats and climate change. Unsustainable exploitation of herbs in wild does not only endanger biodiversity but ultimately impacts on the quality (potency and purity) of medicinal plants preparations. Conservation including use of sustainable harvesting, cultivation and protection of endangered medicinal flora and preservation of genetic resources should be given priority to have Ayurvedic herbs available in the long run. Projects of community-based conservation, medicinal plant nurseries, and seed banks are important towards conservation of biodiversity in plants. Not only that, practices of good agricultural and collection guarantee that Ayurvedic medicines maintain their therapeutic strength, and the environmental influence is kept to a minimum.

7.4 Future Trends in Ayurvedic Research

The emerging technologies that have potential impact on advancing Ayurvedic research are artificial intelligence (AI), nanotechnology, and precision medicine. The discovery of herbal drugs can be optimized by AI-based research methods, and formulation procedures can be streamlined and optimized as well as predictive analysis optimization of Ayurvedic treatments. Big data analytics has the potential of personalizing the use of herbal medicine based on the constitution and a health profile of an individual, once integrated with Ayurveda. The herbal medicine field is also witnessing a revolution resulting in the enhancement of bioavailability, specificity, and efficacy of the Ayurvedic compounds using nanotechnology. The Nanoformulation of Ayurvedic herbs are more readily absorbed, circulate more slowly and have stronger therapeutic properties and hence a good innovation into the integrative medicine. Ayurveda, biotechnology, pharmacology and clinical sciences are some of the disciplines and disciplines that have interdisciplinary ventures that will be of great importance in developing Ayurvedic medicine. Whether Ayurveda can sign in with the modern-day healthcare facilities, backed by strict scientific verifications, sustainable management of resources, and well-designed technologies has been the decider in defining the global acceptance and future of Ayurveda.

Table 6: Key Challenges in Ayurvedic Medicinal Plant Research and Proposed Solutions

Challenge	Description	Proposed Solutions
Regulatory Disparities	Lack of uniform global standards for Ayurvedic formulations	Harmonization of international guidelines, regulatory frameworks
Clinical Validation Issues	Limited large-scale clinical trials and pharmacological studies	Development of multi-center clinical trials, systems biology research
Sustainability Concerns	Overharvesting and depletion of medicinal plant species	Conservation efforts, sustainable harvesting, and plant tissue culture
Bioavailability Limitations	Poor solubility and pharmacokinetics of Ayurvedic bioactives	Use of nanotechnology-based drug delivery systems
Traditional vs. Modern Integration	Challenges in aligning Ayurveda with evidence-based medicine	AI-driven research, personalized herbal medicine, and interdisciplinary collaborations

8. Conclusion

The traditional forms of healthcare consider medicinal plants, particularly Ayurvedic in nature, to have treated people holistically and to offer therapeutic advantages, over centuries. This can be used in the fields of neurology, metabolism,

cardiovascular health, immune modulation, anti-cancer research among others, making them great broad-spectrum substances. Pharmacological activities of these plants have been well documented in traditional Ayurvedic literature and to a larger degree modern scientific technologies have started proving pharmacological values of these plants through clinical trials, bioanalysis and pharmacological trial studies. With all these new developments, issues regarding standardization, clinical validation, and sustainability need to be resolved in order to ensure that Ayurveda becomes a competent, worldwide recognised complementary healthcare system. Ayurvedic wisdom is closely connected with the improvement of modern science; to make a linkage between traditional expertise and scientific evidence-based solution. Herbal research is already being revolutionized by improving the bioavailability and clinical efficacy through improving analytical chemistry, biotechnology, nanotechnology and artificial intelligence. This is going to help harmonize global pharmacopoeias with Ayurvedic pharmacopoeias which will support the global acceptance of herbal medicines and hence, their quality and safety. Moreover, the sustainable harvesting and conservation programs to protect the biodiversity of medicinal plants is essential to the satisfaction of the increased need of herbal formulations. This is needed in future researches that aim at establishing scientific validation of Ayurvedic methods of therapies through large scale randomized controlled trials. Interdisciplinary networks coordinating Ayurveda, pharmacology, and clinical sciences will make it possible to develop the approach to herbal medicine personalization. The changes in policy must focus on enhanced standardization of regulation, ethical commercialization, and fair benefit-sharing of the traditional knowledge holders. Combining several principles used in Ayurveda with the scientific rigor will help transform the herbal medicine by changing it, introducing a new sustainable, holistic, and universally approved way of healthcare distribution.

References

1. Aggarwal, B. B., & Sung, B. (2009). Pharmacological basis for the role of curcumin in chronic diseases: an age-old spice with modern targets. *Trends in pharmacological sciences*, 30(2), 85-94.
2. Balkrishna, A., Sharma, N., Srivastava, D., Kukreti, A., Srivastava, S., & Arya, V. (2024). Exploring the safety, efficacy, and bioactivity of herbal medicines: Bridging traditional wisdom and modern science in healthcare. *Future Integrative Medicine*, 3(1), 35-49.
3. Biswas, K., Chattopadhyay, I., Banerjee, R. K., & Bandyopadhyay, U. (2002). Biological activities and medicinal properties of neem (*Azadirachta indica*). *Current science*, 1336-1345.
4. Brahmachari, G. (2004). Neem—an omnipotent plant: a retrospection. *Chembiochem*, 5(4), 408-421.
5. Calabrese, C., Gregory, W. L., Leo, M., Kraemer, D., Bone, K., & Oken, B. (2008). Effects of a standardized *Bacopa monnieri* extract on cognitive performance, anxiety, and depression in the elderly: a randomized, double-blind, placebo-controlled trial. *The journal of alternative and complementary medicine*, 14(6), 707-713.
6. Chandrasekhar, K., Kapoor, J., & Anishetty, S. (2012). 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 journal of psychological medicine*, 34(3), 255-262.
7. Choudhary, N., & Singh, V. (2021). Neuromodulators in food ingredients: insights from network pharmacological evaluation of Ayurvedic herbs. *arXiv preprint arXiv:2108.09747*.
8. Cohen, M. M. (2014). Tulsi-*Ocimum sanctum*: A herb for all reasons. *Journal of Ayurveda and integrative medicine*, 5(4), 251.
9. Fatima, Nishat & Baqri, S. Shabihe Raza & Alsulimani, Ahmad & Fagoonee, Sharmila & Sláma, Petr & Kesari, Kavindra & Roychoudhury, Shubhadeep & Haque, Shafiul. (2021). Phytochemicals from Indian Ethnomedicines: Promising Prospects for the Management of Oxidative Stress and Cancer. *Antioxidants*. 10. 1606. 10.3390/antiox10101606.
10. Girish, K., & Shankara, B. S. (2008). Neem—a green treasure. *Electronic journal of Biology*, 4(3), 102-111.
11. Goel, A., Kunnumakkara, A. B., & Aggarwal, B. B. (2008). Curcumin as “Curecumin”: from kitchen to clinic. *Biochemical pharmacology*, 75(4), 787-809.
12. Gupta, R., Singhal, S., Goyle, A., & Sharma, V. N. (2001). Antioxidant and hypocholesterolaemic effects of *Terminalia arjuna* tree-bark powder: a randomised placebo-controlled trial. *The Journal of the Association of Physicians of India*, 49, 231-235.
13. Jagetia, G. C., & Rao, S. K. (2006). Evaluation of the antineoplastic activity of guduchi (*Tinospora cordifolia*) in Ehrlich ascites carcinoma bearing mice. *Biological and Pharmaceutical Bulletin*, 29(3), 460-466.
14. Karthikeyan, K., Bai, B. S., Gauthaman, K., Sathish, K. S., & Devaraj, S. N. (2003). Cardioprotective effect of the alcoholic extract of *Terminalia arjuna* bark in an in vivo model of myocardial ischemic reperfusion injury. *Life sciences*, 73(21), 2727-2739.
15. Katiyar, S., Kumari, S., Dev, A., Tripathi, R. S., Srivastava, P. K., & Mishra, A. (2024). Herbal Nanoparticles Drug-Loaded for the Treatment of Neurodegenerative Diseases. *Nanoarchitectonics for Brain Drug Delivery*, 266.
16. Kesarwani, K., & Gupta, R. (2013). Bioavailability enhancers of herbal origin: An overview. *Asian Pacific journal of tropical biomedicine*, 3(4), 253-266.

17. Khan, S., & Balick, M. J. (2001). Therapeutic plants of Ayurveda: a review of selected clinical and other studies for 166 species. *The Journal of Alternative & Complementary Medicine*, 7(5), 405-515.
18. Kunle, O. F., Egharevba, H. O., & Ahmadu, P. O. (2012). Standardization of herbal medicines-A review. *International journal of biodiversity and conservation*, 4(3), 101-112.
19. Pandey, K. B., & Rizvi, S. I. (2009). Plant polyphenols as dietary antioxidants in human health and disease. *Oxidative medicine and cellular longevity*, 2(5), 270-278.
20. Patwardhan, B., Vaidya, A. D., & Chorghade, M. (2004). Ayurveda and natural products drug discovery. *Current science*, 789-799.
21. Prakash, P. A. G. N., & Gupta, N. (2005). Therapeutic uses of *Ocimum sanctum* Linn (Tulsi) with a note on eugenol and its pharmacological actions: a short review. *Indian journal of physiology and pharmacology*, 49(2), 125.
22. Prasad, S., Gupta, S. C., Tyagi, A. K., & Aggarwal, B. B. (2014). Curcumin, a component of golden spice: from bedside to bench and back. *Biotechnology advances*, 32(6), 1053-1064.
23. Ranade, A., Surana, M., Dhokne, S. V., Gaidhani, S., & Pawar, S. D. (2021). Ayurvedic ideology on Rasapanchak-based cognitive drug intervention. In *Medicinal herbs and fungi* (pp. 445–467). Springer. https://doi.org/10.1007/978-3-030-45496-7_31
24. Sharma, H. M., & Clark, C. (1998). Contemporary Ayurveda: Medicine and Research in Maharishi Ayur-Veda. (No Title).
25. Sharma, P. V., & Vijnana, D. G. (2011). Chaukhambha Bharati Academy. *VOL. II*, 341, 758-760.
26. Singh, G., Sharma, P. K., Dudhe, R., & Singh, S. (2010). Biological activities of *Withania somnifera*. *Ann Biol Res*, 1(3), 56-63.
27. Subapriya, R., & Nagini, S. (2005). Medicinal properties of neem leaves: a review. *Current Medicinal Chemistry-Anti-Cancer Agents*, 5(2), 149-156.
28. Tiwari, P., Mishra, B. N., & Sangwan, N. S. (2014). Phytochemical and pharmacological properties of *Gymnema sylvestre*: an important medicinal plant. *BioMed research international*, 2014(1), 830285.
29. World Health Organization. (2023). WHO global report on traditional and complementary medicine. Retrieved from <https://www.who.int/traditional-medicine>